GorllaS.DA5030.Project.Rmd

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08/07/2022

Breast cancer sub-type classification using proteomic data

Problem statement : Luminal A, Luminal B, HER2, Basal-like are the molecular subtypes of breast cancer that are typically recognized. Each one is related to various prognoses, therapies, and treatments.

Objective : The main objective of this project is to perform classification on breast cancer dataset based on the proteomic expression dataset to identify the subtype of breast cancer. A collection of proteins produced by cancer cells is known as the breast cancer proteome. I am examining if the cancer subtype can be correctly identified using only the proteome data for each patient. The target variable in the study is PAM50 mRNA which is used in breast cancer intrinsic subtyping based on gene expression. The variable is categorical presenting four subtypes (basal-like, HER2-enriched, Luminal A and Luminal B). PAMA50 mRNA proteins are my predictor variables.Using supervised ML classification, I am examining if the cancer subtype can be correctly identified using only the proteome data for each patient.

- Question 1 : where does the data come from?

This data collection includes 77 breast cancer samples from the Clinical Proteomic Tumor Analysis Consortium (NCI/NIH) that have had their iTRAQ proteome profiles published. For each sample, it comprises expression levels for around 12,000 proteins, with missing values present when a particular protein could not be measured. Kaggle URL : https://www.kaggle.com/datasets/piotrgrabo/breastcancerproteomes?resource=download

It has three different files : 77cancerproteomesCPTACitraq.csv, clinicaldatabreast_cancer.csv, PAM50_proteins.csv

1. File: 77cancerproteomesCPTACitraq.csv -RefSeqaccessionnumber: RefSeq protein ID (each protein has a unique ID in a RefSeq database) -gene_symbol: a symbol unique to each gene (every protein is encoded by some gene) -gene_name: a full name of that gene -Remaining columns: log2 iTRAQ ratios for each sample (protein expression data, most important), three last columns are from healthy individuals

2. File: clinicaldatabreast_cancer.csv -First column "Complete TCGA ID" is used to match the sample IDs in the main cancer proteomes file (see example script). -All other columns have self-explanatory names, contain data about the cancer classification of a given sample using different methods.

3. File: PAM50_proteins.csv -Contains the list of genes and proteins used by the PAM50 classification system. -The column RefSeqProteinID contains the protein IDs that can be matched with the IDs in the main protein expression data set.

- Provided installation statements for all packages
- Importing all required libraries

```r
#install.packages("stabs")
# install.packages("factoextra")
# install.packages("NbClust")
# install.packages("ggfortify")
# install.packages("glmnet")
# install.packages("foreign")
# install.packages("ggplot2")
# install.packages("MASS")
# install.packages("Hmisc")
# install.packages("reshape2")
# install.packages("randomForest")
# install.packages("data.table")
# install.packages("mlr")
# intsall.packages("caret")
# install.pacakges("dplyr") # data manipulation
# install.packages("readr") # data input and manipulation
# install.packages("caret) #select tuning parameters
# install.packages("MASS") # contains the data
# install.packages("DataExplorer") #data set visualization
# install.packages("nnet") # used for Multinomial Classification
# install.packages("readr") #assist with text manipulation
# install.packages("kernlab") #assist with SVM feature selection
# install.packages("class") # used for an object-oriented style of programmin
# install.packages("KernelKnn") # used for K- Nearest-Neighbors method
# install.pacakges("nnet") # Used for Neural Net
# install.packages("e1071") #supports vector machine algorithm
# install.packages("forecast") # for model prediction
# install.pacakges("rpart") #construct recursive partitions for classification
# install.packages("neuralnet")
# install.packages("NbClust")
# install.packages("psych")
# install.packages("pheatmap")
# install.packages("OneR")
# install.packges("naivebayes")
# install.packages("dplyr")
# install.packages("ggplot2")
# install.packages("psych")
# install.packages("tidyverse")
# install.packages("assertr")
# install.packages("knitr")
# install.packages("psych")
# install.packages("caret")
# install.packages("e1071")
# install.packages("C50")
# install.packages("gmodels")
# install.packages("pROC")
# install.packages("caTools")
```

- Importing all required libraries

```r
#loading required libraries
library(stabs)
library(factoextra)
```

```r
library(NbClust)
library(ggfortify)
library(glmnet)
require(foreign)
require(ggplot2)
require(MASS)
require(Hmisc)
require(reshape2)
library(randomForest)
library(data.table)
library(mlr)
library(caret)
library(dplyr) # data manipulation
library(readr) # data input and manipulation
library(caret) #select tuning parameters
library(MASS) # contains the data
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library(nnet) # Used for Neural Net
library(e1071) #supports vector machine algorithm
library(forecast) # for model prediction
library(rpart) #construct recursive partitions for classification
library(neuralnet)
library(NbClust)
library(psych)
library(pheatmap)
library(OneR)
library(naivebayes)
library(dplyr)
library(ggplot2)
library(psych)
library(pROC)
library(tidyverse)
library(assertr)
library(knitr)
library(psych)
library(caret)
library(e1071)
library(C50)
library(gmodels)
library(pROC)
library(caTools)
library(ggplot2)
library(GGally)
library(ipred)
```

1.Data Acquisition and manipulation

- for importing data, I used the read.csv() function
- Later, I combined all the datasets into one
- Converted the patients id to one format
- used the head(), str(), dim(), glimpse(), summary() to explore the dataset

Data import - PAM50_proteins.csv

First steps: importing the data and getting the data set into a workable format. list of genes and proteins

```
#Importing data which has list of genes and proteins
gene_proteins <- read.csv("/Users/sanjanagorlla/Desktop/multiclass-classfication/BREAST-CANCER-SUBTYPE/I
# 100 rows and 4 columns
head(gene_proteins)
```

```
##   GeneSymbol RefSeqProteinID      Species
## 1        MIA       NP_006524 Homo sapiens
## 2      FGFR4       NP_002002 Homo sapiens
## 3      FGFR4       NP_998812 Homo sapiens
## 4      FGFR4       NP_075252 Homo sapiens
## 5     GPR160       NP_055188 Homo sapiens
## 6     ACTR3B       NP_065178 Homo sapiens
##                                       Gene.Name
## 1                   melanoma inhibitory activity
## 2            fibroblast growth factor receptor 4
## 3            fibroblast growth factor receptor 4
## 4            fibroblast growth factor receptor 4
## 5                 G protein-coupled receptor 160
## 6 ARP3 actin-related protein 3 homolog B (yeast)
```

```
tail(gene_proteins)
```

```
##     GeneSymbol RefSeqProteinID      Species
## 95        MDM2       NP_002383 Homo sapiens
## 96       FOXC1       NP_001444 Homo sapiens
## 97        GRB7    NP_001025173 Homo sapiens
## 98        GRB7       NP_005301 Homo sapiens
## 99        MELK       NP_055606 Homo sapiens
## 100      UBE2T       NP_054895 Homo sapiens
##                                       Gene.Name
## 95     Mdm2 p53 binding protein homolog (mouse)
## 96                               forkhead box C1
## 97       growth factor receptor-bound protein 7
## 98       growth factor receptor-bound protein 7
## 99     maternal embryonic leucine zipper kinase
## 100 ubiquitin-conjugating enzyme E2T (putative)
```

```
str(gene_proteins)
```

```
## 'data.frame':    100 obs. of  4 variables:
```

```
##  $ GeneSymbol     : chr  "MIA" "FGFR4" "FGFR4" "FGFR4" ...
##  $ RefSeqProteinID: chr  "NP_006524" "NP_002002" "NP_998812" "NP_075252" ...
##  $ Species        : chr  "Homo sapiens" "Homo sapiens" "Homo sapiens" "Homo sapiens" ...
##  $ Gene.Name      : chr  "melanoma inhibitory activity" "fibroblast growth factor receptor 4" "fibrol
```

```
dim(gene_proteins)
```

```
## [1] 100   4
```

```
glimpse(gene_proteins)
```

```
## Rows: 100
## Columns: 4
## $ GeneSymbol      <chr> "MIA", "FGFR4", "FGFR4", "FGFR4", "GPR160", "ACTR3B", ~
## $ RefSeqProteinID <chr> "NP_006524", "NP_002002", "NP_998812", "NP_075252", "N~
## $ Species         <chr> "Homo sapiens", "Homo sapiens", "Homo sapiens", "Homo ~
## $ Gene.Name       <chr> "melanoma inhibitory activity", "fibroblast growth fac~
```

```
summary(gene_proteins)
```

```
##   GeneSymbol        RefSeqProteinID      Species           Gene.Name
##  Length:100         Length:100         Length:100         Length:100
##  Class :character   Class :character   Class :character   Class :character
##  Mode  :character   Mode  :character   Mode  :character   Mode  :character
```

Data import - clinicaldatabreast_cancer.csv

main cancer dataset (has information about patients suffering from each sub-type classified based on PAM50.mRNA)

```
clinical <- read.csv("/Users/sanjanagorlla/Desktop/multiclass-classfication/BREAST-CANCER-SUBTYPE/clini
# 105 obseravtions  and 30 columns
head(clinical)
```

```
##   Complete.TCGA.ID Gender Age.at.Initial.Pathologic.Diagnosis ER.Status
## 1     TCGA-A2-A0T2 FEMALE                                  66  Negative
## 2     TCGA-A2-A0CM FEMALE                                  40  Negative
## 3     TCGA-BH-A18V FEMALE                                  48  Negative
## 4     TCGA-BH-A18Q FEMALE                                  56  Negative
## 5     TCGA-BH-A0E0 FEMALE                                  38  Negative
## 6     TCGA-A7-A0CE FEMALE                                  57  Negative
##   PR.Status HER2.Final.Status Tumor Tumor..T1.Coded Node Node.Coded Metastasis
## 1  Negative          Negative    T3         T_Other   N3   Positive         M1
## 2  Negative          Negative    T2         T_Other   N0   Negative         M0
## 3  Negative          Negative    T2         T_Other   N1   Positive         M0
## 4  Negative          Negative    T2         T_Other   N1   Positive         M0
## 5  Negative          Negative    T3         T_Other   N3   Positive         M0
## 6  Negative          Negative    T2         T_Other   N0   Negative         M0
##   Metastasis.Coded AJCC.Stage Converted.Stage Survival.Data.Form Vital.Status
## 1         Positive   Stage IV   No_Conversion           followup     DECEASED
```

```
## 2        Negative  Stage IIA       Stage IIA          followup     DECEASED
## 3        Negative  Stage IIB   No_Conversion         enrollment     DECEASED
## 4        Negative  Stage IIB   No_Conversion         enrollment     DECEASED
## 5        Negative Stage IIIC   No_Conversion           followup       LIVING
## 6        Negative  Stage IIA       Stage IIA          followup       LIVING
##   Days.to.Date.of.Last.Contact Days.to.date.of.Death OS.event OS.Time
## 1                          240                   240        1     240
## 2                          754                   754        1     754
## 3                         1555                  1555        1    1555
## 4                         1692                  1692        1    1692
## 5                          133                    NA        0     133
## 6                          309                    NA        0     309
##   PAM50.mRNA SigClust.Unsupervised.mRNA SigClust.Intrinsic.mRNA miRNA.Clusters
## 1 Basal-like                          0                     -13              3
## 2 Basal-like                        -12                     -13              4
## 3 Basal-like                        -12                     -13              5
## 4 Basal-like                        -12                     -13              5
## 5 Basal-like                          0                     -13              5
## 6 Basal-like                          0                     -13              5
##   methylation.Clusters RPPA.Clusters CN.Clusters
## 1                    5         Basal           3
## 2                    4         Basal           4
## 3                    5         Basal           1
## 4                    5         Basal           1
## 5                    5         Basal           1
## 6                    5         Basal           1
##   Integrated.Clusters..with.PAM50. Integrated.Clusters..no.exp.
## 1                                2                            2
## 2                                2                            1
## 3                                2                            2
## 4                                2                            2
## 5                                2                            2
## 6                                2                            2
##   Integrated.Clusters..unsup.exp.
## 1                               2
## 2                               1
## 3                               2
## 4                               2
## 5                               2
## 6                               2
```

```
tail(clinical)
```

```
##     Complete.TCGA.ID Gender Age.at.Initial.Pathologic.Diagnosis ER.Status
## 100     TCGA-BH-A0BZ FEMALE                                  59  Positive
## 101     TCGA-BH-A0C7 FEMALE                                  48  Positive
## 102     TCGA-BH-A0DD   MALE                                  58  Positive
## 103     TCGA-C8-A12U FEMALE                                  46  Positive
## 104     TCGA-C8-A12W FEMALE                                  49  Positive
## 105     TCGA-E2-A15A FEMALE                                  45  Positive
##     PR.Status HER2.Final.Status Tumor Tumor..T1.Coded Node Node.Coded
## 100  Positive          Negative    T3         T_Other   N1   Positive
## 101  Negative          Positive    T2         T_Other   N1   Positive
## 102  Positive          Positive    T2         T_Other   N1   Positive
```

```
## 103  Positive          Negative    T2         T_Other   N1   Positive
## 104  Positive          Negative    T4         T_Other   N1   Positive
## 105  Positive          Negative    T2         T_Other   N3   Positive
##     Metastasis Metastasis.Coded AJCC.Stage Converted.Stage Survival.Data.Form
## 100         M0         Negative Stage IIIA      Stage IIIA         enrollment
## 101         M0         Negative  Stage IIB       Stage IIB         enrollment
## 102         M0         Negative  Stage IIB       Stage IIB         enrollment
## 103         M0         Negative   Stage IB       Stage IIB         enrollment
## 104         M0         Negative Stage IIIB      Stage IIIB         enrollment
## 105         M0         Negative Stage IIIC      Stage IIIC         enrollment
##     Vital.Status Days.to.Date.of.Last.Contact Days.to.date.of.Death OS.event
## 100       LIVING                         1492                    NA        0
## 101       LIVING                         1305                    NA        0
## 102       LIVING                         1393                    NA        0
## 103       LIVING                            0                    NA        0
## 104       LIVING                            0                    NA        0
## 105       LIVING                          502                    NA        0
##     OS.Time PAM50.mRNA SigClust.Unsupervised.mRNA SigClust.Intrinsic.mRNA
## 100    1492  Luminal B                         -5                      -2
## 101    1305  Luminal B                         -3                       0
## 102    1393  Luminal B                         -3                      -6
## 103       0  Luminal B                         -5                      -2
## 104       0  Luminal B                         -5                      -2
## 105     502  Luminal B                         -5                      -2
##     miRNA.Clusters methylation.Clusters RPPA.Clusters CN.Clusters
## 100              6                    4             X           4
## 101              4                    4        LumA/B           5
## 102              4                    4        LumA/B           3
## 103              5                    4         Basal           5
## 104              4                    4        ReacII           3
## 105              4                    4          Her2           4
##     Integrated.Clusters..with.PAM50. Integrated.Clusters..no.exp.
## 100                                4                            1
## 101                                4                            1
## 102                                4                            1
## 103                                4                            1
## 104                                4                            1
## 105                                4                            1
##     Integrated.Clusters..unsup.exp.
## 100                               1
## 101                               3
## 102                               3
## 103                               1
## 104                               1
## 105                               1
```

```
summary(clinical)
```

```
##  Complete.TCGA.ID      Gender          Age.at.Initial.Pathologic.Diagnosis
##  Length:105         Length:105         Min.   :30.00
##  Class :character   Class :character   1st Qu.:49.00
##  Mode  :character   Mode  :character   Median :58.00
##                                        Mean   :58.69
##                                        3rd Qu.:67.00
```

```
##                                        Max.   :88.00
##
##   ER.Status          PR.Status          HER2.Final.Status     Tumor
##  Length:105         Length:105         Length:105         Length:105
##  Class :character   Class :character   Class :character   Class :character
##  Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##
##  Tumor..T1.Coded        Node            Node.Coded         Metastasis
##  Length:105         Length:105         Length:105         Length:105
##  Class :character   Class :character   Class :character   Class :character
##  Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##
##  Metastasis.Coded    AJCC.Stage         Converted.Stage    Survival.Data.Form
##  Length:105         Length:105         Length:105         Length:105
##  Class :character   Class :character   Class :character   Class :character
##  Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##
##  Vital.Status       Days.to.Date.of.Last.Contact Days.to.date.of.Death
##  Length:105         Min.   :   0.0               Min.   : 160.0
##  Class :character   1st Qu.: 240.0               1st Qu.: 947.5
##  Mode  :character   Median : 643.0               Median :1364.0
##                     Mean   : 788.4               Mean   :1254.5
##                     3rd Qu.:1288.0               3rd Qu.:1627.5
##                     Max.   :2850.0               Max.   :2483.0
##                                                  NA's   :94
##     OS.event         OS.Time        PAM50.mRNA
##  Min.   :0.0000   Min.   :   0.0   Length:105
##  1st Qu.:0.0000   1st Qu.: 240.0   Class :character
##  Median :0.0000   Median : 665.0   Mode  :character
##  Mean   :0.1048   Mean   : 817.6
##  3rd Qu.:0.0000   3rd Qu.:1305.0
##  Max.   :1.0000   Max.   :2850.0
##
##  SigClust.Unsupervised.mRNA SigClust.Intrinsic.mRNA miRNA.Clusters
##  Min.   :-12.000            Min.   :-13.000         Min.   :1
##  1st Qu.: -6.000            1st Qu.:-12.000         1st Qu.:3
##  Median : -5.000            Median : -6.000         Median :4
##  Mean   : -4.886            Mean   : -7.181         Mean   :4
##  3rd Qu.: -3.000            3rd Qu.: -2.000         3rd Qu.:5
##  Max.   :  0.000            Max.   :  0.000         Max.   :7
##
##  methylation.Clusters RPPA.Clusters       CN.Clusters
##  Min.   :1.000        Length:105         Min.   :1.00
##  1st Qu.:2.000        Class :character   1st Qu.:1.00
##  Median :4.000        Mode  :character   Median :3.00
```

```
##  Mean   :3.343                           Mean   :2.59
##  3rd Qu.:4.000                           3rd Qu.:3.00
##  Max.   :5.000                           Max.   :5.00
##
##  Integrated.Clusters..with.PAM50. Integrated.Clusters..no.exp.
##  Min.   :1.000                    Min.   :1.000
##  1st Qu.:2.000                    1st Qu.:1.000
##  Median :3.000                    Median :2.000
##  Mean   :2.743                    Mean   :1.981
##  3rd Qu.:4.000                    3rd Qu.:3.000
##  Max.   :4.000                    Max.   :4.000
##
##  Integrated.Clusters..unsup.exp.
##  Min.   :1.000
##  1st Qu.:1.000
##  Median :2.000
##  Mean   :2.352
##  3rd Qu.:3.000
##  Max.   :5.000
##
```

```
dim(clinical)
```

```
## [1] 105  30
```

```
clinical$PAM50.mRNA
```

```
##   [1] "Basal-like"    "Basal-like"    "Basal-like"    "Basal-like"
##   [5] "Basal-like"    "Basal-like"    "Basal-like"    "Basal-like"
##   [9] "Basal-like"    "Basal-like"    "Basal-like"    "Basal-like"
##  [13] "Basal-like"    "Basal-like"    "Basal-like"    "Basal-like"
##  [17] "Basal-like"    "Basal-like"    "Basal-like"    "Basal-like"
##  [21] "Basal-like"    "Basal-like"    "Basal-like"    "Basal-like"
##  [25] "Basal-like"    "HER2-enriched" "HER2-enriched" "HER2-enriched"
##  [29] "HER2-enriched" "HER2-enriched" "HER2-enriched" "HER2-enriched"
##  [33] "HER2-enriched" "HER2-enriched" "HER2-enriched" "HER2-enriched"
##  [37] "HER2-enriched" "HER2-enriched" "HER2-enriched" "HER2-enriched"
##  [41] "HER2-enriched" "HER2-enriched" "HER2-enriched" "Luminal A"
##  [45] "Luminal A"     "Luminal A"     "Luminal A"     "Luminal A"
##  [49] "Luminal A"     "Luminal A"     "Luminal A"     "Luminal A"
##  [53] "Luminal A"     "Luminal A"     "Luminal A"     "Luminal A"
##  [57] "Luminal A"     "Luminal A"     "Luminal A"     "Luminal A"
##  [61] "Luminal A"     "Luminal A"     "Luminal A"     "Luminal A"
##  [65] "Luminal A"     "Luminal A"     "Luminal A"     "Luminal A"
##  [69] "Luminal A"     "Luminal A"     "Luminal A"     "Luminal A"
##  [73] "Luminal B"     "Luminal B"     "Luminal B"     "Luminal B"
##  [77] "Luminal B"     "Luminal B"     "Luminal B"     "Luminal B"
##  [81] "Luminal B"     "Luminal B"     "Luminal B"     "Luminal B"
##  [85] "Luminal B"     "Luminal B"     "Luminal B"     "Luminal B"
##  [89] "Luminal B"     "Luminal B"     "Luminal B"     "Luminal B"
##  [93] "Luminal B"     "Luminal B"     "Luminal B"     "Luminal B"
##  [97] "Luminal B"     "Luminal B"     "Luminal B"     "Luminal B"
## [101] "Luminal B"     "Luminal B"     "Luminal B"     "Luminal B"
## [105] "Luminal B"
```

```r
str(clinical)
```

```
## 'data.frame':    105 obs. of  30 variables:
##  $ Complete.TCGA.ID                   : chr  "TCGA-A2-A0T2" "TCGA-A2-A0CM" "TCGA-BH-A18V" "TCGA-BH-A1
##  $ Gender                             : chr  "FEMALE" "FEMALE" "FEMALE" "FEMALE" ...
##  $ Age.at.Initial.Pathologic.Diagnosis: int  66 40 48 56 38 57 74 60 61 67 ...
##  $ ER.Status                          : chr  "Negative" "Negative" "Negative" "Negative" ...
##  $ PR.Status                          : chr  "Negative" "Negative" "Negative" "Negative" ...
##  $ HER2.Final.Status                  : chr  "Negative" "Negative" "Negative" "Negative" ...
##  $ Tumor                              : chr  "T3" "T2" "T2" "T2" ...
##  $ Tumor..T1.Coded                    : chr  "T_Other" "T_Other" "T_Other" "T_Other" ...
##  $ Node                               : chr  "N3" "N0" "N1" "N1" ...
##  $ Node.Coded                         : chr  "Positive" "Negative" "Positive" "Positive" ...
##  $ Metastasis                         : chr  "M1" "M0" "M0" "M0" ...
##  $ Metastasis.Coded                   : chr  "Positive" "Negative" "Negative" "Negative" ...
##  $ AJCC.Stage                         : chr  "Stage IV" "Stage IIA" "Stage IIB" "Stage IIB" ...
##  $ Converted.Stage                    : chr  "No_Conversion" "Stage IIA" "No_Conversion" "No_Conversi
##  $ Survival.Data.Form                 : chr  "followup" "followup" "enrollment" "enrollment" ...
##  $ Vital.Status                       : chr  "DECEASED" "DECEASED" "DECEASED" "DECEASED" ...
##  $ Days.to.Date.of.Last.Contact       : int  240 754 1555 1692 133 309 425 643 775 964 ...
##  $ Days.to.date.of.Death              : int  240 754 1555 1692 NA NA NA NA NA NA ...
##  $ OS.event                           : int  1 1 1 1 0 0 0 0 0 0 ...
##  $ OS.Time                            : int  240 754 1555 1692 133 309 425 643 775 964 ...
##  $ PAM50.mRNA                         : chr  "Basal-like" "Basal-like" "Basal-like" "Basal-like" ...
##  $ SigClust.Unsupervised.mRNA         : int  0 -12 -12 -12 0 0 0 -12 -12 -12 ...
##  $ SigClust.Intrinsic.mRNA            : int  -13 -13 -13 -13 -13 -13 -13 -13 -13 -13 ...
##  $ miRNA.Clusters                     : int  3 4 5 5 5 5 3 5 2 5 ...
##  $ methylation.Clusters               : int  5 4 5 5 5 5 5 5 5 5 ...
##  $ RPPA.Clusters                      : chr  "Basal" "Basal" "Basal" "Basal" ...
##  $ CN.Clusters                        : int  3 4 1 1 1 1 1 1 1 3 ...
##  $ Integrated.Clusters..with.PAM50.   : int  2 2 2 2 2 2 2 2 2 2 ...
##  $ Integrated.Clusters..no.exp.       : int  2 1 2 2 2 2 2 2 2 2 ...
##  $ Integrated.Clusters..unsup.exp.    : int  2 1 2 2 2 2 2 2 2 2 ...
```

```r
summary(clinical)
```

```
##  Complete.TCGA.ID      Gender          Age.at.Initial.Pathologic.Diagnosis
##  Length:105         Length:105         Min.   :30.00
##  Class :character   Class :character   1st Qu.:49.00
##  Mode  :character   Mode  :character   Median :58.00
##                                        Mean   :58.69
##                                        3rd Qu.:67.00
##                                        Max.   :88.00
##
##   ER.Status          PR.Status         HER2.Final.Status     Tumor
##  Length:105         Length:105         Length:105         Length:105
##  Class :character   Class :character   Class :character   Class :character
##  Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##
##  Tumor..T1.Coded        Node             Node.Coded         Metastasis
```

```
##  Length:105         Length:105         Length:105         Length:105
##  Class :character   Class :character   Class :character   Class :character
##  Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##
##  Metastasis.Coded    AJCC.Stage        Converted.Stage    Survival.Data.Form
##  Length:105         Length:105         Length:105         Length:105
##  Class :character   Class :character   Class :character   Class :character
##  Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##
##  Vital.Status       Days.to.Date.of.Last.Contact Days.to.date.of.Death
##  Length:105         Min.   :   0.0              Min.   : 160.0
##  Class :character   1st Qu.: 240.0              1st Qu.: 947.5
##  Mode  :character   Median : 643.0              Median :1364.0
##                     Mean   : 788.4              Mean   :1254.5
##                     3rd Qu.:1288.0              3rd Qu.:1627.5
##                     Max.   :2850.0              Max.   :2483.0
##                                                 NA's   :94
##     OS.event         OS.Time        PAM50.mRNA
##  Min.   :0.0000   Min.   :   0.0   Length:105
##  1st Qu.:0.0000   1st Qu.: 240.0   Class :character
##  Median :0.0000   Median : 665.0   Mode  :character
##  Mean   :0.1048   Mean   : 817.6
##  3rd Qu.:0.0000   3rd Qu.:1305.0
##  Max.   :1.0000   Max.   :2850.0
##
##  SigClust.Unsupervised.mRNA SigClust.Intrinsic.mRNA miRNA.Clusters
##  Min.   :-12.000            Min.   :-13.000         Min.   :1
##  1st Qu.: -6.000            1st Qu.:-12.000         1st Qu.:3
##  Median : -5.000            Median : -6.000         Median :4
##  Mean   : -4.886            Mean   : -7.181         Mean   :4
##  3rd Qu.: -3.000            3rd Qu.: -2.000         3rd Qu.:5
##  Max.   :  0.000            Max.   :  0.000         Max.   :7
##
##  methylation.Clusters RPPA.Clusters       CN.Clusters
##  Min.   :1.000        Length:105         Min.   :1.00
##  1st Qu.:2.000        Class :character   1st Qu.:1.00
##  Median :4.000        Mode  :character   Median :3.00
##  Mean   :3.343                           Mean   :2.59
##  3rd Qu.:4.000                           3rd Qu.:3.00
##  Max.   :5.000                           Max.   :5.00
##
##  Integrated.Clusters..with.PAM50. Integrated.Clusters..no.exp.
##  Min.   :1.000                    Min.   :1.000
##  1st Qu.:2.000                    1st Qu.:1.000
##  Median :3.000                    Median :2.000
##  Mean   :2.743                    Mean   :1.981
##  3rd Qu.:4.000                    3rd Qu.:3.000
##  Max.   :4.000                    Max.   :4.000
```

```
##
##  Integrated.Clusters..unsup.exp.
##  Min.   :1.000
##  1st Qu.:1.000
##  Median :2.000
##  Mean   :2.352
##  3rd Qu.:3.000
##  Max.   :5.000
##
```

Data import - 77_cancer_proteomes_CPTAC_itraq.csv

The following datset has information about the protein expression data

```
proteomes <- read.csv("/Users/sanjanagorlla/Desktop/multiclass-classfication/BREAST-CANCER-SUBTYPE/77_ca
# 12553 observations(proteins) and 86 columns
head(proteomes)
```

```
##   RefSeq_accession_number gene_symbol          gene_name AO.A12D.01TCGA
## 1               NP_958782        PLEC  plectin isoform 1       1.096131
## 2               NP_958785        <NA> plectin isoform 1g       1.111370
## 3               NP_958786        PLEC plectin isoform 1a       1.111370
## 4               NP_000436        <NA> plectin isoform 1c       1.107561
## 5               NP_958781        <NA> plectin isoform 1e       1.115180
## 6               NP_958780        PLEC plectin isoform 1f       1.107561
##   C8.A131.01TCGA AO.A12B.01TCGA BH.A18Q.02TCGA C8.A130.02TCGA C8.A138.03TCGA
## 1       2.609943     -0.6598280      0.1953407     -0.4940596       2.765081
## 2       2.650422     -0.6487422      0.2154129     -0.5038992       2.779709
## 3       2.650422     -0.6542851      0.2154129     -0.5006193       2.779709
## 4       2.646374     -0.6321133      0.2053768     -0.5104589       2.797995
## 5       2.646374     -0.6404277      0.2154129     -0.5038992       2.787023
## 6       2.646374     -0.6542851      0.2154129     -0.5038992       2.779709
##   E2.A154.03TCGA C8.A12L.04TCGA A2.A0EX.04TCGA AO.A12D.05TCGA AN.A04A.05TCGA
## 1      0.8626593       1.407570       1.185108       1.100688      0.3845877
## 2      0.8701860       1.407570       1.192612       1.100688      0.3713928
## 3      0.8701860       1.410312       1.188860       1.100688      0.3713928
## 4      0.8664226       1.407570       1.185108       1.100688      0.3779903
## 5      0.8701860       1.413053       1.200116       1.093358      0.3746916
## 6      0.8701860       1.407570       1.188860       1.097023      0.3779903
##   BH.A0AV.05TCGA C8.A12T.06TCGA A8.A06Z.07TCGA A2.A0CM.07TCGA BH.A18U.08TCGA
## 1      0.3505357     -0.2049179     -0.4964091      0.6834035     -0.2650304
## 2      0.3674053     -0.1624185     -0.4985089      0.6944241     -0.2516423
## 3      0.3674053     -0.1666684     -0.4964091      0.6980976     -0.2516423
## 4      0.3606575     -0.1836682     -0.4922095      0.6870771     -0.2516423
## 5      0.3707793     -0.1666684     -0.4880099      0.6870771     -0.2516423
## 6      0.3674053     -0.1666684     -0.4964091      0.6980976     -0.2516423
##   A2.A0EQ.08TCGA AR.A0U4.09TCGA AO.A0J9.10TCGA AR.A1AP.11TCGA AN.A0FK.11TCGA
## 1     -0.9126703    -0.03322133    0.020007050      0.4610875      0.9735642
## 2     -0.9279787    -0.03021642    0.011955318      0.4610875      0.9774761
## 3     -0.9279787    -0.02721152    0.011955318      0.4610875      0.9774761
## 4     -0.9318057    -0.03021642    0.003903587      0.4610875      0.9696523
## 5     -0.9279787    -0.03021642    0.011955318      0.4610875      0.9852998
## 6     -0.9279787    -0.03021642    0.011955318      0.4610875      0.9774761
```

```
##   AO.A0J6.11TCGA A7.A13F.12TCGA BH.A0E1.12TCGA A7.A0CE.13TCGA A2.A0YC.13TCGA
## 1      0.8311317       1.279185      0.7620444      -1.123173      0.8188241
## 2      0.8565398       1.275167      0.7620444      -1.123173      0.8148772
## 3      0.8565398       1.275167      0.7663844      -1.116861      0.8148772
## 4      0.8367780       1.279185      0.7577045      -1.129486      0.7990900
## 5      0.8650092       1.279185      0.7663844      -1.129486      0.8188241
## 6      0.8565398       1.279185      0.7620444      -1.120017      0.8148772
##   AO.A0JC.14TCGA A8.A08Z.14TCGA AR.A0TX.14TCGA A8.A076.15TCGA AO.A126.15TCGA
## 1     -0.3072668      0.5688946     -0.5834286       1.873982      0.1958767
## 2     -0.3072668      0.5688946     -0.5725489       1.870383      0.1958767
## 3     -0.3072668      0.5688946     -0.5671090       1.870383      0.1958767
## 4     -0.3072668      0.5688946     -0.5834286       1.859587      0.2189346
## 5     -0.3010327      0.5688946     -0.5725489       1.870383      0.1997197
## 6     -0.3072668      0.5688946     -0.5779888       1.870383      0.1997197
##   BH.A0C1.16TCGA A2.A0EY.16TCGA AR.A1AW.17TCGA AR.A1AV.17TCGA C8.A135.17TCGA
## 1     -0.5183665       1.174881      0.5783087     -0.7598231       1.120502
## 2     -0.5100020       1.183209      0.5822129     -0.7598231       1.137618
## 3     -0.5072138       1.183209      0.5783087     -0.7491137       1.137618
## 4     -0.5183665       1.174881      0.5900212     -0.7357270       1.137618
## 5     -0.5127902       1.179045      0.5861170     -0.7491137       1.120502
## 6     -0.5072138       1.183209      0.5783087     -0.7437590       1.127348
##   A2.A0EV.18TCGA AN.A0AM.18TCGA D8.A142.18TCGA AN.A0FL.19TCGA BH.A0DG.19TCGA
## 1      0.4529859       1.501967      0.5385958       2.455138     -0.2056375
## 2      0.4725901       1.510348      0.5422105       2.480137     -0.2056375
## 3      0.4725901       1.501967      0.5422105       2.480137     -0.2056375
## 4      0.4585871       1.501967      0.5349810       2.461956     -0.2150062
## 5      0.4725901       1.501967      0.5422105       2.477864     -0.2056375
## 6      0.4725901       1.510348      0.5422105       2.471046     -0.2103218
##   AR.A0TV.20TCGA C8.A12Z.20TCGA AO.A0JJ.20TCGA AO.A0JE.21TCGA AN.A0AJ.21TCGA
## 1      -1.514278     -0.7871950      0.7571881      0.5597770     -0.4281815
## 2      -1.528285     -0.7559406      0.7808707      0.5634069     -0.4063780
## 3      -1.528285     -0.7559406      0.7741042      0.5597770     -0.4063780
## 4      -1.531087     -0.7746932      0.7639546      0.5416274     -0.4063780
## 5      -1.514278     -0.7715678      0.7707210      0.5597770     -0.4063780
## 6      -1.525484     -0.7715678      0.7774874      0.5597770     -0.4063780
##   A7.A0CJ.22TCGA AO.A12F.22TCGA A8.A079.23TCGA A2.A0T3.24TCGA A2.A0YD.24TCGA
## 1     -1.0012398      -1.947792       1.048959      0.5837133     0.06377853
## 2     -1.0046198      -1.952718       1.052257      0.5806231     0.09333637
## 3     -1.0046198      -1.955180       1.052257      0.5806231     0.08446902
## 4     -0.9978599      -1.947792       1.058852      0.5868034     0.06673431
## 5     -1.0012398      -1.957643       1.052257      0.5868034     0.08446902
## 6     -1.0012398      -1.955180       1.052257      0.5868034     0.09333637
##   AR.A0TR.25TCGA AO.A03O.25TCGA AO.A12E.26TCGA A8.A06N.26TCGA A2.A0YG.27TCGA
## 1      -1.101675       1.053225      0.2648591      0.2385471    -0.07820182
## 2      -1.108783       1.055948      0.2757113      0.2498182    -0.06805814
## 3      -1.108783       1.055948      0.2757113      0.2441826    -0.07143937
## 4      -1.096937       1.058671      0.2784244      0.2498182    -0.05791445
## 5      -1.111152       1.058671      0.2784244      0.2498182    -0.06467691
## 6      -1.106413       1.055948      0.2729983      0.2498182    -0.06805814
##   BH.A18N.27TCGA AN.A0AL.28TCGA A2.A0T6.29TCGA E2.A158.29TCGA E2.A15A.29TCGA
## 1       1.101261      0.3236627      0.7939756      -1.086529       2.180123
## 2       1.101261      0.3269726      0.8181815      -1.095492       2.180123
## 3       1.097767      0.3269726      0.8147235      -1.095492       2.180123
## 4       1.090779      0.3302826      0.8008915      -1.095492       2.180123
```

```
## 5       1.108248      0.3269726      0.8181815      -1.095492       2.180123
## 6       1.101261      0.3269726      0.8112655      -1.093252       2.180123
##   AO.A0JM.30TCGA C8.A12V.30TCGA A2.A0D2.31TCGA C8.A12U.31TCGA AR.A1AS.31TCGA
## 1       1.395247      0.6739047     0.10749090     -0.4815502       1.222507
## 2       1.408922      0.6887176     0.10416449     -0.4778898       1.218974
## 3       1.412341      0.6887176     0.10749090     -0.4815502       1.222507
## 4       1.408922      0.6776079     0.09751166     -0.4705692       1.204839
## 5       1.408922      0.6887176     0.10416449     -0.4815502       1.222507
## 6       1.412341      0.6887176     0.10416449     -0.4852105       1.218974
##   A8.A09G.32TCGA C8.A131.32TCGA C8.A134.32TCGA A2.A0YF.33TCGA BH.A0DD.33TCGA
## 1      -1.523343       2.707250      0.1401818      0.3113192     -0.6923158
## 2      -1.512646       2.733832      0.1260538      0.2961771     -0.6594687
## 3      -1.509972       2.737629      0.1331178      0.2961771     -0.6641611
## 4      -1.517995       2.733832      0.1119257      0.2961771     -0.6571224
## 5      -1.509972       2.752819      0.1260538      0.2961771     -0.6618149
## 6      -1.512646       2.737629      0.1260538      0.2961771     -0.6618149
##   BH.A0E9.33TCGA AR.A0TT.34TCGA AO.A12B.34TCGA A2.A0SW.35TCGA AO.A0JL.35TCGA
## 1       1.466665     -0.5114212     -0.9639039     -0.4877725       -0.10668
## 2       1.482283     -0.5260667     -0.9382095     -0.4877725       -0.10668
## 3       1.474474     -0.5260667     -0.9439194     -0.4877725       -0.10668
## 4       1.458856     -0.5333894     -0.9353546     -0.4877725       -0.10668
## 5       1.474474     -0.5297281     -0.9353546     -0.5038532       -0.10668
## 6       1.474474     -0.5297281     -0.9382095     -0.4877725       -0.10668
##   BH.A0BV.35TCGA A2.A0YM.36TCGA BH.A0C7.36TCGA A2.A0SX.36TCGA X263d3f.I.CPTAC
## 1    -0.06583842      0.6558497     -0.5522120     -0.3985598       0.5985845
## 2    -0.05589267      0.6581426     -0.5477494     -0.3926014       0.6066975
## 3    -0.06583842      0.6558497     -0.5522120     -0.3926014       0.6039931
## 4    -0.05589267      0.6558497     -0.5522120     -0.3926014       0.6039931
## 5    -0.06252317      0.6512639     -0.5566746     -0.3955806       0.6039931
## 6    -0.05589267      0.6581426     -0.5477494     -0.3926014       0.6066975
##   blcdb9.I.CPTAC c4155b.C.CPTAC
## 1     -0.1912845      0.5669753
## 2     -0.1839177      0.5787017
## 3     -0.1860225      0.5767473
## 4     -0.1860225      0.5767473
## 5     -0.1670792      0.5767473
## 6     -0.1839177      0.5787017
```

```
tail(proteomes)
```

```
##       RefSeq_accession_number gene_symbol
## 12548               NP_997203      OTUD6A
## 12549            NP_001191293        <NA>
## 12550               NP_775791        <NA>
## 12551               NP_004065       COX8A
## 12552               NP_068752        MIIP
## 12553               NP_219494    KIAA1737
##                                      gene_name AO.A12D.01TCGA
## 12548               OTU domain-containing protein 6A             NA
## 12549                    protein FAM24B precursor             NA
## 12550       putative uncharacterized protein C9orf62             NA
## 12551 cytochrome c oxidase subunit 8A, mitochondrial             NA
## 12552      migration and invasion-inhibitory protein     -0.6335172
## 12553               uncharacterized protein KIAA1737     12.6664882
```

```
##       C8.A131.01TCGA A0.A12B.01TCGA BH.A18Q.02TCGA C8.A130.02TCGA
## 12548             NA             NA      -8.111243    -1.75352923
## 12549             NA             NA     -16.029761     1.72969151
## 12550             NA             NA      -2.046065    -0.42518234
## 12551             NA             NA      -1.778435    -0.14967335
## 12552      4.8403254      -1.965192             NA             NA
## 12553      0.1407356      -2.854835      -3.069752    -0.04799742
##       C8.A138.03TCGA E2.A154.03TCGA C8.A12L.04TCGA A2.A0EX.04TCGA
## 12548       4.707022      -4.733495             NA             NA
## 12549       4.107251      -9.584499      -5.196859      -6.101005
## 12550      -3.203370      -4.786183             NA             NA
## 12551       1.971481      -3.103949      -0.933726      -1.726336
## 12552             NA             NA             NA             NA
## 12553             NA             NA             NA             NA
##       A0.A12D.05TCGA AN.A04A.05TCGA BH.A0AV.05TCGA C8.A12T.06TCGA
## 12548             NA             NA             NA             NA
## 12549     -2.5788279      0.9024874      -7.011385      -11.02102
## 12550             NA             NA             NA             NA
## 12551      1.2949255      1.7370646      -1.393788             NA
## 12552     -0.1893414      0.3614967      -3.057136             NA
## 12553     13.0664447      0.1437809             NA             NA
##       A8.A06Z.07TCGA A2.A0CM.07TCGA BH.A18U.08TCGA A2.A0EQ.08TCGA
## 12548             NA             NA      -11.55786      -6.373934
## 12549             NA             NA      -12.62890      -1.123160
## 12550             NA             NA             NA             NA
## 12551             NA             NA             NA             NA
## 12552             NA             NA             NA             NA
## 12553             NA             NA             NA             NA
##       AR.A0U4.09TCGA A0.A0J9.10TCGA AR.A1AP.11TCGA AN.A0FK.11TCGA
## 12548             NA             NA      -1.073848      -3.059596
## 12549             NA      3.4097859             NA             NA
## 12550             NA      1.7632069             NA             NA
## 12551             NA     -0.3382950             NA             NA
## 12552             NA      2.7012335             NA             NA
## 12553             NA      0.6560938      -1.177280      -3.266926
##       A0.A0J6.11TCGA A7.A13F.12TCGA BH.A0E1.12TCGA A7.A0CE.13TCGA
## 12548      -3.231339      0.9698297      -7.609707             NA
## 12549             NA             NA             NA             NA
## 12550             NA             NA             NA      -1.306238
## 12551             NA             NA             NA             NA
## 12552             NA     -1.3202008      -2.006840             NA
## 12553      -3.753616             NA             NA             NA
##       A2.A0YC.13TCGA A0.A0JC.14TCGA A8.A08Z.14TCGA AR.A0TX.14TCGA
## 12548             NA             NA             NA             NA
## 12549             NA             NA             NA             NA
## 12550       4.509094      2.6071730     0.48649433      -3.542726
## 12551             NA             NA             NA             NA
## 12552             NA      0.2912064    -0.05448119      -2.136516
## 12553             NA      0.5281020    -3.43647384     -10.008030
##       A8.A076.15TCGA A0.A126.15TCGA BH.A0C1.16TCGA A2.A0EY.16TCGA
## 12548             NA             NA      -9.512991       4.597606
## 12549             NA             NA      -6.217378       6.179888
## 12550             NA             NA             NA             NA
## 12551             NA             NA             NA             NA
```

```
## 12552      0.6720037   -6.0643526            NA            NA
## 12553      5.1056477    0.5648036            NA            NA
##        AR.A1AW.17TCGA AR.A1AV.17TCGA C8.A135.17TCGA A2.A0EV.18TCGA
## 12548      -1.201996    2.7849772     -11.185872   -12.2785457
## 12549       1.468461   -4.1439828     -13.630031   -10.3377293
## 12550      -1.475288   -0.5724091      -3.702775    -0.6532514
## 12551             NA           NA             NA            NA
## 12552             NA           NA             NA            NA
## 12553       1.113181   -5.3675279      -8.953951            NA
##        AN.A0AM.18TCGA D8.A142.18TCGA AN.A0FL.19TCGA BH.A0DG.19TCGA
## 12548    -5.42108597   -12.337110             NA            NA
## 12549    -1.27228306    -9.546530      -3.012765     -0.753707
## 12550     0.03521846    -4.066584             NA            NA
## 12551             NA           NA             NA            NA
## 12552             NA           NA             NA            NA
## 12553             NA           NA             NA            NA
##        AR.A0TV.20TCGA C8.A12Z.20TCGA AO.A0JJ.20TCGA AO.A0JE.21TCGA
## 12548             NA           NA             NA            NA
## 12549      -2.116583    -6.703657      0.8147029            NA
## 12550             NA           NA             NA     -1.494749
## 12551       2.040722    -4.375203     -0.2916098            NA
## 12552             NA           NA             NA            NA
## 12553             NA           NA             NA            NA
##        AN.A0AJ.21TCGA A7.A0CJ.22TCGA AO.A12F.22TCGA A8.A079.23TCGA
## 12548             NA           NA             NA            NA
## 12549             NA           NA             NA            NA
## 12550      -3.017946           NA             NA            NA
## 12551             NA           NA             NA     -1.351759
## 12552             NA           NA             NA      2.875880
## 12553             NA           NA             NA            NA
##        A2.A0T3.24TCGA A2.A0YD.24TCGA AR.A0TR.25TCGA AO.A03O.25TCGA
## 12548             NA           NA             NA            NA
## 12549     -12.265010    -7.677420       1.475930    -0.5997658
## 12550             NA           NA       0.528281     0.5276447
## 12551      -1.264179    -4.801442       1.492514     0.7536714
## 12552      -1.100403    -2.590516      -4.098615    -5.0113722
## 12553      -5.590348    -6.740437             NA            NA
##        AO.A12E.26TCGA A8.A06N.26TCGA A2.A0YG.27TCGA BH.A18N.27TCGA
## 12548             NA           NA     -10.245556     -9.481603
## 12549       1.716341  -0.02350419             NA            NA
## 12550             NA           NA      -1.254869      4.036092
## 12551             NA           NA             NA            NA
## 12552             NA           NA             NA            NA
## 12553             NA           NA             NA            NA
##        AN.A0AL.28TCGA A2.A0T6.29TCGA E2.A158.29TCGA E2.A15A.29TCGA
## 12548             NA           NA             NA            NA
## 12549       4.633196   -13.120988      0.3789715     -3.863634
## 12550             NA           NA             NA            NA
## 12551             NA           NA             NA            NA
## 12552             NA     1.181271      0.6657973      4.072432
## 12553             NA           NA             NA            NA
##        AO.A0JM.30TCGA C8.A12V.30TCGA A2.A0D2.31TCGA C8.A12U.31TCGA
## 12548     -10.289998    1.4960184      -8.324969    -2.1140524
## 12549      -9.920774    3.8697791      -4.679219     1.0557838
```

```
## 12550            NA           NA           NA           NA
## 12551     -2.375620   -0.3370729     -1.106650    1.0265012
## 12552            NA           NA           NA           NA
## 12553            NA           NA     -6.941181    0.7446567
##       AR.A1AS.31TCGA A8.A09G.32TCGA C8.A131.32TCGA C8.A134.32TCGA
## 12548      4.7986122           NA           NA           NA
## 12549      3.0529642    -9.744192     -2.130632    0.5392989
## 12550            NA           NA           NA           NA
## 12551      1.5405403           NA           NA           NA
## 12552            NA    -4.034527      2.027516   -1.2796861
## 12553      0.9327439           NA           NA           NA
##       A2.A0YF.33TCGA BH.A0DD.33TCGA BH.A0E9.33TCGA AR.A0TT.34TCGA
## 12548       1.412905    -5.987738     -8.482188           NA
## 12549            NA           NA           NA    -2.576435
## 12550            NA           NA           NA           NA
## 12551            NA           NA           NA           NA
## 12552            NA           NA           NA           NA
## 12553            NA           NA           NA    -1.983293
##       AO.A12B.34TCGA A2.A0SW.35TCGA AO.A0JL.35TCGA BH.A0BV.35TCGA
## 12548            NA           NA           NA           NA
## 12549       -6.66235           NA           NA           NA
## 12550            NA           NA           NA           NA
## 12551            NA           NA           NA           NA
## 12552            NA           NA           NA           NA
## 12553       -6.00286           NA           NA           NA
##       A2.A0YM.36TCGA BH.A0C7.36TCGA A2.A0SX.36TCGA X263d3f.I.CPTAC
## 12548            NA           NA           NA            NA
## 12549            NA           NA           NA   -8.02007140
## 12550            NA           NA           NA    0.04960831
## 12551            NA           NA           NA            NA
## 12552            NA           NA           NA    0.01986083
## 12553            NA           NA           NA            NA
##       blcdb9.I.CPTAC c4155b.C.CPTAC
## 12548            NA           NA
## 12549     -3.0938223   -4.6024175
## 12550     -0.6469766    0.2405902
## 12551            NA           NA
## 12552     -1.7183267   -0.3691832
## 12553            NA           NA
```

```
dim(proteomes)
```

```
## [1] 12553    86
```

Combining the datasets

- Two data sets need to be combined before analysis
- using the cbind()
- new column was formed in each data set
- the two data sets were connected based on this new column

```
# Transposing the proteome matrix will result in rows rather than columns of observations.
## save rownames
# RefSeq_accession_number : ID of proteins
n <- proteomes$RefSeq_accession_number
#Transpose all columns except the first three
proteomes <- as.data.frame(t(proteomes[,4:86]))
colnames(proteomes) <- n
#Row names in the first column,
proteomes <- cbind(rownames(proteomes), data.frame(proteomes, row.names=NULL))
colnames(proteomes)[1] <- "Complete.TCGA.ID"
```

Manipulating the format

working with the Patient IDs : - Unfortunately, the patient IDs in the clinical dataset and the proteomic data set have different formats. - To enable combining of the two data sets on this variable, this piece of code reformats the id in the clinical data set. - defined the code which does the job - used sapply() to implement the function defined

```
# To enable the combining of data sets, Complete.TCGA.ID is being reorganized into a clinical format.
# Defining the restructuring formula:

get.clinical.id <- function(proteome.id) {
  x = substr(proteome.id, 4, 7)
  y = substr(proteome.id, 0, 2)
  paste("TCGA",y,x,sep="-")
}

#sapply to proteomes' id column
proteomes$Complete.TCGA.ID <- sapply(proteomes$Complete.TCGA.ID, get.clinical.id)
proteomes_all <- proteomes
```

- Question 2 : how do you plan on assessing data quality and deal with missing values? ANSWER : I have explored the proteomes data set using head(), dim(), str(), dim(), glimpse(), summary() functions

- Question 3 : what strategy are you using for data imputation and why? if the data set has no missing data, can you randomly remove data and then impute the data and compare performance of your algorithms with imputed vs full data? why do they differ? how do they differ?

I have used plot intro() from the DataExplorer package to check if the missing values are present. There are 10% of missing values in the dataset.Discarded variables with more than 25% of the data missing because they wouldn't be significant for further research. Used the mean imputation method, imputed the NA values with the mean of a specific column for the remaining variables with missing data.

Exploring the dataset merging and manipulating the datasets

After merging and manipulating the datasets retrieved - The proteome data set is the final one and to be used in the further analysis using the head str dim glimpse summary functions, the dimensions of the data can be observed

```
#head(proteomes)
#dim(proteomes)
#tail(proteomes)
#summary(proteomes)
#glimpse(proteomes)
#str(proteomes)
```

- Question : how do you assess normality, distribution, skew – and does it matter for your algorithms? To predict the cancer sub-type correctly using the proteome data for each patient, I am going to implement following algorithms (SVM, Neural Networks, Naive Bayes and Random forests) : I am going to assess the distribution of the data using histograms and have built pair.panels() plot. The algorithms which I am going to use does not assume normality (SVM, Neural Networks,Naive Bayes and random forests) and works well regardless of the distribution. The dataset is reasonably well balanced, although HER2 is slightly underrepresented

Data Exploration

1. exploratory data plots - plot_intro(), ggplots after the feature selection
2. detection of outliers for continuous features - box(), defined outlier() to detect the outliers
3. correlation/collinearity/chi-squared analysis - cor(),
4. evaluation of distribution - barplots, histograms, boxplots for each subtype, pair.panels() plot

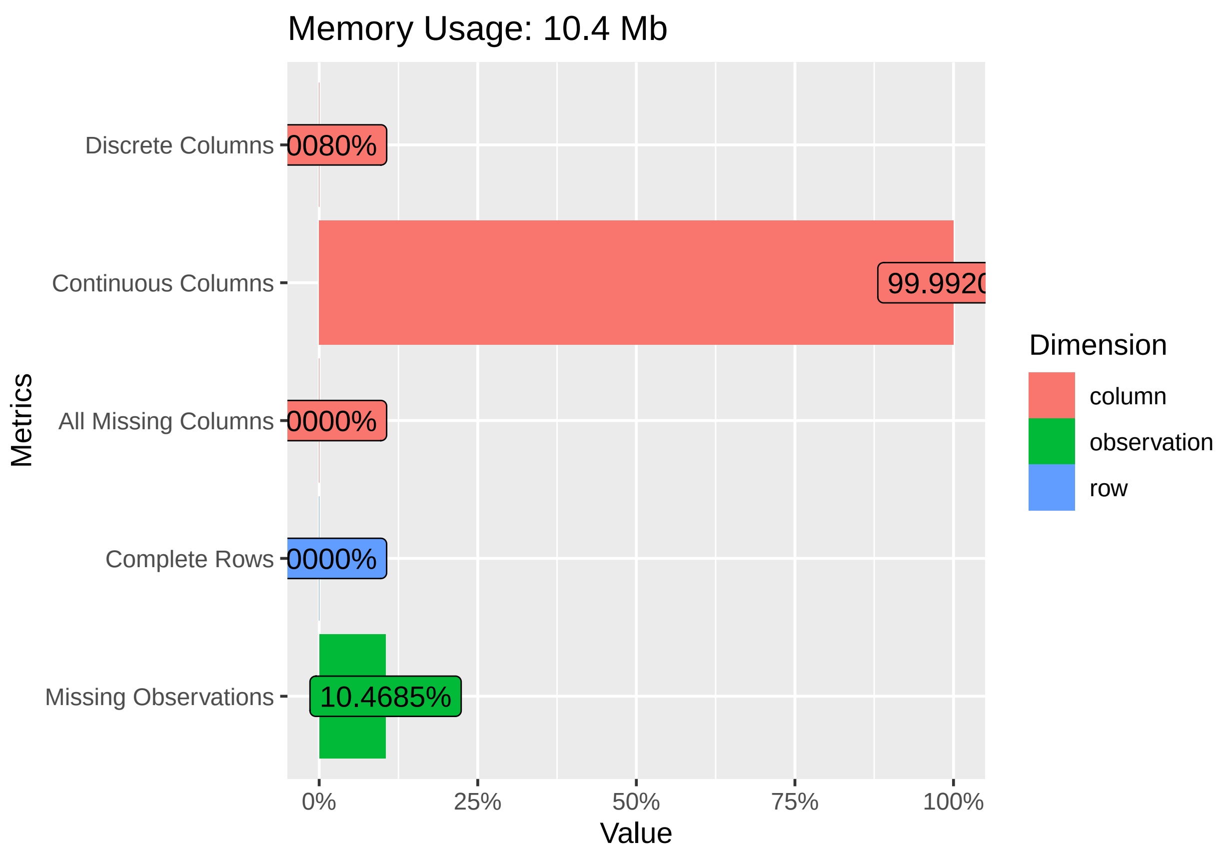
- what kinds of exploratory data analysis and visualization do you plan on doing?

2. Data Exploration

- I have used plot_intro function from DataExplorer package
- plot_intro provides an insight of what type of data is present along with that it provides the information about missing values
- plotted a graph to show the proportion of missing data for each variable.
- Apart from that, I have used str and summary to understand the structure of the data present
- Discarded variables with more than 25% of the data missing because they wouldn't be significant for further research.
- Used the mean imputation method, imputed the NA values with the mean of a specific column for the remaining variables with missing data.
- After cleaning the data, using the ggplot() I have analyzed the distribution of each subtype in the dataset

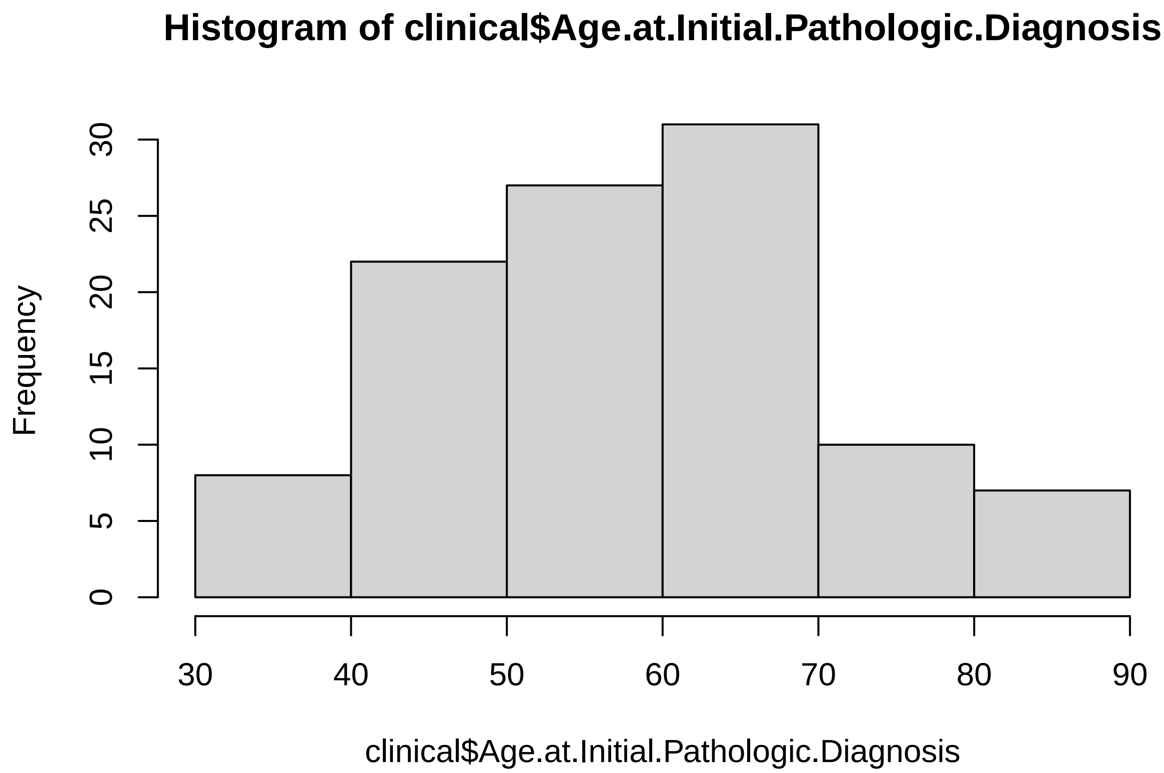
1. exploratory data plots: I used plot intro() from the DataExplorer package. plot intro gives an understanding of the sort of data present as well as information about missing values. In addition, I have used str() and summary() to comprehend the data's structure.

```
#Visualizing structure of the data set
plot_intro(proteomes)
```

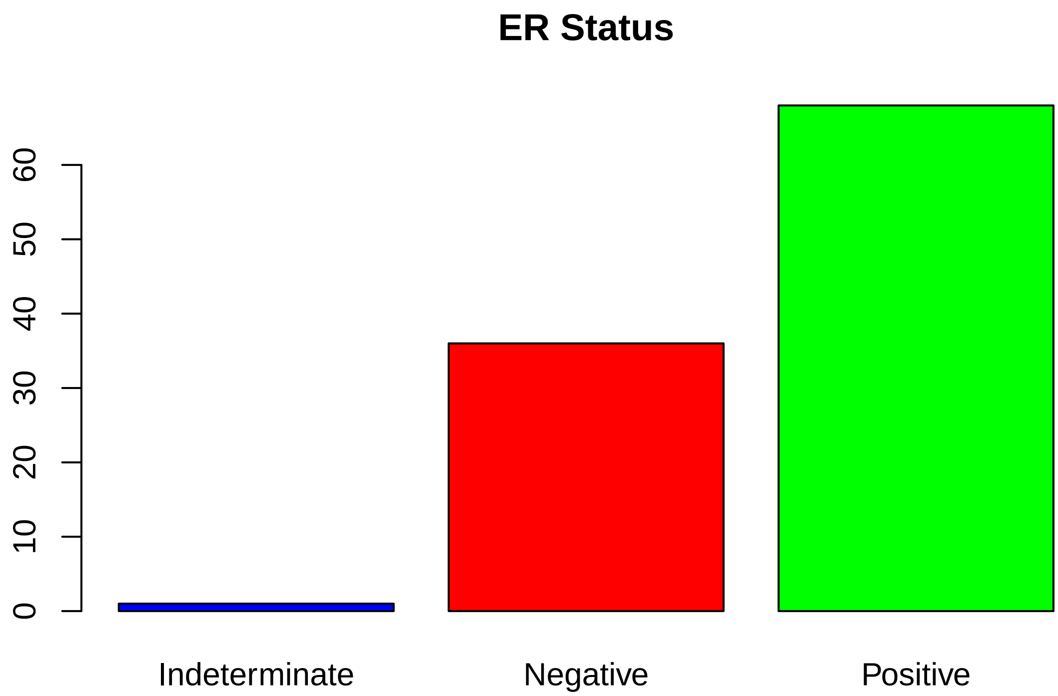


It is essential to explore the clinical dataset as it has all the information about the pateints

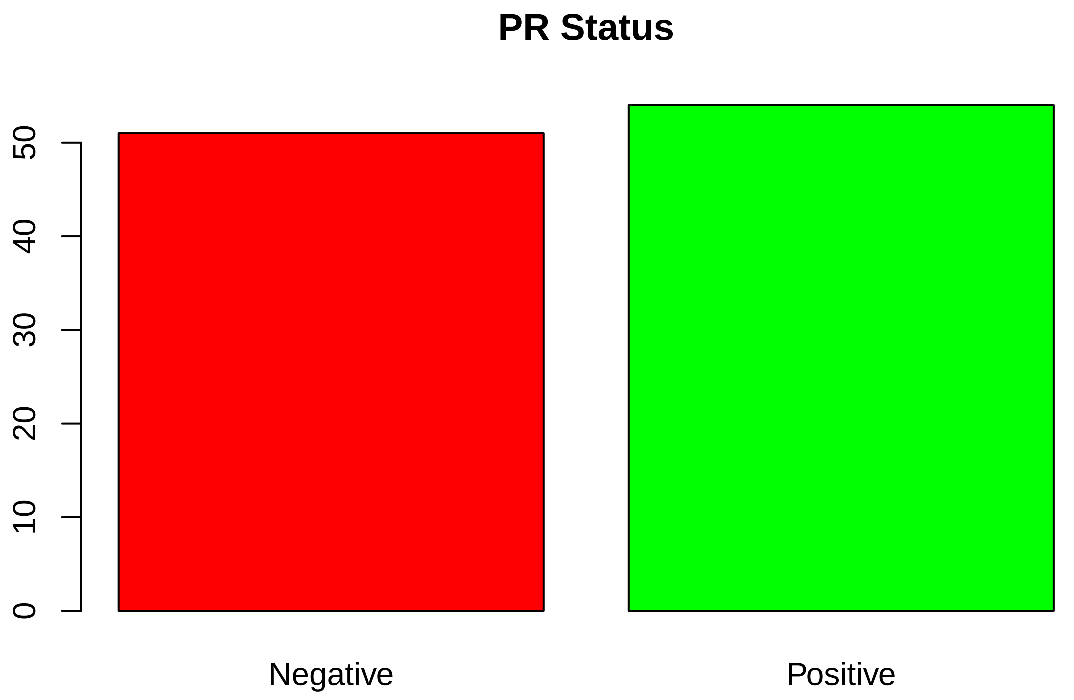
```
clinical$Age.at.Initial.Pathologic.Diagnosis <- as.numeric(clinical$Age.at.Initial.Pathologic.Diagnosis)
h1 <- hist(clinical$Age.at.Initial.Pathologic.Diagnosis)
```



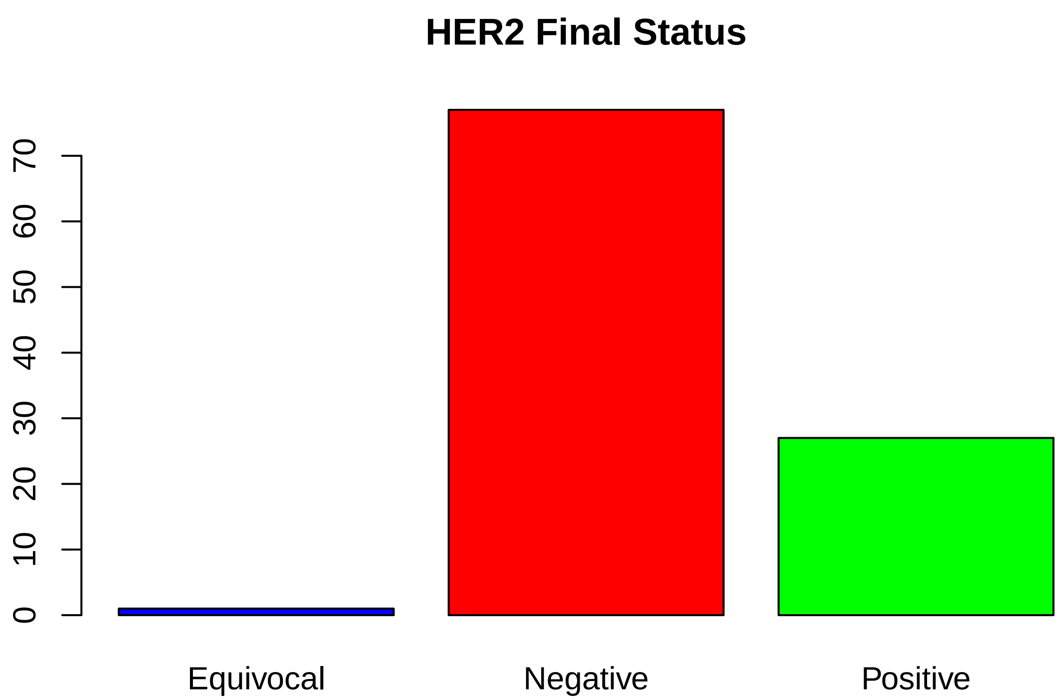

```
b1<- barplot(table(clinical$ER.Status), col=c("blue", "red", "green"), main = "ER Status")
```



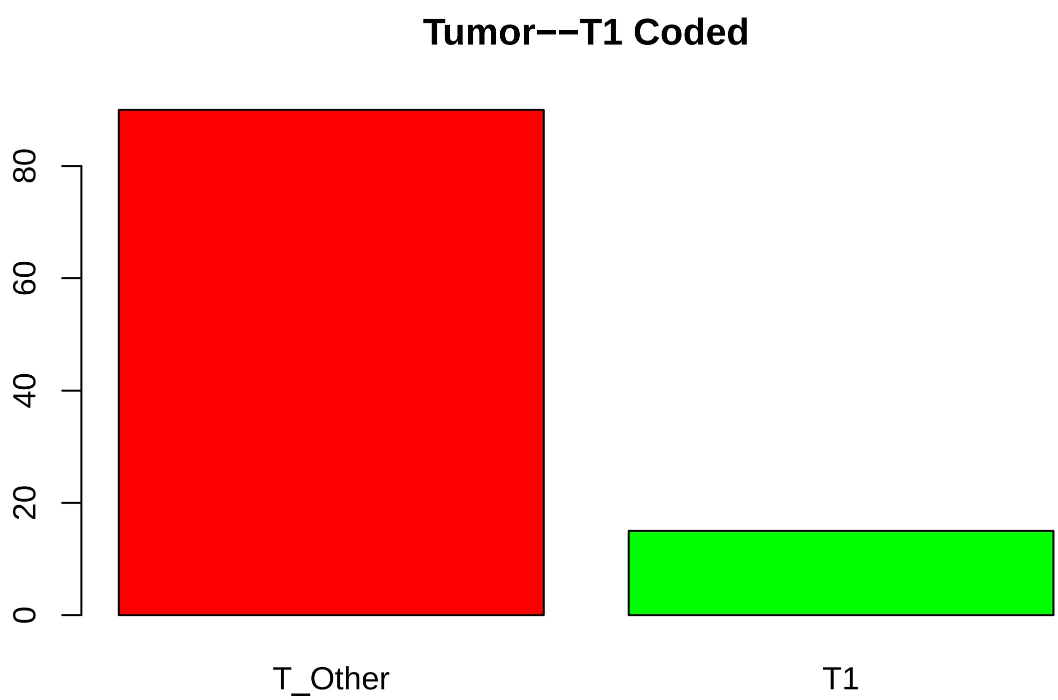

```r
b2<- barplot(table(clinical$PR.Status), col=c("red", "green"), main = "PR Status")
```



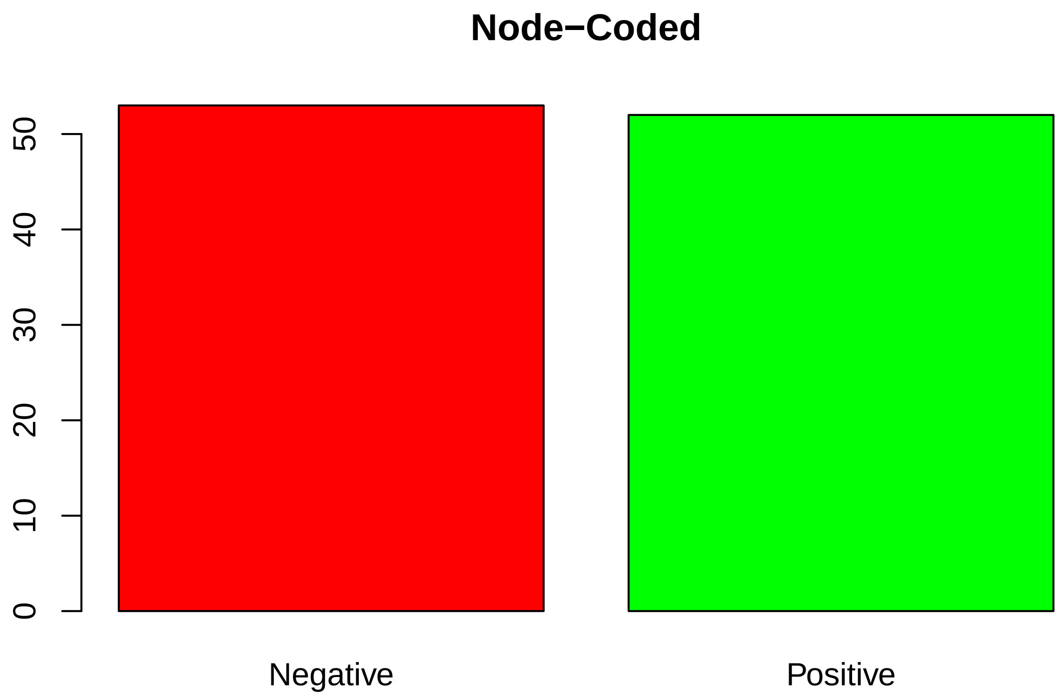

```
b3<- barplot(table(clinical$HER2.Final.Status), col=c("blue", "red", "green"), main = "HER2 Final Statu
```



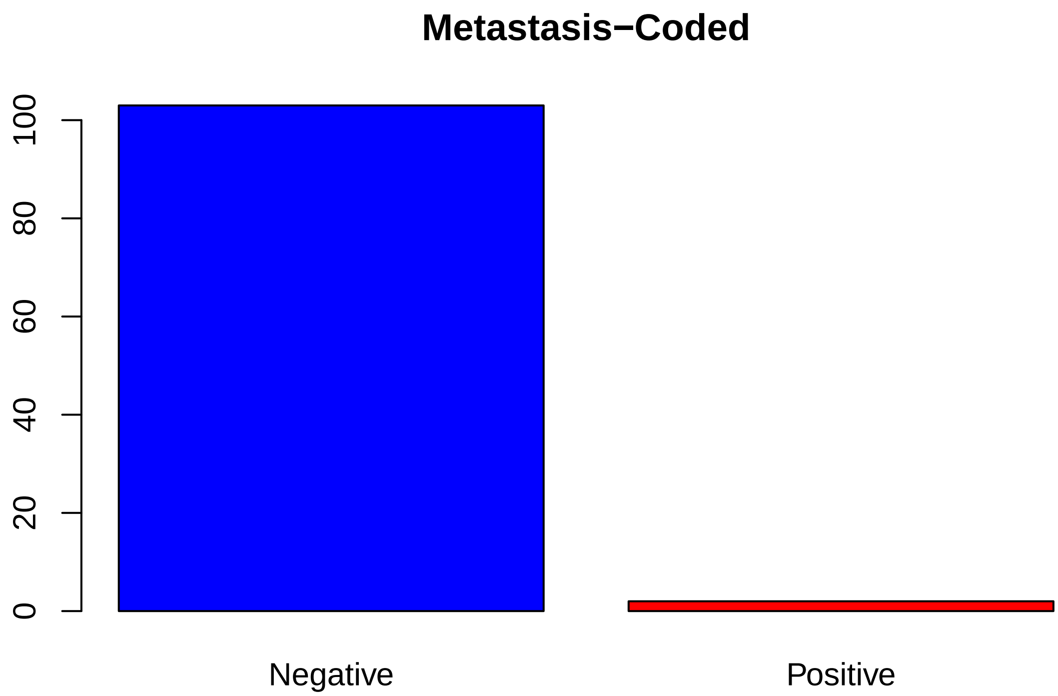

```
b4<- barplot(table(clinical$Tumor..T1.Coded), col=c("red", "green"), main = "Tumor--T1 Coded")
```



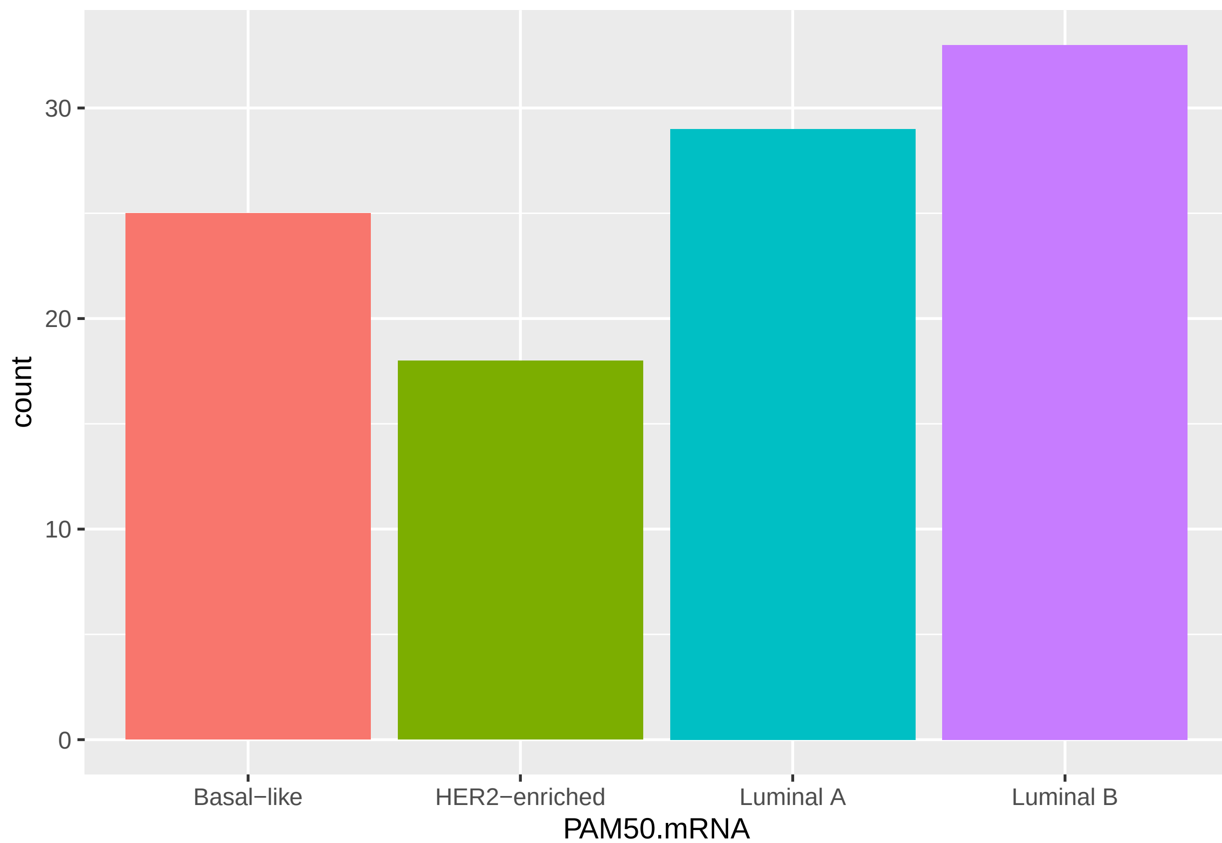

```r
b5<- barplot(table(clinical$Node.Coded), col=c("red", "green"), main = "Node-Coded")
```




```
b6<- barplot(table(clinical$Metastasis.Coded), col=c("blue", "red", "green"), main = "Metastasis-Coded")
```




```
b7<- ggplot(clinical,aes(x= `PAM50.mRNA`,fill=`PAM50.mRNA`))+geom_bar()+theme(legend.position = "none")
b7
```



Missing Values

This plot_intro() plot shows that the dataset has missing observations. we can know the count of na's from summary() and also colSums()

```
# colSums(is.na(proteomes))
# I have already used the sumarry() in the previous section
```

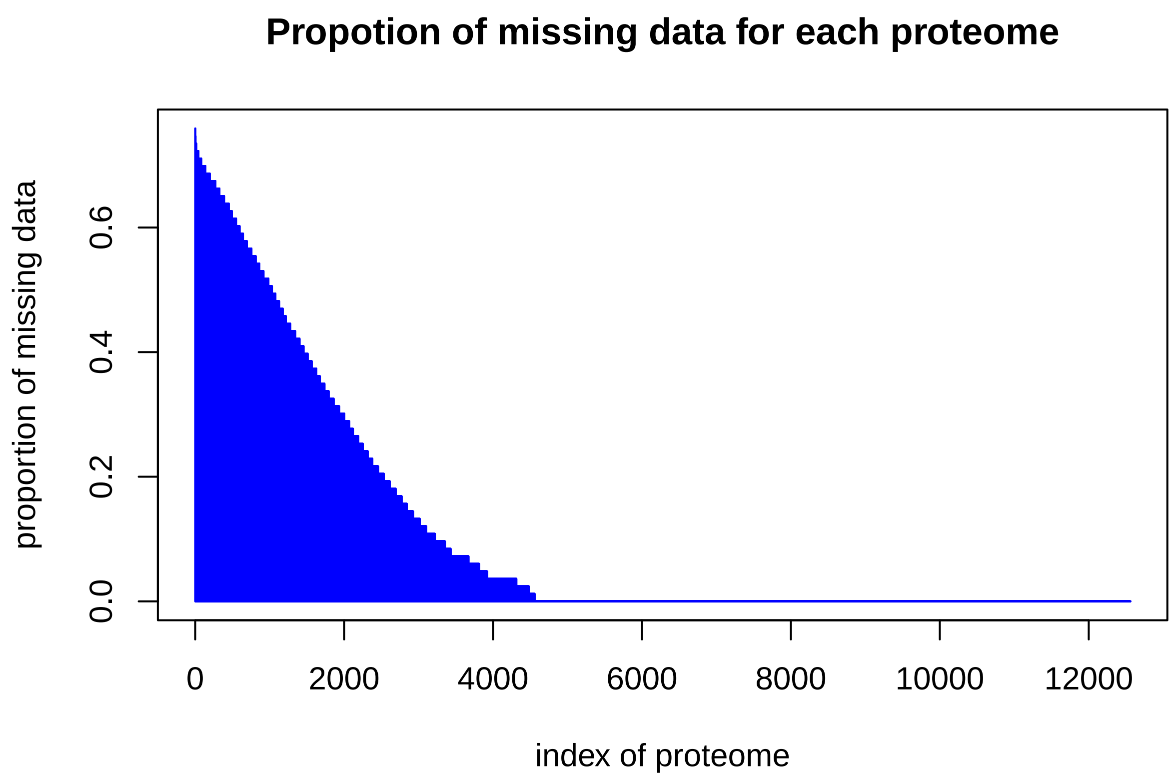
- how do you plan on assessing data quality and deal with missing values? what strategy are you using for data imputation and why?

According to the plot we see that we have 10% of missing values in the dataset. Without suffering too much of a loss, we can exclude all variables with >25 percent missing data. Using the mean, the remaining missing data can be imputed (a more sophisticated form of imputation would be preferable but is quite computationally expensive and we dont have a huge amount of missing data, so I stuck with means in my analysis).

1. Discarded variables with more than 25% of the data missing because they wouldn't be significant for further research.
2. Used the mean imputation method, we impute the NA values with the mean of a specific column for the remaining variables with missing data. (for which i have implemented the for-loop which did the job)

Step 1 - Missing data : The code below counts missing data by column and plots a graph to show the proportion of missing data for each variable.

```r
#looking for proteomes with many NAs
naCounts <- colSums(is.na(proteomes)) / nrow(proteomes)

#plotting missing data proportions

plot(sort(naCounts, decreasing = TRUE), col ="blue", type = 'h', xlab = "index of proteome", ylab="propo
```




```r
#how many have more than 25% missing data
length(naCounts[naCounts>0.25])
```

```
## [1] 2251
```

Without suffering too much loss, we can exclude all variables with >25% missing data. Using the mean, the remaining missing data can be imputed (a more sophisticated form of imputation would be preferable but is quite computationally expensive and we dont have a huge amount of missing data, so I stuck with means in my analysis).

Step 2:

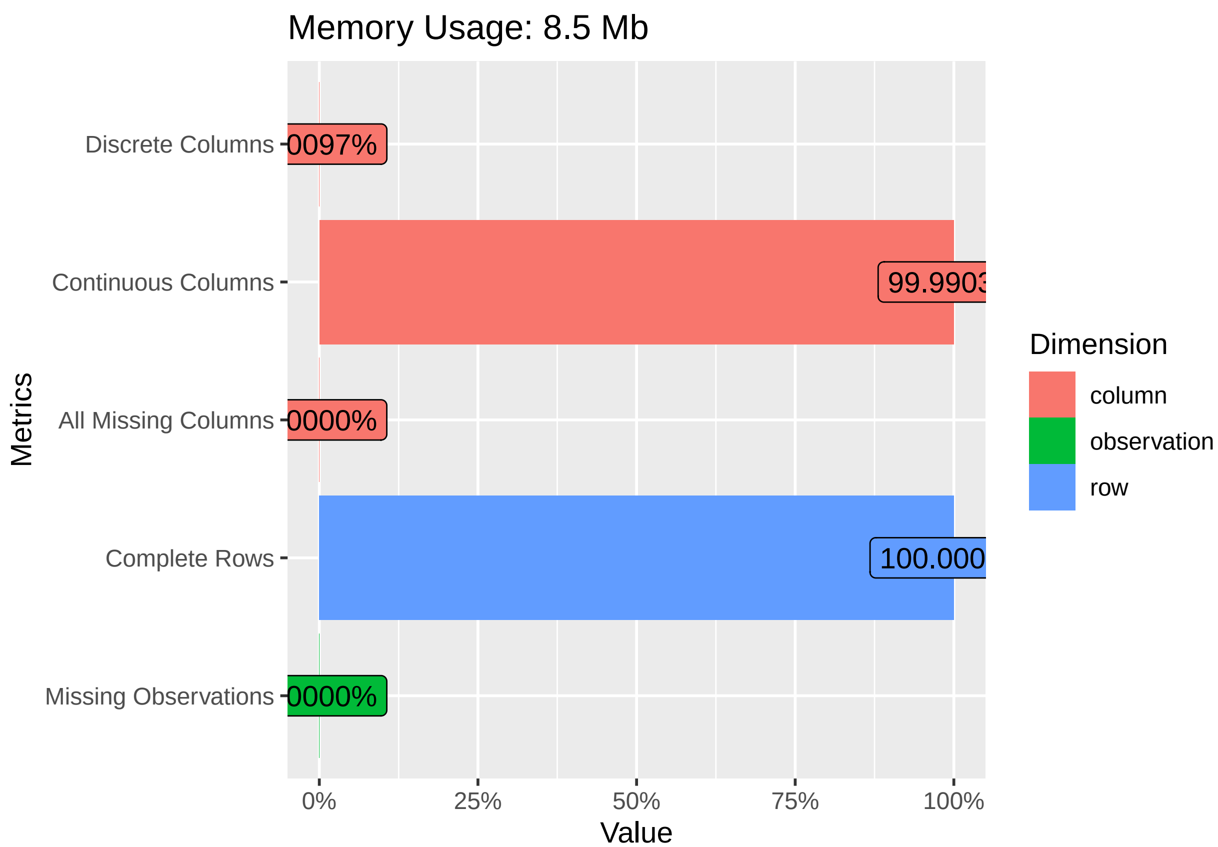
```r
#remove variables with >25% missing data
proteomes <- proteomes[ , colSums(is.na(proteomes))  / nrow(proteomes) < 0.25] #removing variables with
#loop to impute means for remaining missing data
for (i in which(sapply(proteomes, is.numeric))) {
    proteomes[is.na(proteomes[, i]), i] <- mean(proteomes[, i],  na.rm = TRUE)
}
```

Now the dataset is clean, Lets explore if there are any missing values

```
dim(proteomes) # a total of 2251 variables are removed
```

```
## [1]    83 10303
```

```
plot_intro(proteomes)
```



The proteome dataset is now clean, Therefore, I have now joined the proteome dataset and clinical datset using inner_join() from dplyr package.

```
#inner join on data to create full data set
data <-  inner_join(clinical, proteomes, by = "Complete.TCGA.ID")
#replacing lengthy col name
colnames(data)[3] <- "diag_age"
```

Exploring the final datset

```
dim(data)
```

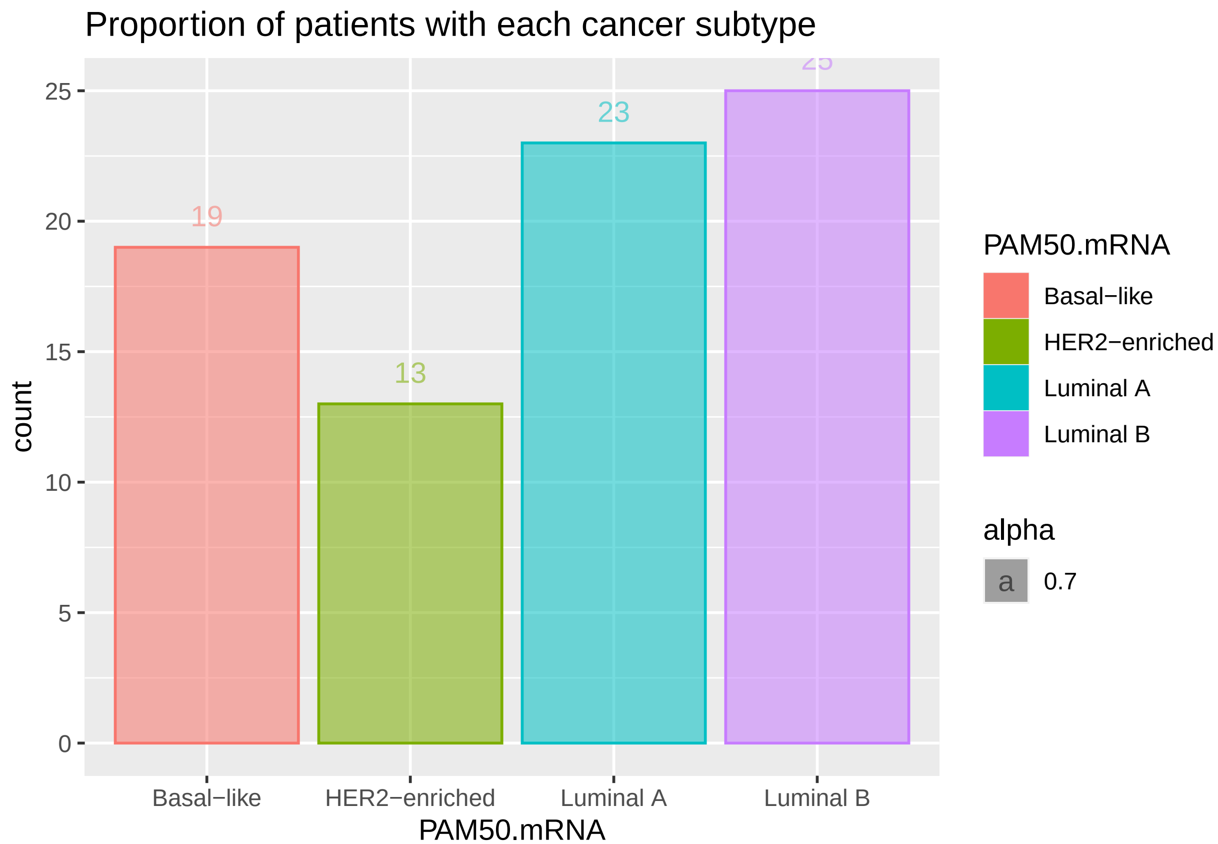
```
## [1]    80 10332
```

```r
#head(data)
#tail(data)
#str(data)
```

Evaluation of distribution

The main idea of the project is to check if the proteomic datset can classify the subtype of breast cancer.Therefore, it is important to check the number of observations in each subtype The plot below shows how many patients have each subtype of breast cancer.

```r
#Barplot of subtypes
ggplot(data, aes(PAM50.mRNA, col = PAM50.mRNA, fill = PAM50.mRNA, alpha=0.7)) + geom_bar() + ggtitle("P
```



Therefore , They are reasonably well balanced, although HER2 is slightly underrepresented.

3. Data Cleaning & Shaping

Data Imputation

- Data imputation is already done in previous chunks
- Mean imputation for proteome dataset is done

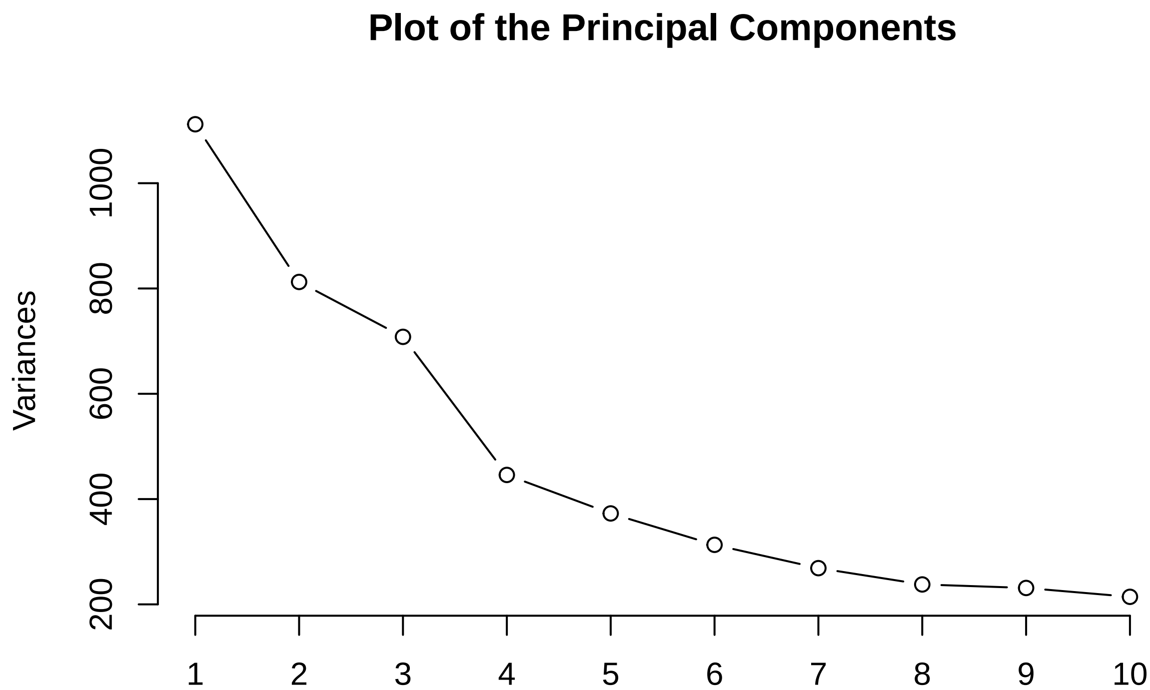
Proper Encoding of Data

- Encoding was done for only PAM50.mRNA column
- PAM50.mRNA is categorized into four types "Basal.like", "HER2-enriched", "Luminal.A", "Luminal.B"

Normalization/Standardization

- Normalizing the data does not make any difference in the predictions as the protein expression data already ranges on -1 0 1 scale ### Feature engineering - PCA
- Principal component analysis is also done using prComp function
- Principal components are taken into consideration only when the cumulative variance is greater than 85%
- To get the cumulative variance of 85 or greater, I was forced to select 48 components
- But i want to know the list of features(proteins) important of the classification of breast cancer subtype, Because of this I haven't used Principal components for my models ### Feature selection - repeated lasso regression
- I selected variables using repeated lasso regression as my method. -A total of 30 proteins were selected over more than 20 times.
- These proteins are taken into consideration for further analysis
- Checked the distribution of cancer subtype using these proteins

```
################################
### Feature engineering: PCA ###
################################

#Performing PCA on the dataset
data_PCA <- prcomp(data[,31:ncol(data)], center = T, scale = T)
#Printing Principal components
#print(data_PCA)
#Summary of Principal components
#summary(data_PCA)
#str(data_PCA)
#Plotting variance plot of the Principal components
screeplot(data_PCA, type = "l", main = "Plot of the Principal Components")
```



- how will you select the features? will you use PCA? I will use repeated lasso regression to select the features. When the cumulative variance exceeds 85%, only principal components are taken into account. I had to choose 48 components for the cumulative variance to be 85 or higher. However, I'm curious about the list of characteristics (proteins) crucial to the classification of breast cancer subtypes. As a result, I haven't employed principal components in my models.

- what kind of feature engineering will you use? will you add new derived features? I have used feature selection technique. No, i havent added any new features

- what do you plan on predicting? predict the breast cancer subtype using the set of proteins selected using feature selection(repeated lasso regression)

- what kind of normalization, standardization, regularization, or transformation do you plan on using and why? Normalizing the data does not make any difference in the predictions as the protein expression data already ranges on -1 0 1 scale

Feature selection : repeated lasso regression

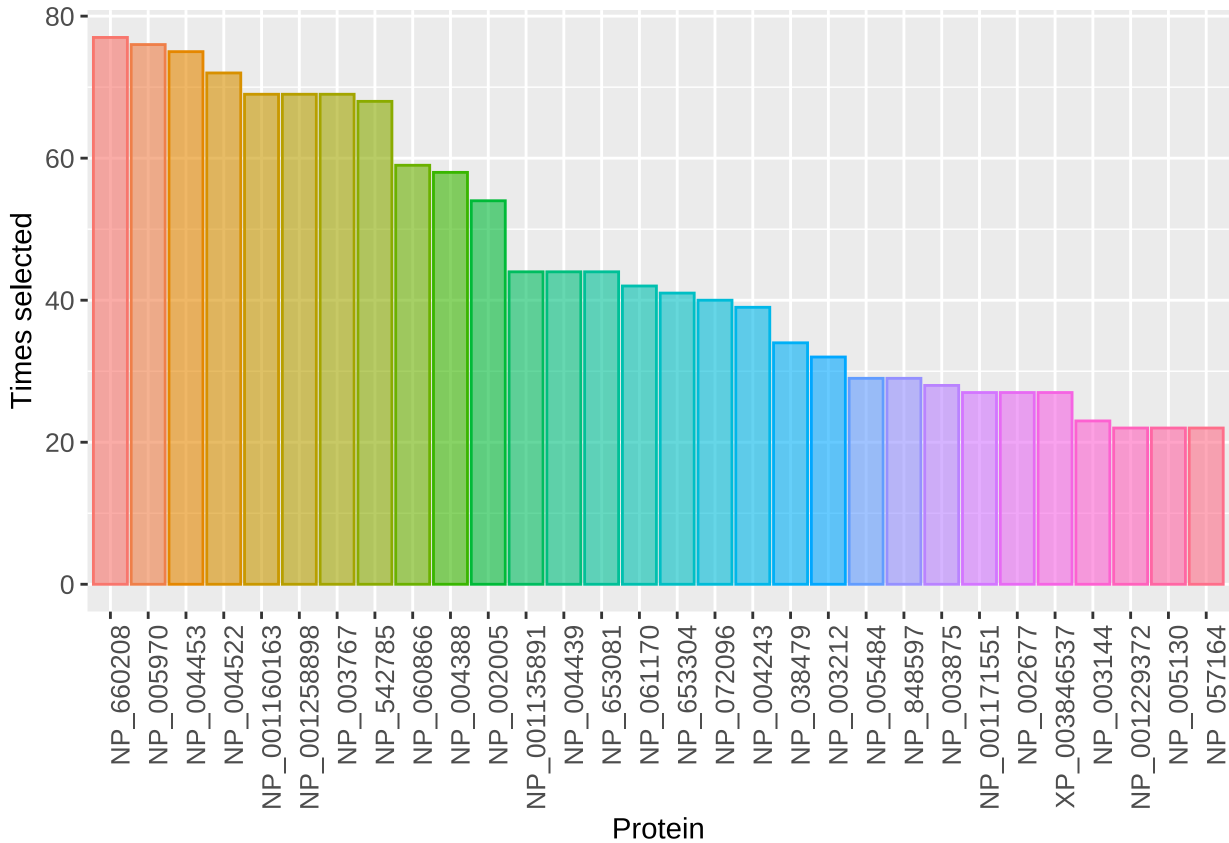
The PAM50 genetic test is used to identify the subtype of breast cancer. A list of proteins linked to the PAM50 genes is included in this data collection. Therefore, it would appear likely that these are the best factors to utilize when categorizing breast cancer subtypes. To test if machine learning techniques might be used to find a set of proteins with as good or higher prediction power at classifying cancer subtypes, I chose an approach that was independent of biology. I'm selecting variables using repeated lasso regression as my method. The data set is reduced via lasso regression, which also creates a sparse set of predictor variables. However, because of the stochastic nature of the reduction, the findings are not always reliable. To get around this, I conducted 100 iterations of the lasso regression and prioritized the variables according to how frequently they were used in the final model.

```
# Defining  a function that performs lasso regression again and returns the chosen model variables
LassoSub=function(k=1, Xdata, Ydata){
  set.seed(k)
  s=sample(nrow(data), size=0.8*nrow(data))
  Xsub=Xdata[s, ]
  Ysub=Ydata[s]
  model.sub=cv.glmnet(x=Xsub, y=Ysub, alpha=1, family="multinomial") #cross validated lasso
  coef.sub=coef(model.sub, s='lambda.1se')[-1] #using lambda +1se hyperparameter value for parsimony
  return(coef.sub)
}
```

```
options(warn = -1) #turn off warnings
#Run model 100 times and save results
niter=100
lasso.stab=sapply(1:niter, FUN=LassoSub, Xdata=as.matrix(data[,31:ncol(data)]), Ydata=as.matrix(data[,2

#create a matrix of all predictor variables
stability_matrix <- matrix(nrow=length(lasso.stab[[1]]),ncol=length(lasso.stab))
rownames(stability_matrix) <- rownames(lasso.stab[[1]])

#loop through to put list contents into matrix
for (i in 1:300){
  temp.data.frame <- as.matrix(lasso.stab[[i]])
  stability_matrix[,i] <- temp.data.frame
}

stability_matrix <- ifelse(stability_matrix != 0, 1, 0) #Replacing beta values with binary 1/0 (selecte
stability_matrix <- stability_matrix[2:nrow(stability_matrix),] #remove intercept value
stable_variables <- as.data.frame(rowSums(stability_matrix)) #create data frame with count of how many
stable_variables$protein <- rownames(stable_variables) #create column of variable names

colnames(stable_variables)[1] <- "times_selected" #assign appropriate column name
stable_variables <- stable_variables[!is.na(stable_variables$times_selected),]  #remove NAs
stable_variables <- stable_variables[stable_variables$times_selected != 0,] #remove all variables that

stable_variables <- stable_variables[order(-stable_variables$times_selected),] #ordering by number of t
```

visualizing the selected features

```
#plotting stable variables
ggplot(stable_variables[1:30,], aes(x=reorder(as.factor(protein),-abs(times_selected),mean), y=times_sel
```




```r
STABVARS <- stable_variables$protein[1:30]

STABVARS.ind <- which(colnames(data) %in% STABVARS)
```

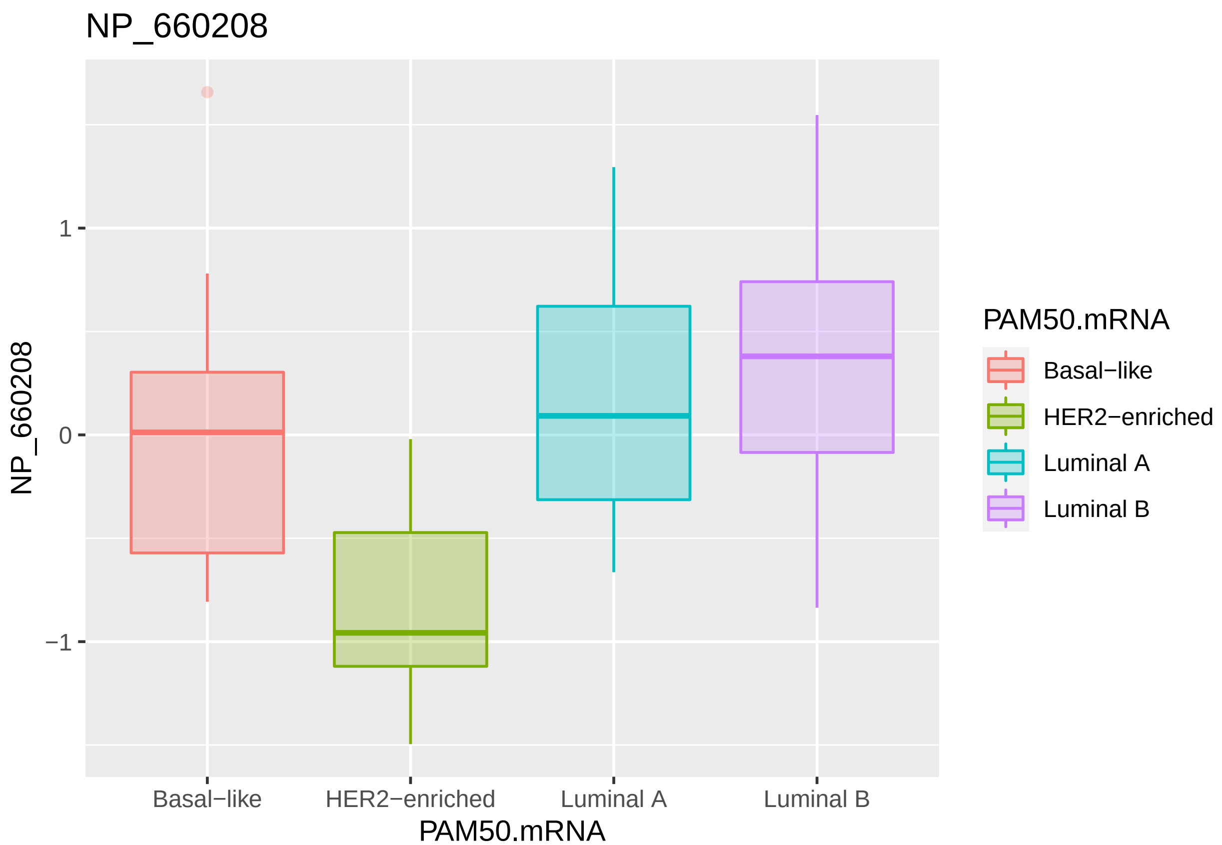
We now have a collection of variables that the lasso regression repeatedly chose. Due to the size of the data set, instability still exists after 100 iterations, and only roughly 30 variables were chosen more frequently than 20% of the time. These are the factors that we will classify using.

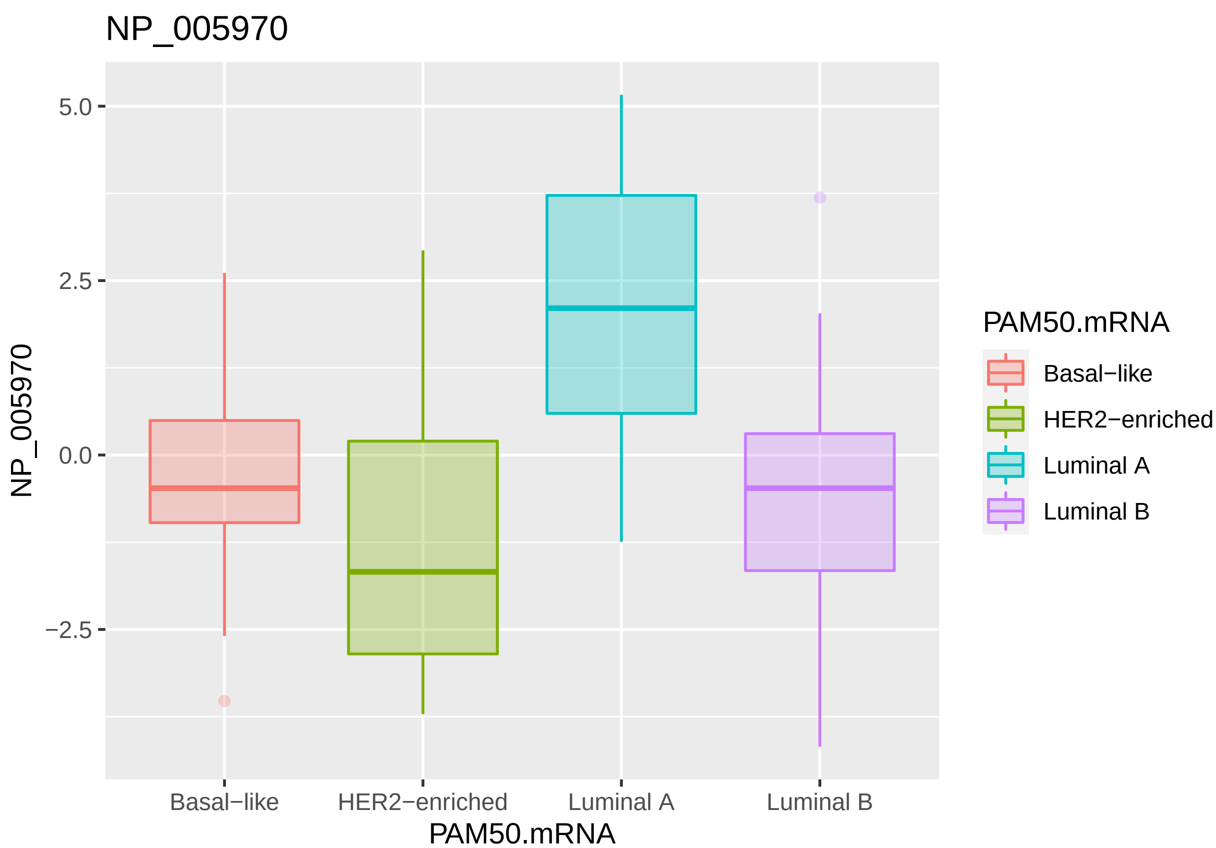
An indication of how well the chosen protein variables will be able to categorize the subtypes will be provided by visualizing the relative amounts of the most-selected protein in patients with each subtype of cancer:

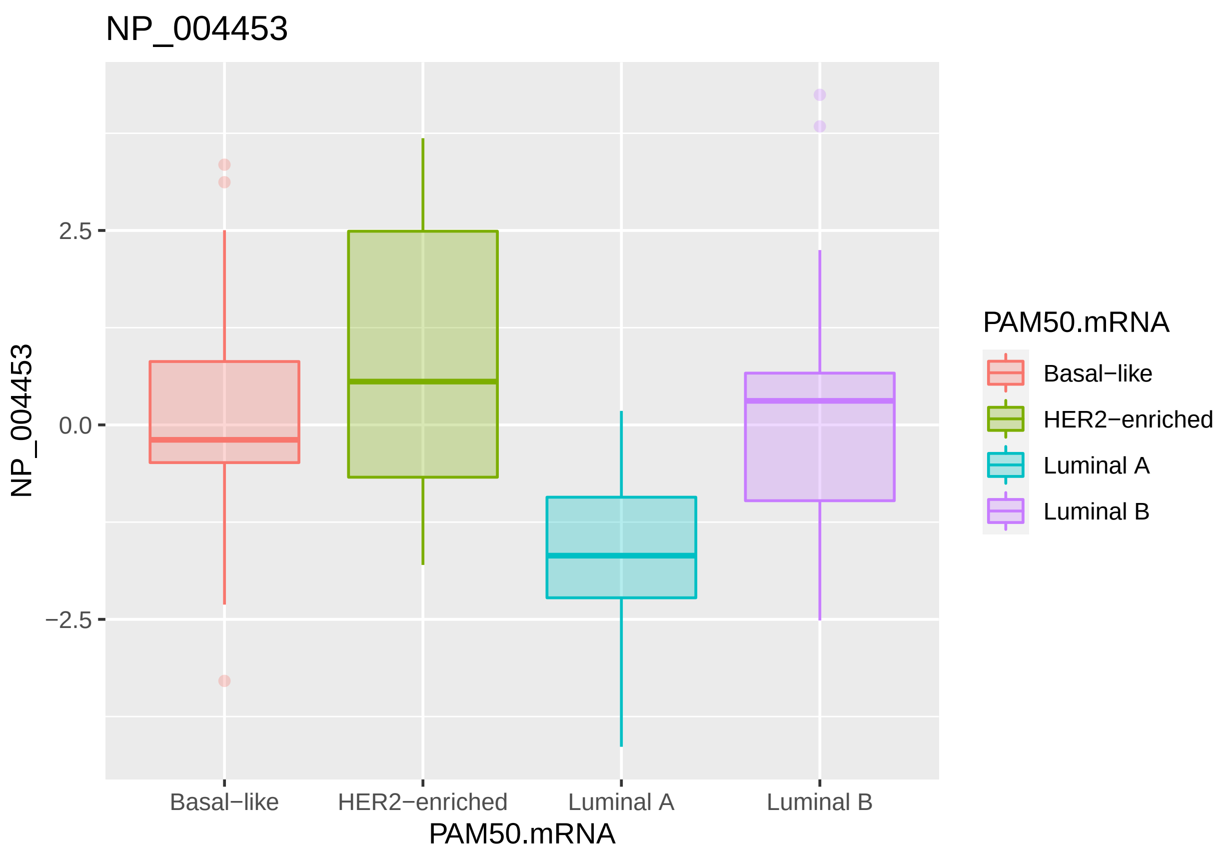
```r
library(gridExtra)
```

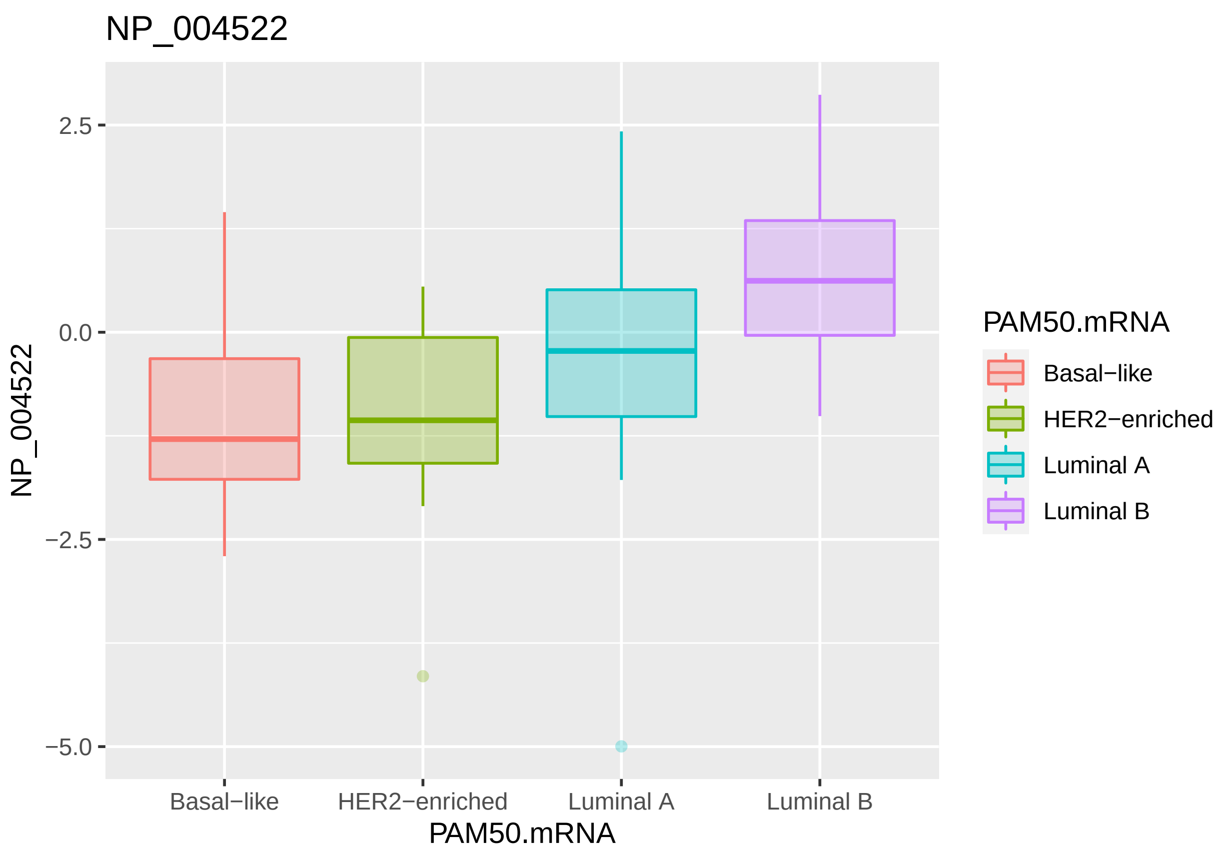
```
##
## Attaching package: 'gridExtra'

## The following object is masked from 'package:dplyr':
##
##     combine

## The following object is masked from 'package:randomForest':
##
##     combine
```

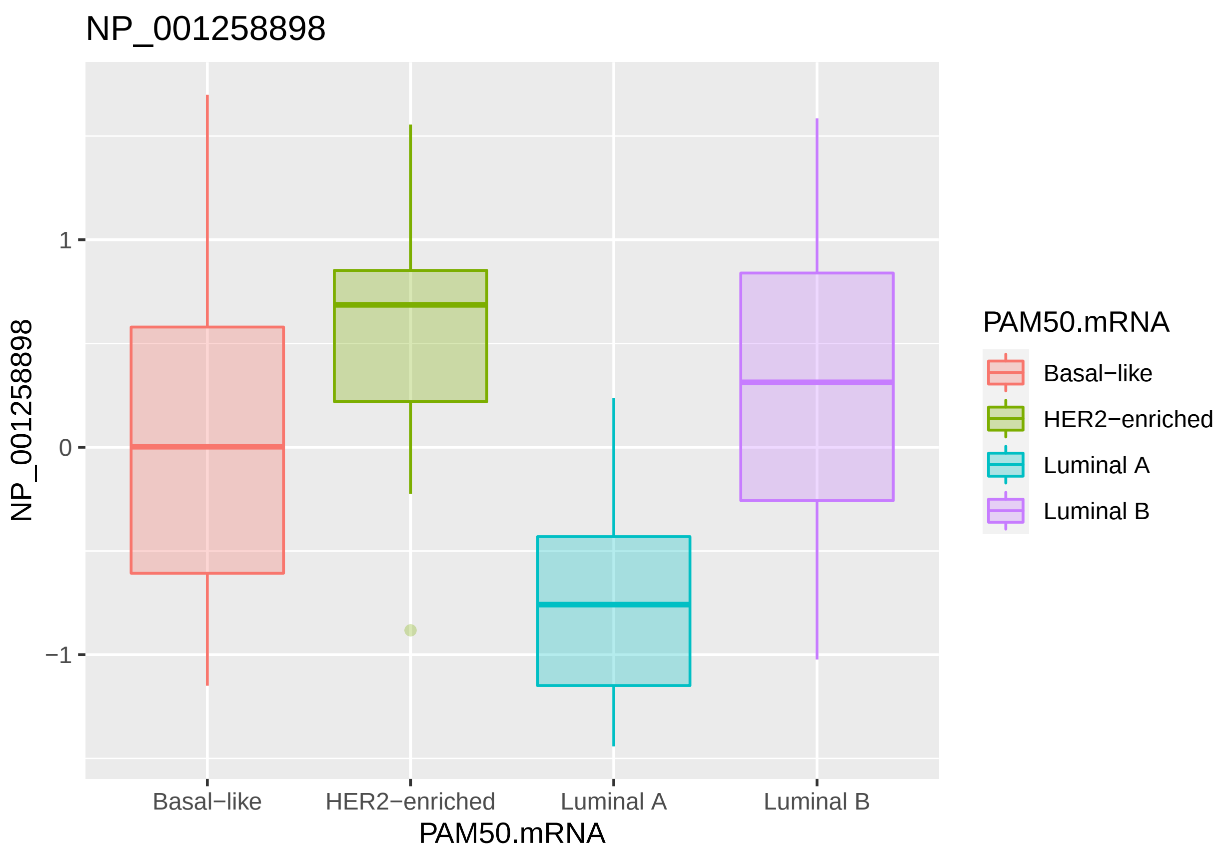
```
for (i in 1:length(STABVARS[1:5])){
print(ggplot(data, aes_string("PAM50.mRNA", STABVARS[i], col="PAM50.mRNA", fill="PAM50.mRNA")) + geom_bo
}
```




NP_005970
5.0
2.5
0.0
−2.5
NP_005970
Basal−like
HER2−enriched
Luminal A
Luminal B
PAM50.mRNA
PAM50.mRNA
Basal−like
HER2−enriched
Luminal A
Luminal B


NP_004453
2.5
0.0
−2.5
NP_004453
Basal−like
HER2−enriched
Luminal A
Luminal B
PAM50.mRNA
PAM50.mRNA
Basal−like
HER2−enriched
Luminal A
Luminal B


NP_004522
2.5
0.0
−2.5
−5.0
NP_004522
Basal−like
HER2−enriched
Luminal A
Luminal B
PAM50.mRNA
PAM50.mRNA
Basal−like
HER2−enriched
Luminal A
Luminal B



This is promising. There are clear differences in the levels of each of the selected proteins.

Now that i have slected the proteins, I am going to create a subset of data with the selected features(predictor variables) and response variable only and stored as final_data

```
final_data <- data[,c(21, STABVARS.ind)]
head(final_data)
```

```
##    PAM50.mRNA  NP_038479 NP_001258898   NP_542785  NP_002005 XP_003846537
## 1 Basal-like -0.3708959  -0.01456473  0.05890562 -2.1305106   -0.4957955
## 2 Basal-like -1.6044748  -0.51053492  3.17273051 -0.9688522   -0.6711132
## 3 Basal-like -3.0516640   0.53387720  3.71857004 -0.3435704   -0.3498830
## 4 Basal-like -1.0663490   1.69892745  2.96770134 -3.2821848   -0.4373841
## 5 Basal-like -0.3009396  -1.09705962  0.03501174 -1.2946781   -0.3376402
## 6 Basal-like  0.6787788  -0.70384668 -1.91679672 -2.7445377   -0.4103540
##     NP_660208 NP_004439  NP_004388 NP_001229372  NP_005130 NP_004243 NP_003144
## 1 -0.09170859 -4.419112  0.1691111    -3.004808  2.2373013 -3.717470 0.1948258
## 2 -0.51388030 -5.187379  0.4863889    -3.273820 -2.2066435 -2.905828 0.9748146
## 3  1.65751511 -3.099008 -0.7349499    -2.969601 -0.4698218 -3.076914 0.3539689
## 4 -0.70126018 -3.130366  0.7843981    -2.859260  3.8894601 -3.180972 0.3397851
## 5  0.78031558 -2.062567 -0.1823685    -1.774609 -0.2388310 -1.785901 1.5453813
## 6  0.41280109 -3.322351 -0.2659006    -2.127745 -0.6167161 -1.937433 1.4835906
##    NP_001171551  NP_072096   NP_005484   NP_061170  NP_653304  NP_653081
## 1     0.1948258 -0.5215101 -0.96600568 -1.41417478  0.5548304 -0.2753844
## 2     0.9547423 -0.5506795 -0.29643048 -2.19660738 -0.8751815  0.2890113
## 3     0.3508126  0.8747561  0.29399945 -3.01378855 -1.5334903 -1.4072388
```

```
## 4    0.3470145 -1.2145533 -0.11205750 -1.51096203  0.1301301  0.3723177
## 5    1.5990205  0.2693307  0.62504394  0.48671103 -1.4414803  0.6448058
## 6    1.5432063  0.3623570  0.07115731 -0.06412445 -2.9967579 -0.3690816
##    NP_057164  NP_004453    NP_003212    NP_060866 NP_001160163   NP_003875
## 1 -0.6243686 -2.3105130  0.007476375 -1.399480707  1.340963113  0.04810062
## 2  0.6034772 -0.3499566 -0.376719645 -1.457277986  0.740637896  1.71079864
## 3  1.8279546 -3.2915417 -0.476134402  0.335031167  2.493930969 -3.12110229
## 4 -0.1771228  1.3374534  0.159048035 -0.451843095  1.055503657 -0.82416136
## 5  1.4155177 -0.2021304 -1.819778494 -0.600190397  1.886978849  0.83677799
## 6  0.6375064  3.3454346 -2.334106568  0.002369978  0.002369978 -0.66257428
##   NP_002677 NP_001135891  NP_004522  NP_003767  NP_848597  NP_005970
## 1 -7.684869    0.9038146 -2.3839833 -0.3892635  0.3819222  0.8193237
## 2 -8.877335   -1.2933543 -0.7514024 -1.0558322 -0.7346755 -0.9655069
## 3 -7.479934   -0.4603530 -0.7412624 -1.0095468 -0.1952249  2.6107136
## 4 -7.963274   -1.7784528 -0.7771697 -0.7446371  0.2277281 -0.2638766
## 5 -4.388818    0.6306902  1.4493952 -0.5521973  1.9688493  1.8389858
## 6 -3.342988   -1.0913487  1.2864003  0.2889839 -0.5502216  1.5019339
```

```
dim(final_data)
```

```
## [1] 80 31
```

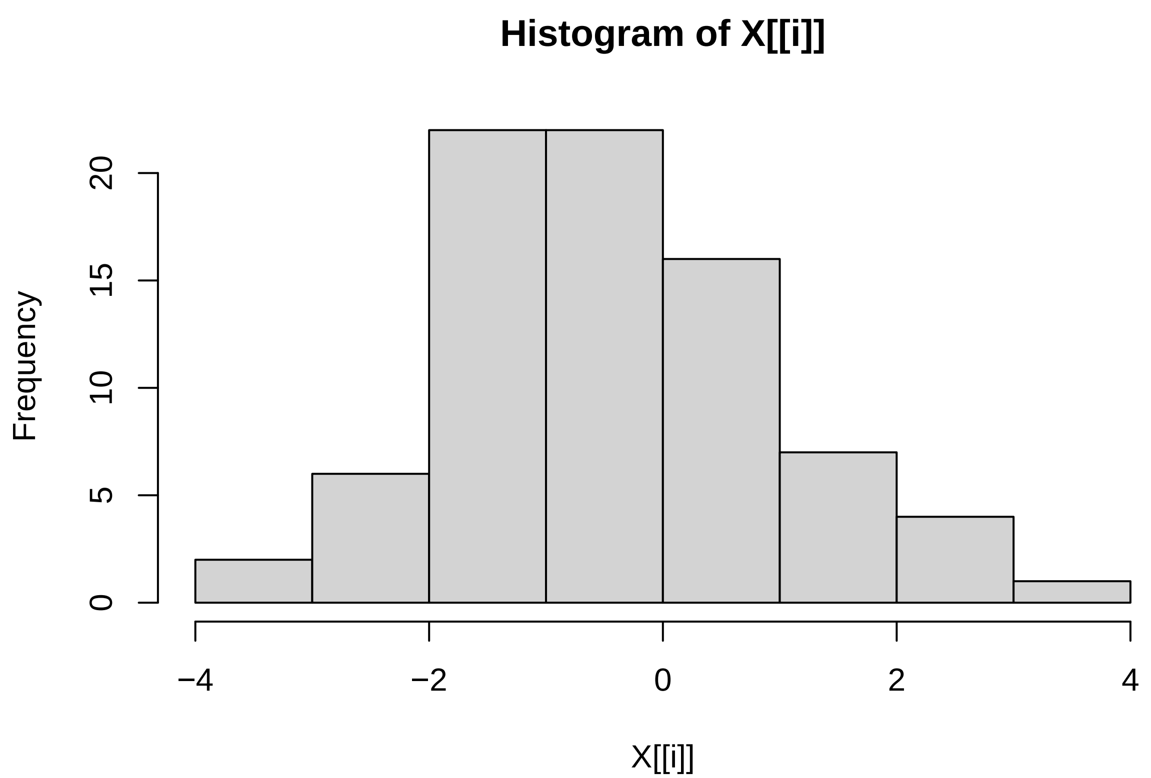
```
tail(final_data)
```

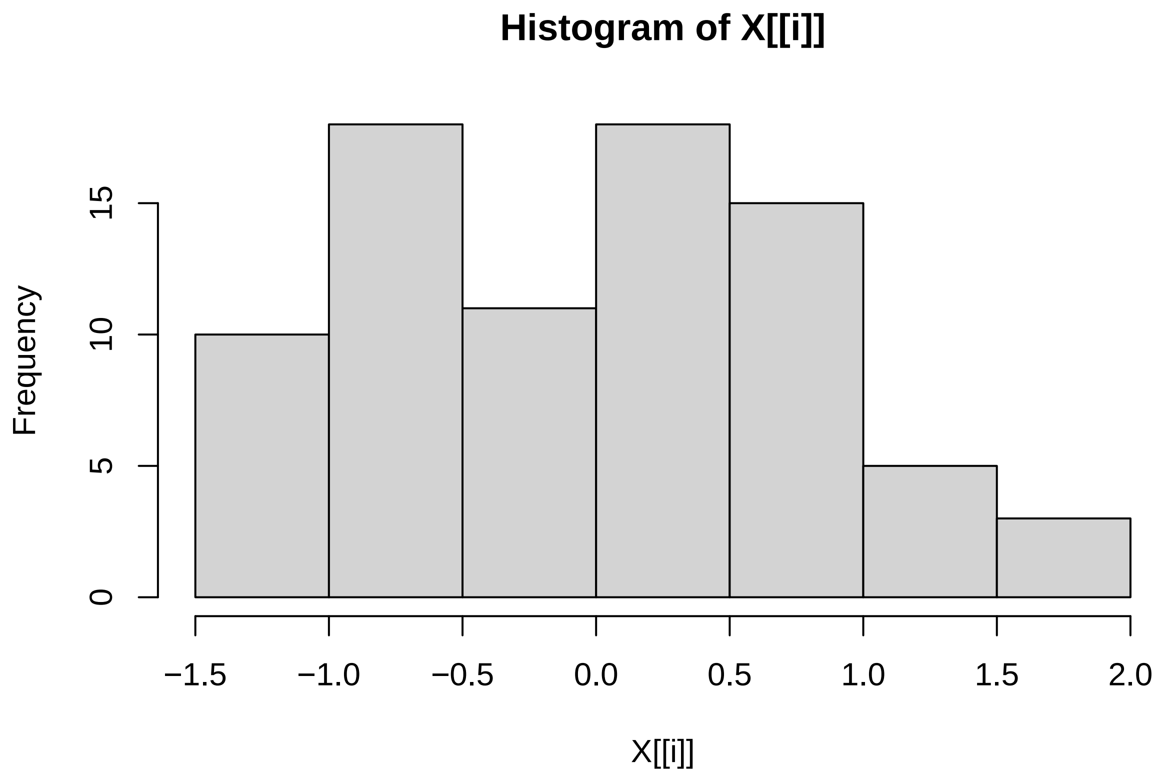
```
##    PAM50.mRNA  NP_038479 NP_001258898  NP_542785  NP_002005 XP_003846537
## 75  Luminal B -0.6318314    0.4327078 -5.5679315  0.8108994 -0.060341913
## 76  Luminal B -0.3073523   -0.7009215 -2.6553809 -0.8374660  0.624362546
## 77  Luminal B -2.5001368   -1.0230163 -2.3908031 -1.5362152 -0.001080874
## 78  Luminal B -1.5815337    0.8397669 -4.2961120 -0.4483087 -1.344565342
## 79  Luminal B -1.2355758    0.3127390 -3.2926750  3.4240101 -0.115518269
## 80  Luminal B  0.4533356    1.4196209  0.3012351 -0.1103309 -0.696365039
##     NP_660208  NP_004439   NP_004388 NP_001229372 NP_005130  NP_004243
## 75  0.3346582 -2.0577536  0.22820424    -1.704775 -5.100095 -1.6375408
## 76  1.0580919 -1.0382666 -0.41980067    -1.388998 -4.925767  0.7448429
## 77  0.5255059 -2.7790493  0.08370852    -2.292626 -2.281469  1.8062721
## 78  0.7435718  0.9922713  0.34940658     0.935962 -1.445453 -1.3633351
## 79 -0.1704231 -4.5628057 -0.77071534    -5.997651 -2.066468  5.6714458
## 80  0.4533356 -4.6822921  0.09097858    -6.543286 -4.404932  1.9922345
##      NP_003144 NP_001171551  NP_072096  NP_005484  NP_061170  NP_653304
## 75 -0.92317894  -0.92037752  0.1665730  0.6316086 -0.9427889  0.6456157
## 76 -0.11190639   0.04337942  0.6243625 -0.0931650  3.1383863 -1.2738726
## 77 -0.11487717  -0.11487717 -0.8869070  0.7419420  3.6292442 -0.6236136
## 78 -0.01660397   0.08662977  0.7060322  1.4286685 -0.7439326 -2.8344160
## 79 -0.30219453  -0.30219453 -0.6389439  0.2688152  5.6897474 -0.6096613
## 80  0.17597590   0.15360819 -0.2803255 -0.6874180 -2.5439384 -0.9066216
##      NP_653081    NP_057164  NP_004453   NP_003212 NP_060866 NP_001160163
## 75  0.53355890 -0.015519210  0.3150482 -3.45005881 0.2786298   1.29274343
## 76  0.16921448 -1.466641235 -0.1841946  0.01392866 0.4958501   0.06316141
## 77  0.03908252  1.083330908  1.3198487 -0.25544907 0.4451791   0.72632291
## 78 -0.19726303 -0.664161107  0.8045736  0.03970534 0.9993099   0.90546108
## 79 -1.01961703 -0.569397806  0.4591518 -1.41493146 2.9262067   0.05285640
## 80 -0.24901071 -0.007439371 -2.1413195 -1.23766378 0.1088728  -0.69636504
##      NP_003875   NP_002677 NP_001135891  NP_004522 NP_003767  NP_848597
```

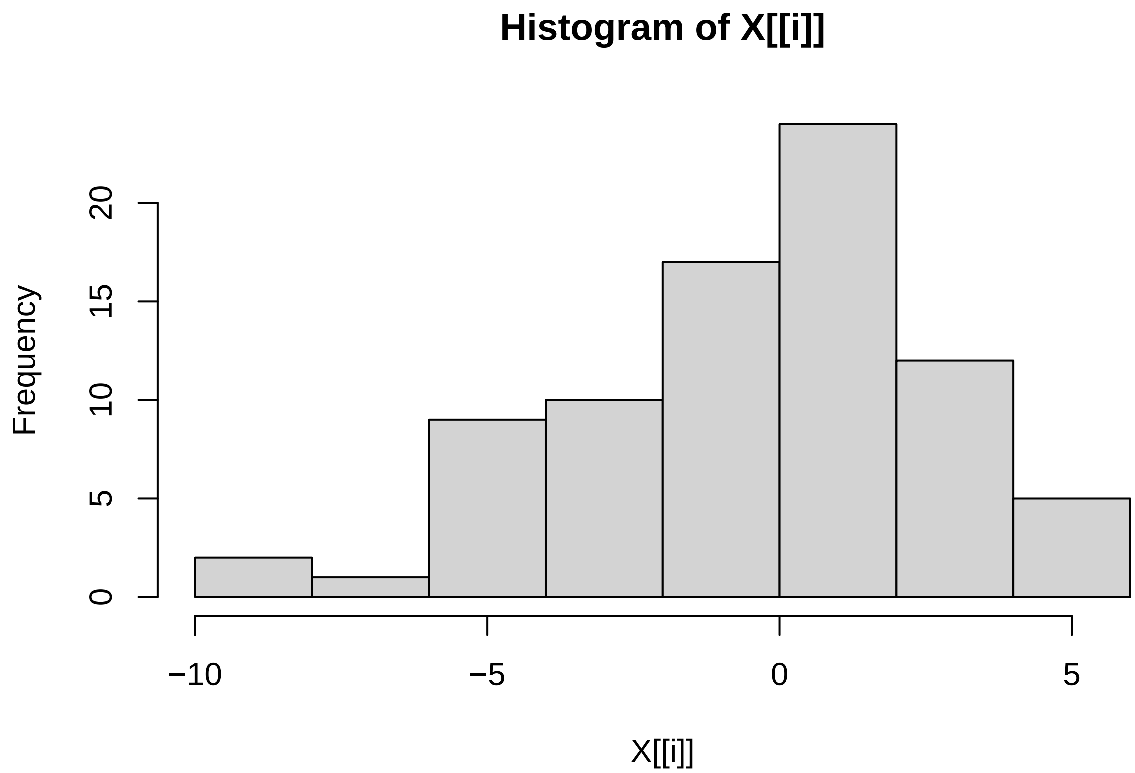
```
## 75  0.80809795  -4.1644206    0.9957930  1.9650840 1.4468215  0.9565732
## 76  0.04810062  -0.7973058   -1.0409439  0.2950495 2.6778835  3.2187065
## 77 -4.15353011  -5.7756852    0.3492332  1.6790880 0.4741860 -1.2930036
## 78 -4.17645469  -4.9108220   -0.7275091  0.8303820 1.1658917  0.2602502
## 79 -0.78535662 -10.4852016    0.2871168 -0.9720329 0.3127390 -0.7377725
## 80  0.78885134  -9.2050444    1.5493537  1.0796316 0.6054361 -0.9513570
##     NP_005970
## 75 -0.4749519
## 76 -1.2470992
## 77  0.2711377
## 78  1.2573943
## 79 -4.1821325
## 80  0.5696477
```

Checking the distribution of 30 proteins - built histogram using lapply()

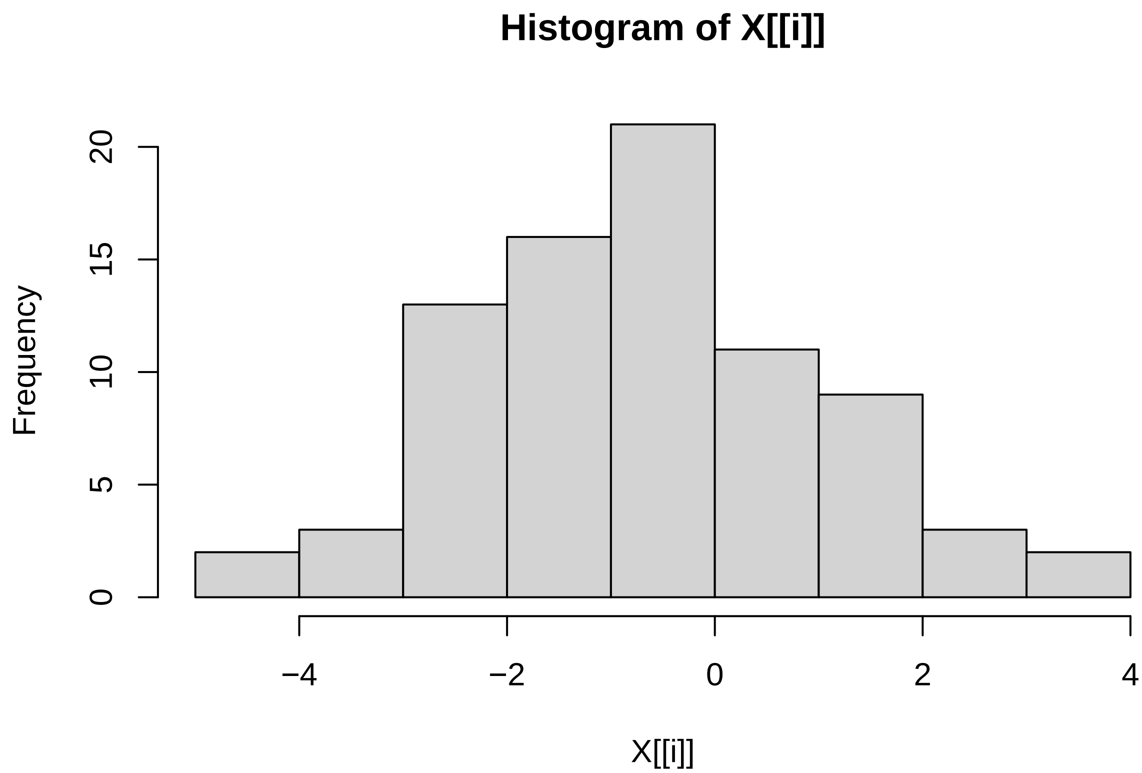
```
lapply(final_data[, 2:ncol(final_data)], hist)
```

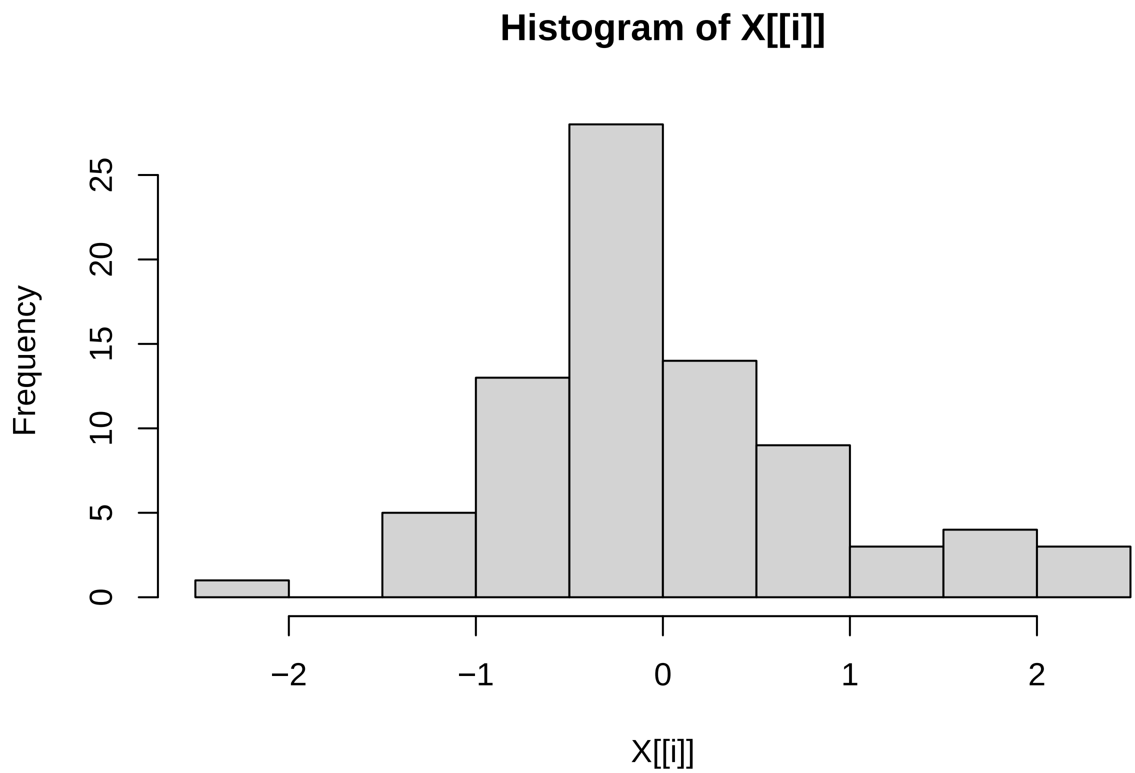



Histogram of X[[i]]
Frequency
0
5
10
15
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0
X[[i]]

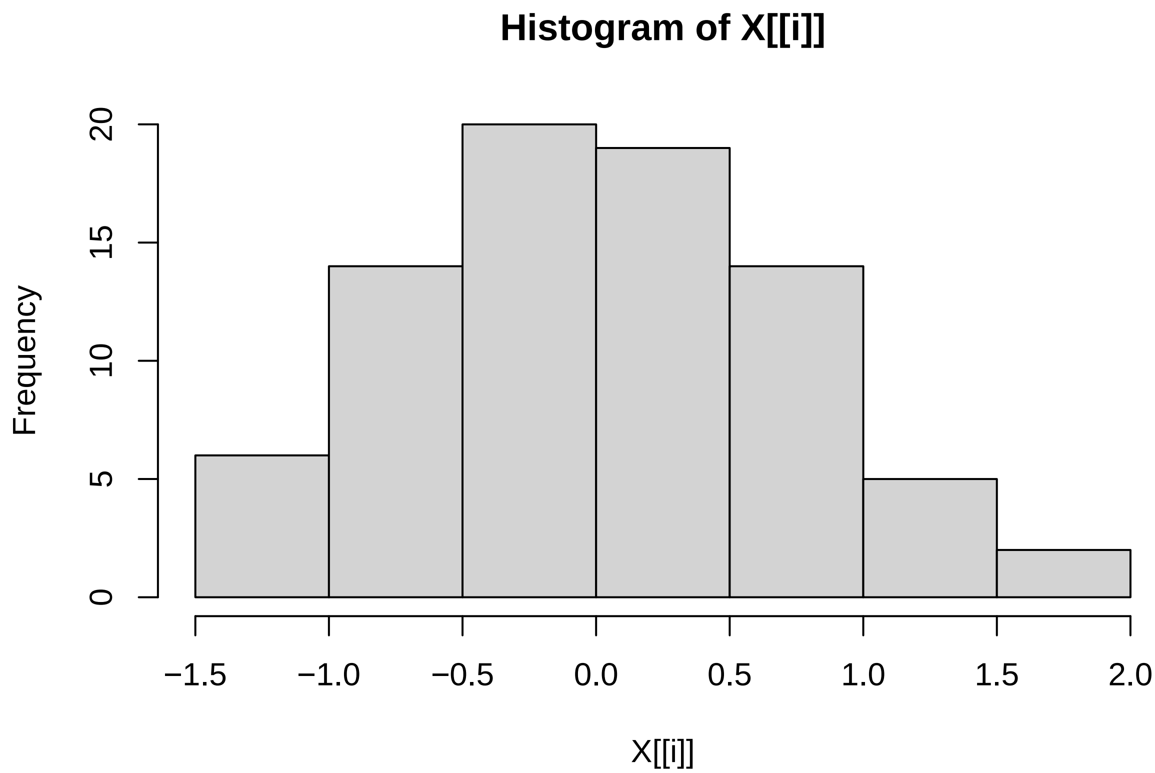


Histogram of X[[i]]
Frequency
0
5
10
15
20
−10
−5
0
5
X[[i]]

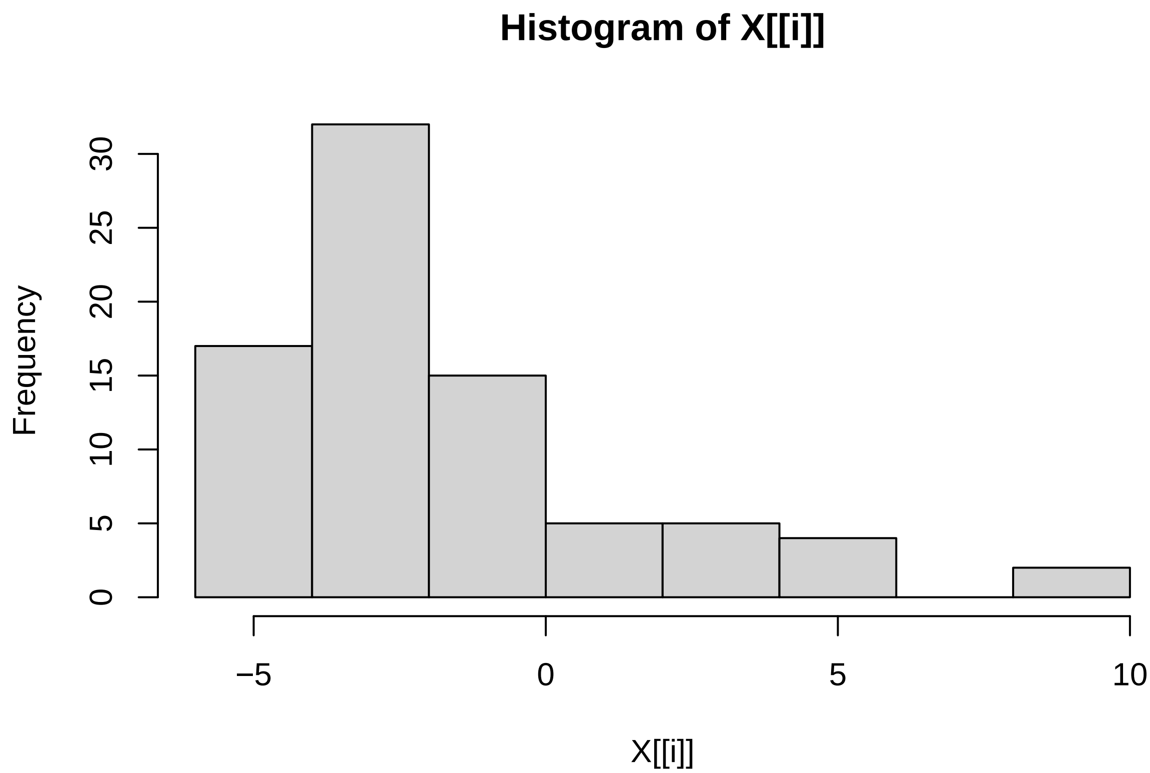

Histogram of X[[i]]
Frequency
0
5
10
15
20
−4
−2
0
2
4
X[[i]]

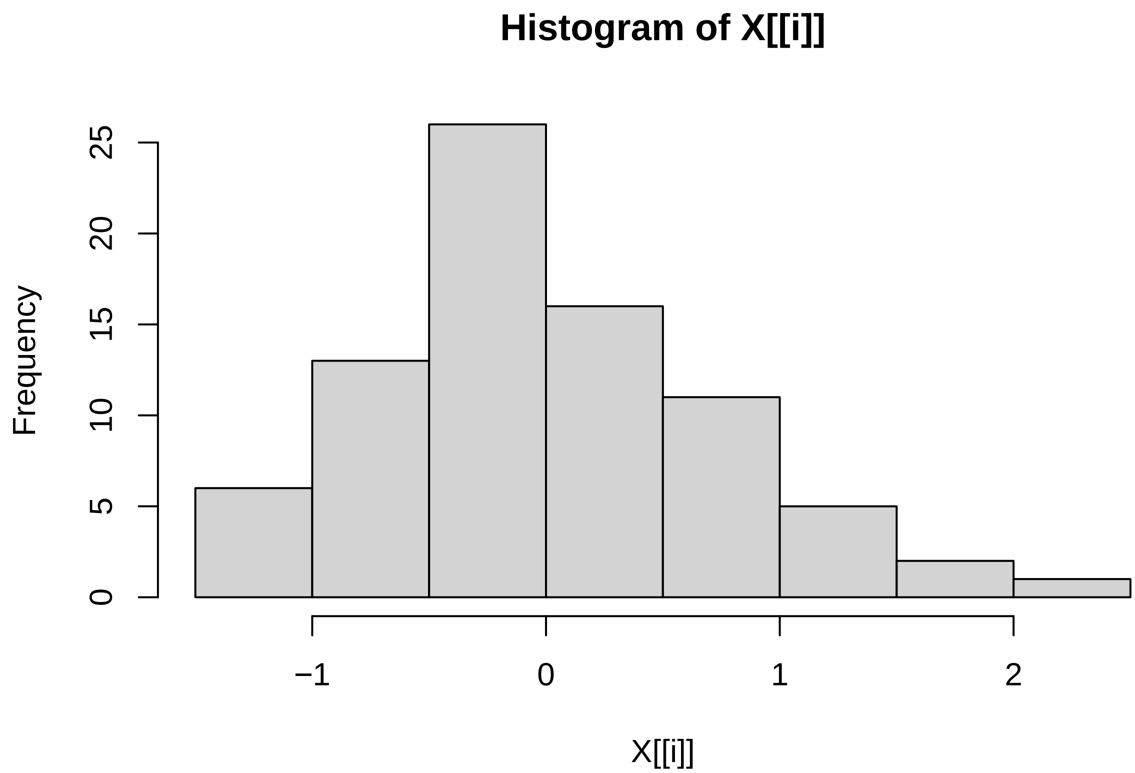


Histogram of X[[i]]
Frequency
0
5
10
15
20
25
−2
−1
0
1
2
X[[i]]

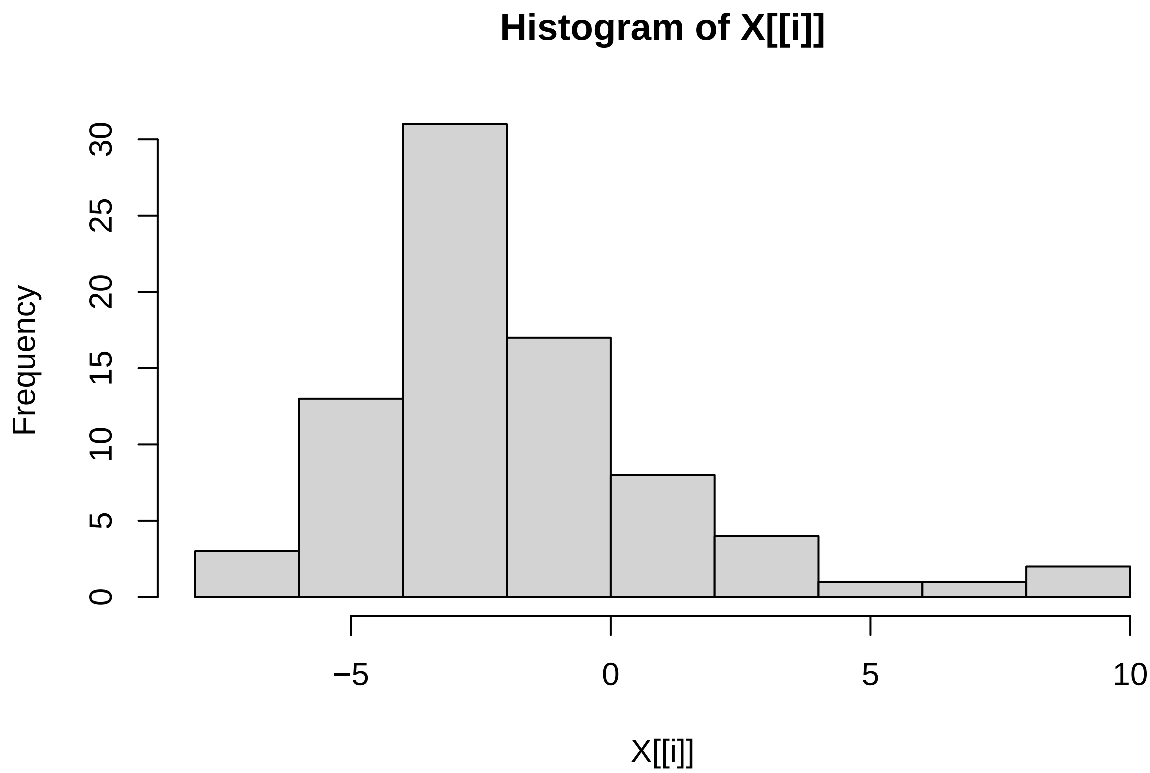


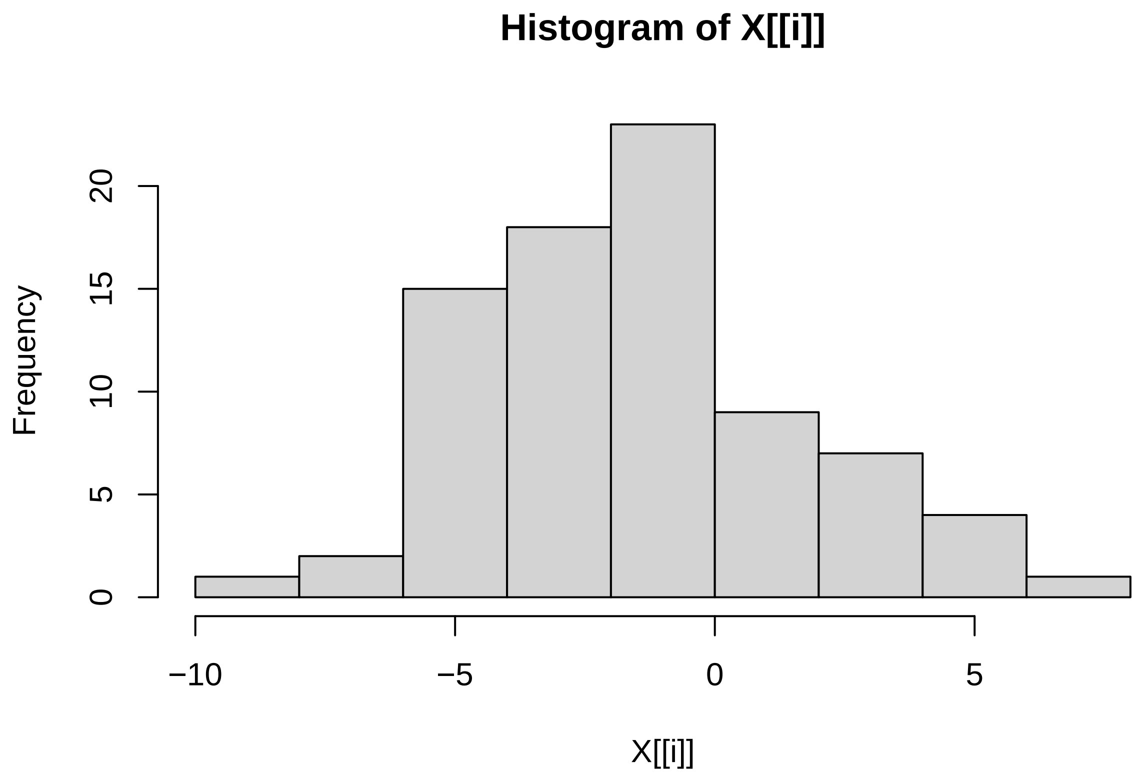
Histogram of X[[i]]
Frequency
0
5
10
15
20
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0
X[[i]]

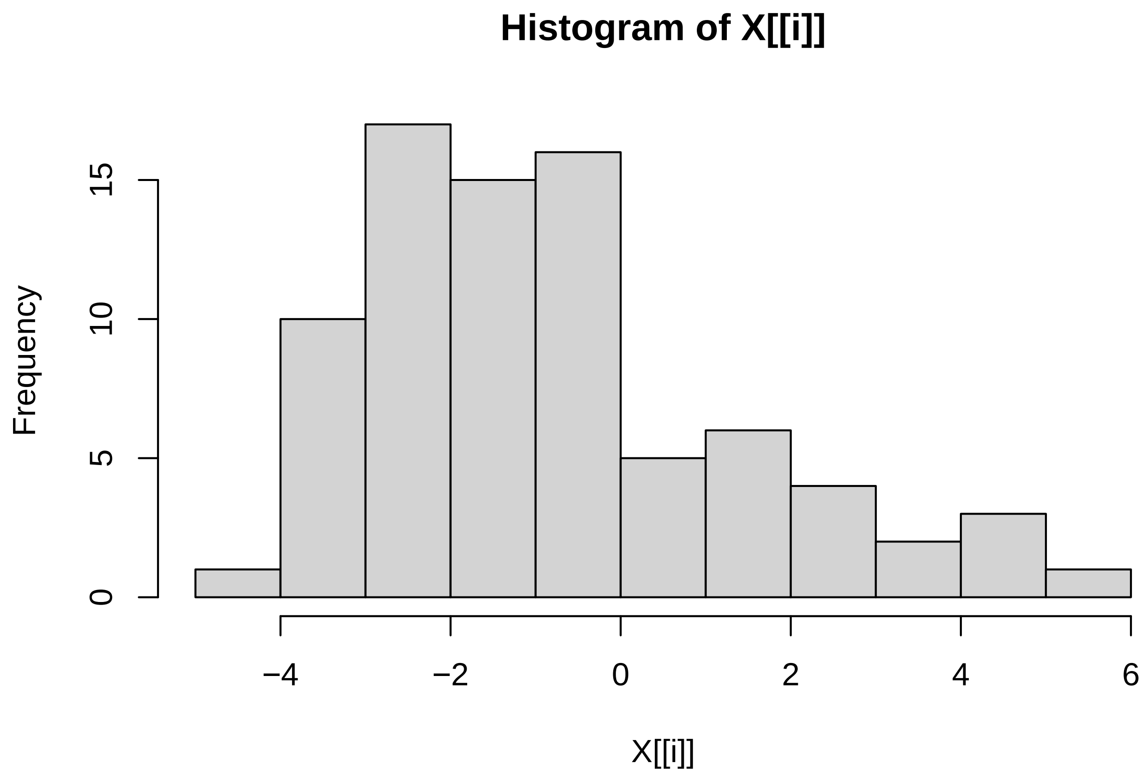

Histogram of X[[i]]
Frequency
0
5
10
15
20
25
30
−5
0
5
10
X[[i]]

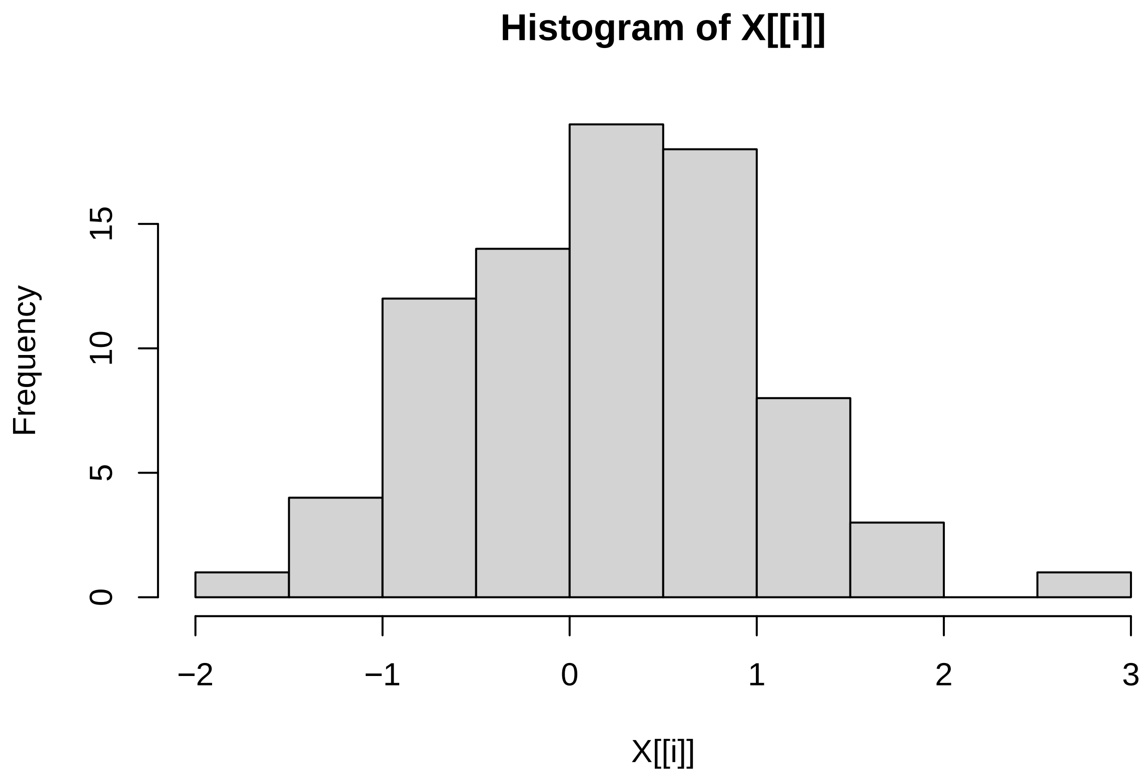


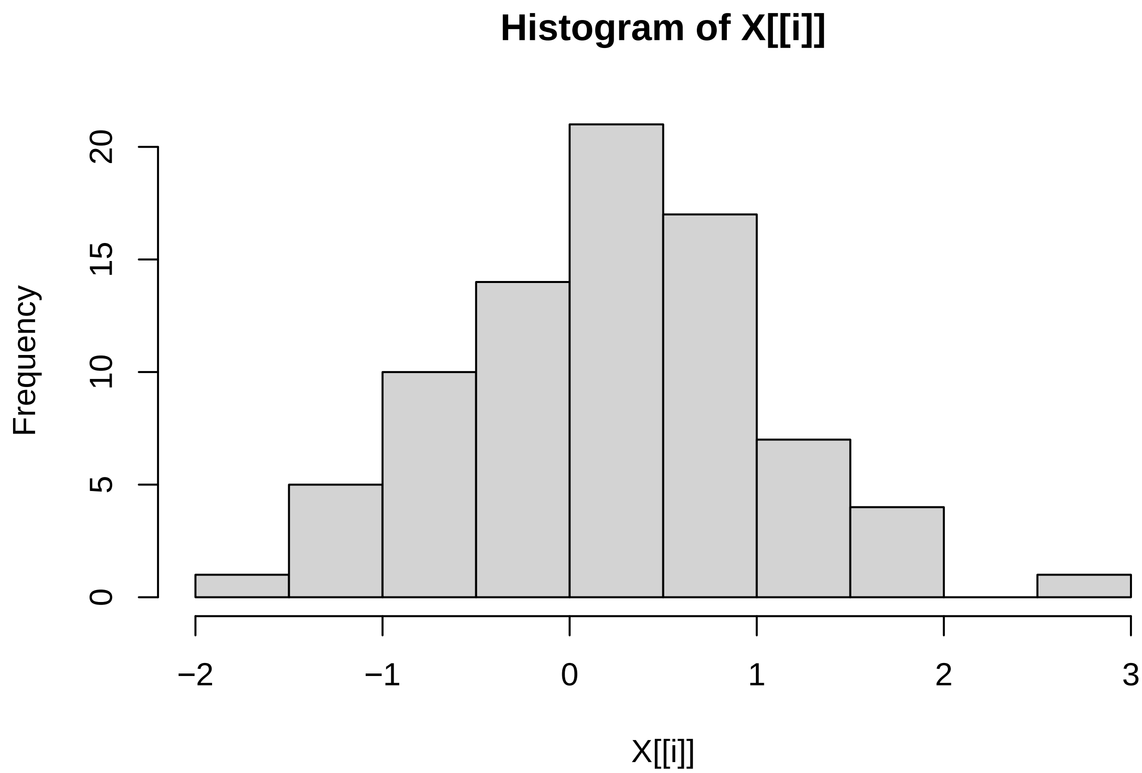
Histogram of X[[i]]
Frequency
0
5
10
15
20
25
−1
0
1
2
X[[i]]

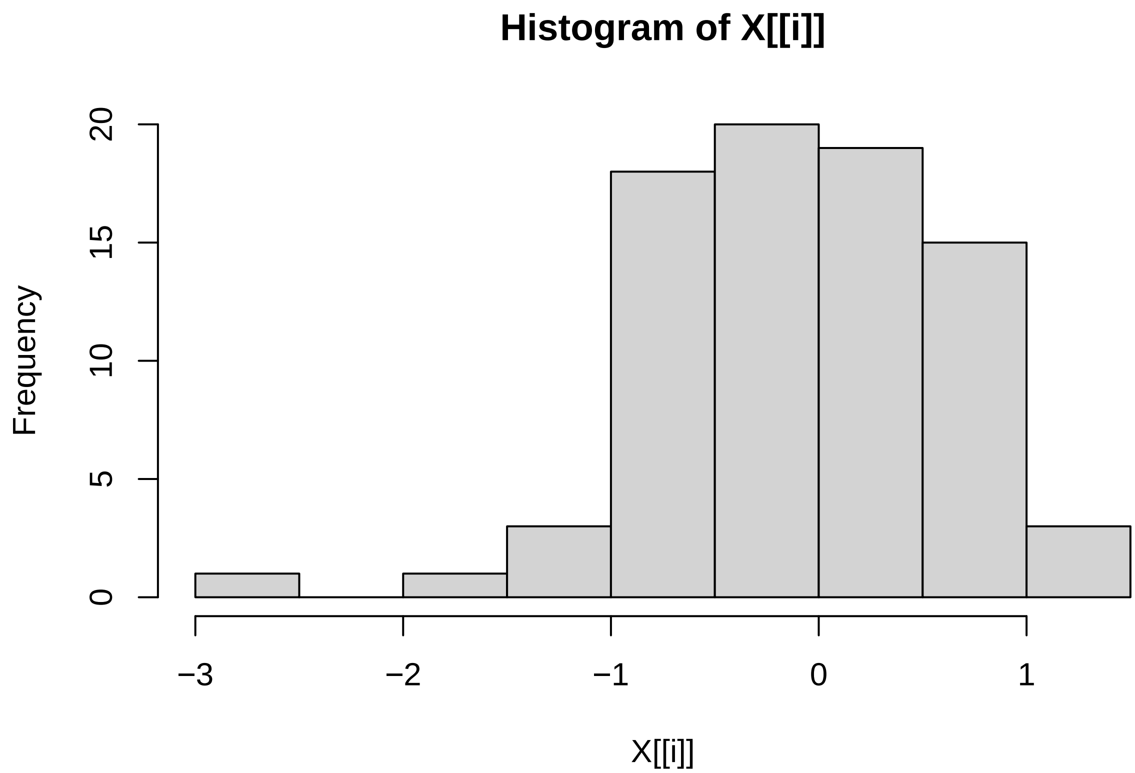

Histogram of X[[i]]
Frequency
0
5
10
15
20
25
30
−5
0
5
10
X[[i]]

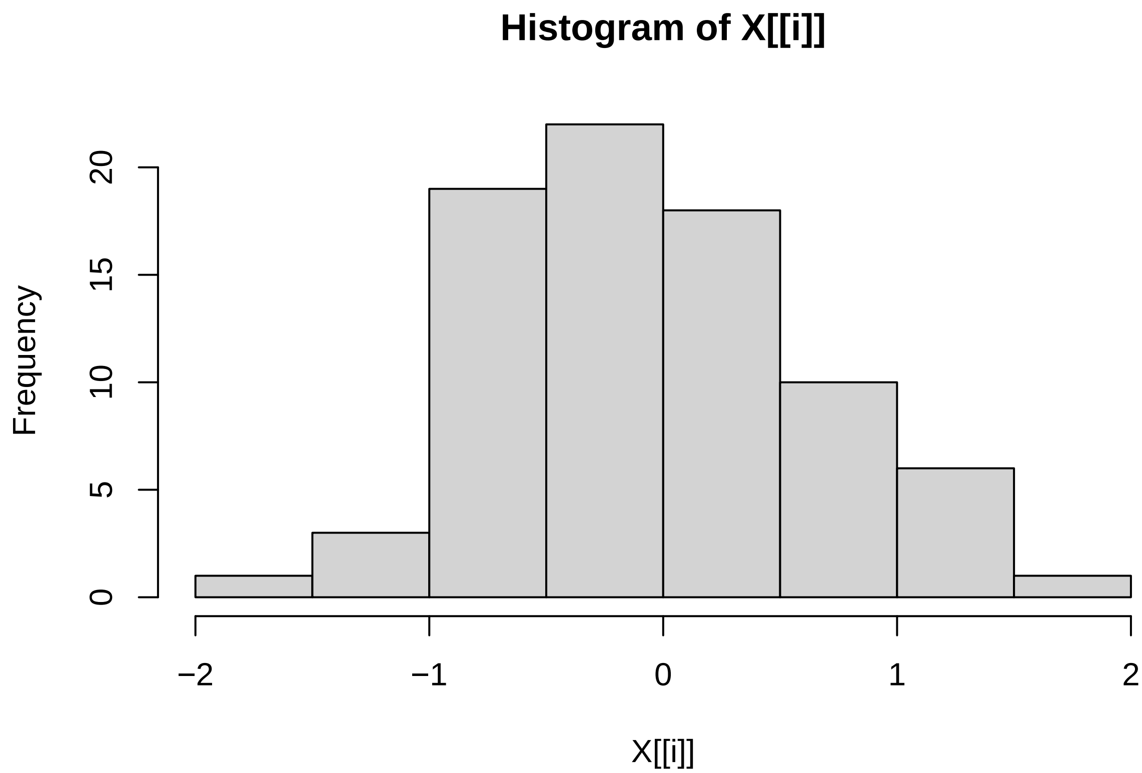

Histogram of X[[i]]
Frequency
0
5
10
15
20
−10
−5
0
5
X[[i]]


Histogram of X[[i]]
Frequency
0
5
10
15
−4
−2
0
2
4
6
X[[i]]

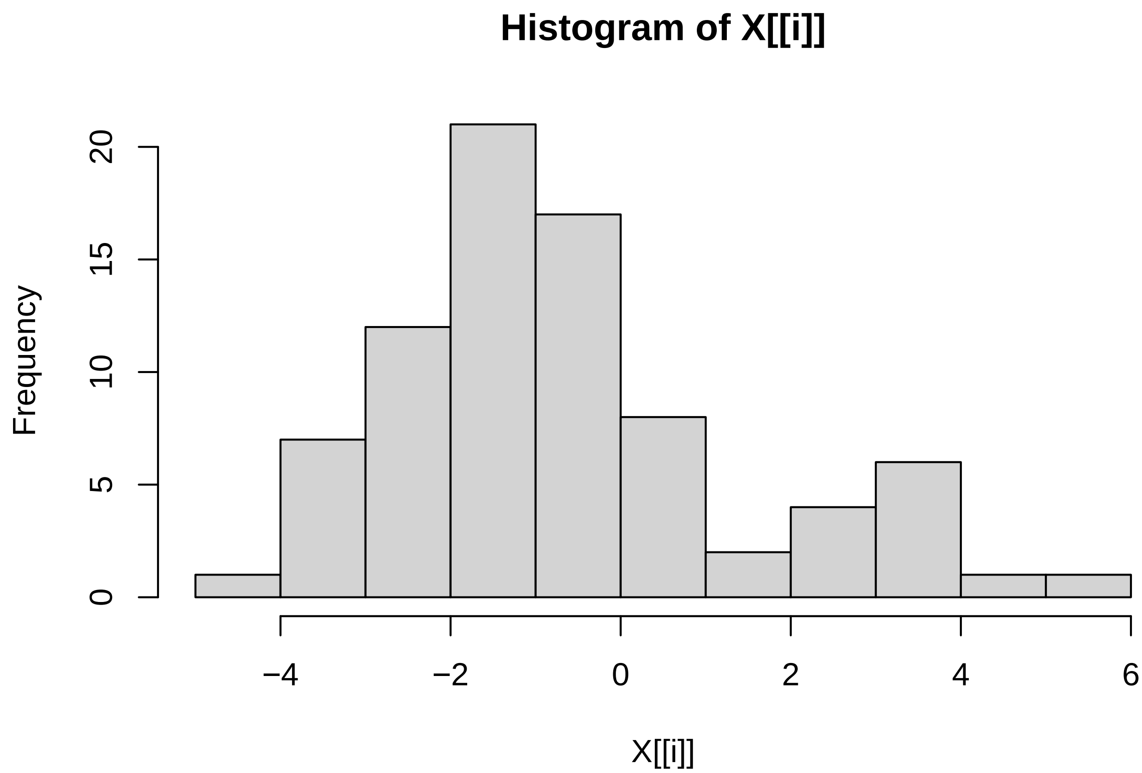

Histogram of X[[i]]
Frequency
0
5
10
15
−2
−1
0
1
2
3
X[[i]]


Histogram of X[[i]]
Frequency
0
5
10
15
20
−2
−1
0
1
2
3
X[[i]]

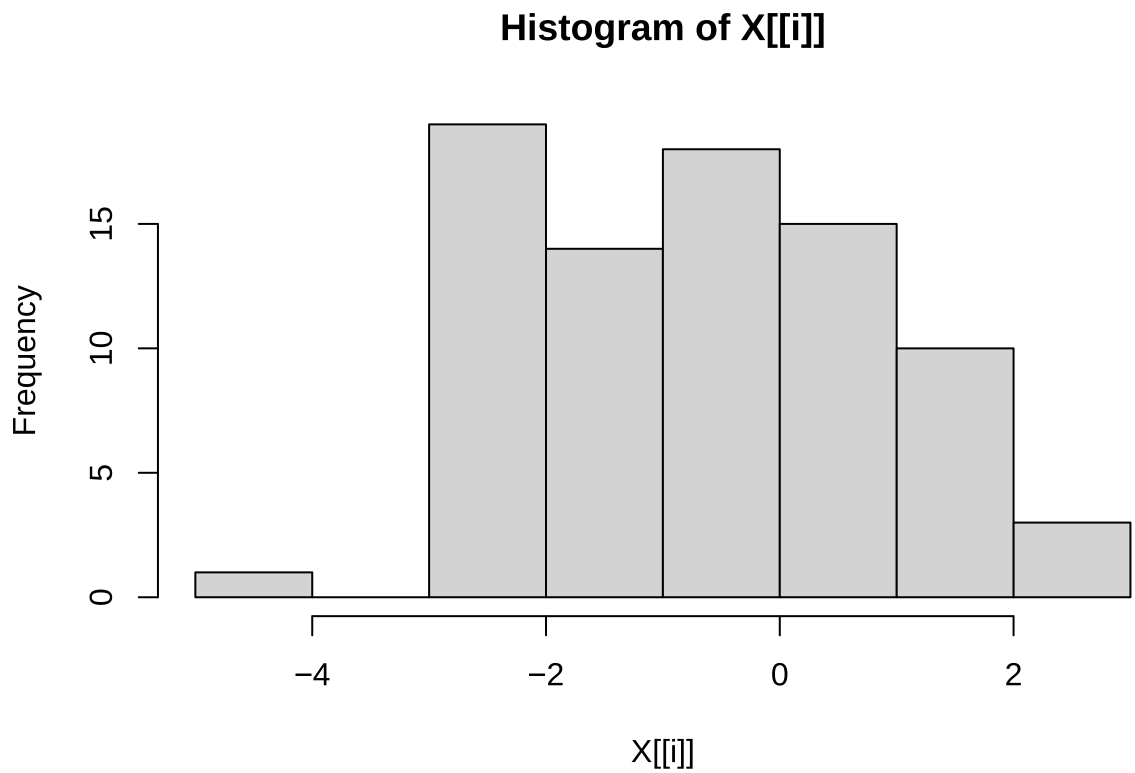

Histogram of X[[i]]
Frequency
0
5
10
15
20
−3
−2
−1
0
1
X[[i]]

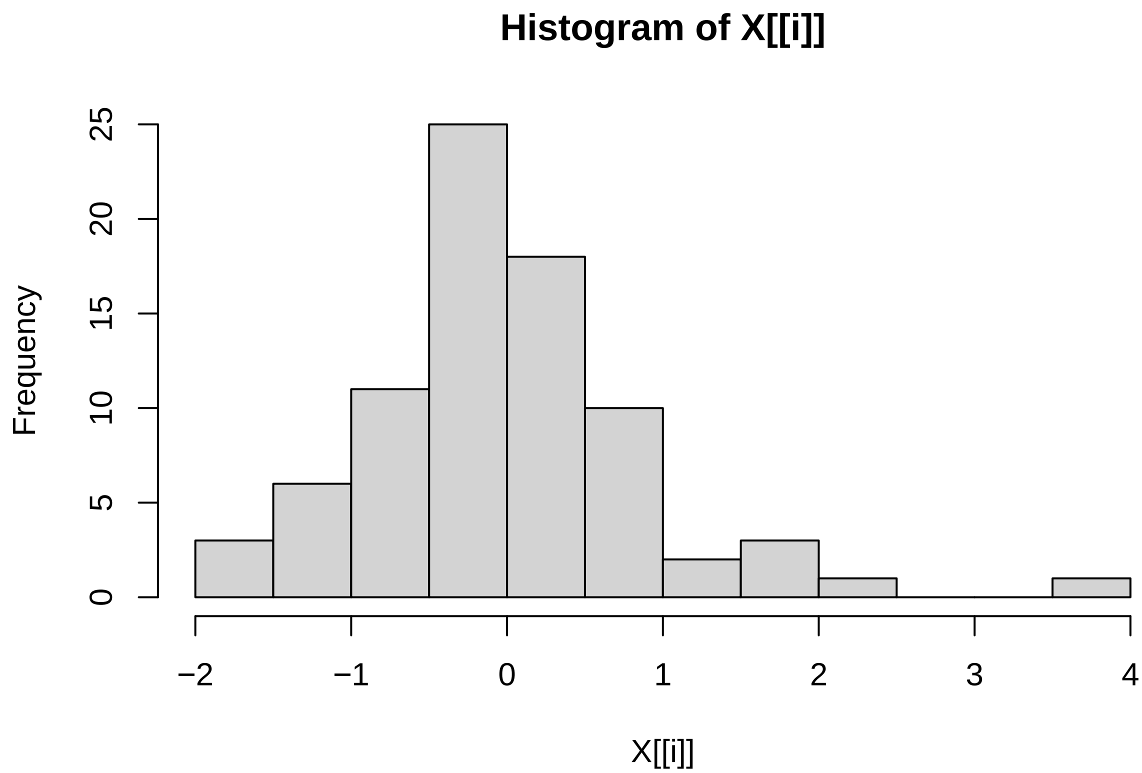


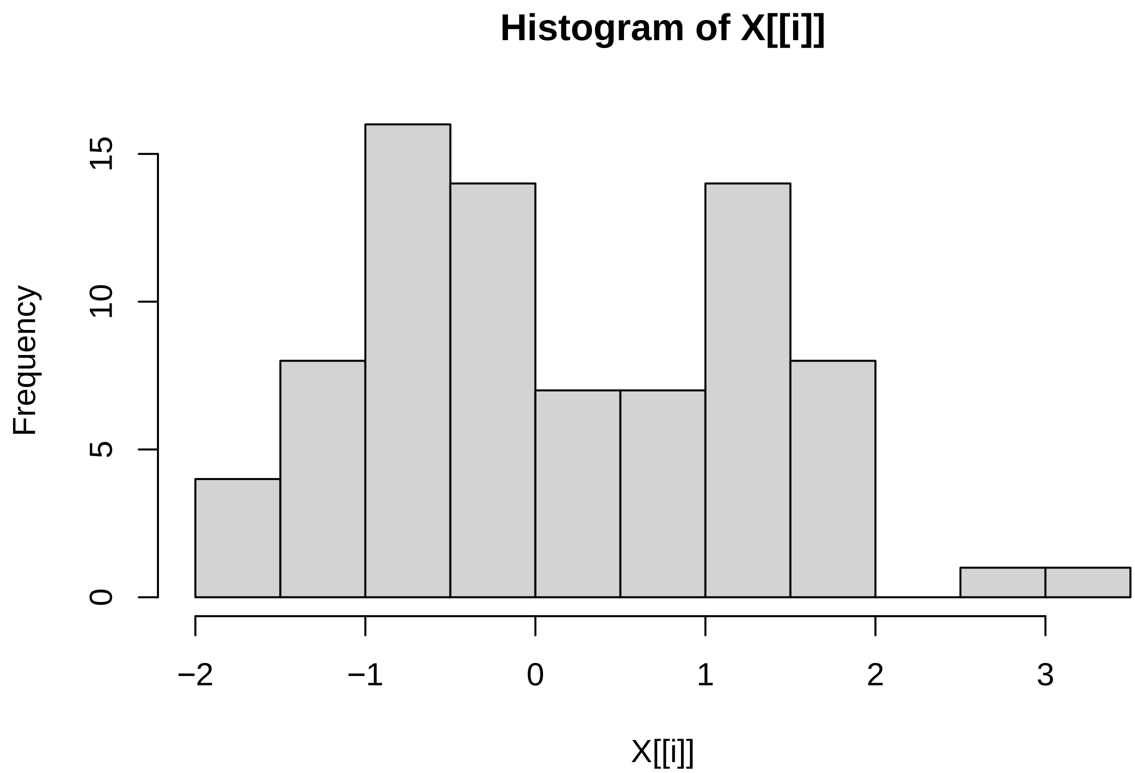
Histogram of X[[i]]
Frequency
0
5
10
15
20
−2
−1
0
1
2
X[[i]]

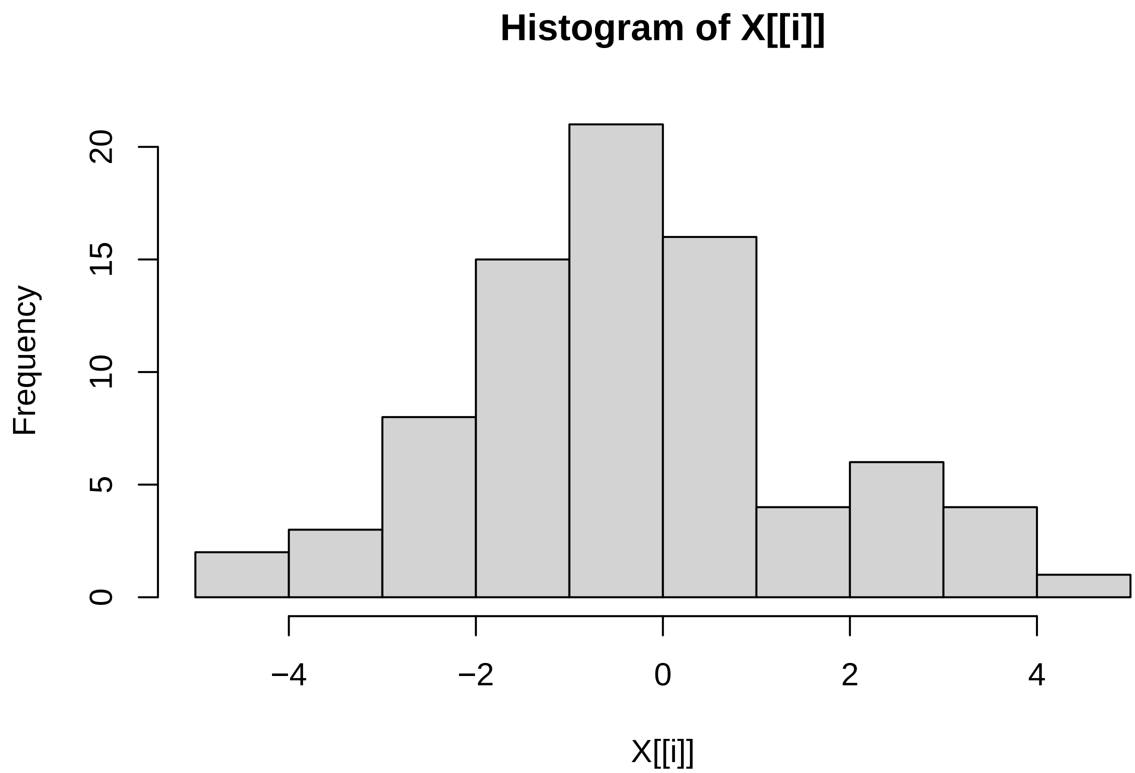


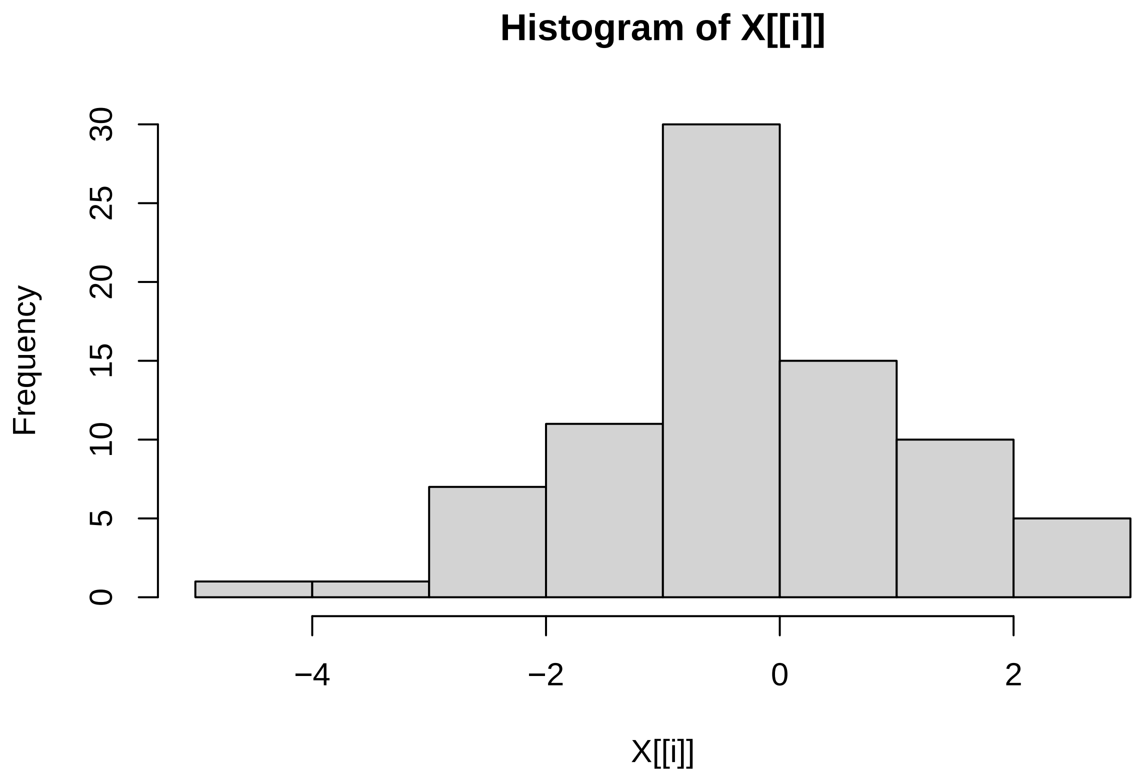
Histogram of X[[i]]
Frequency
0
5
10
15
20
−4
−2
0
2
4
6
X[[i]]

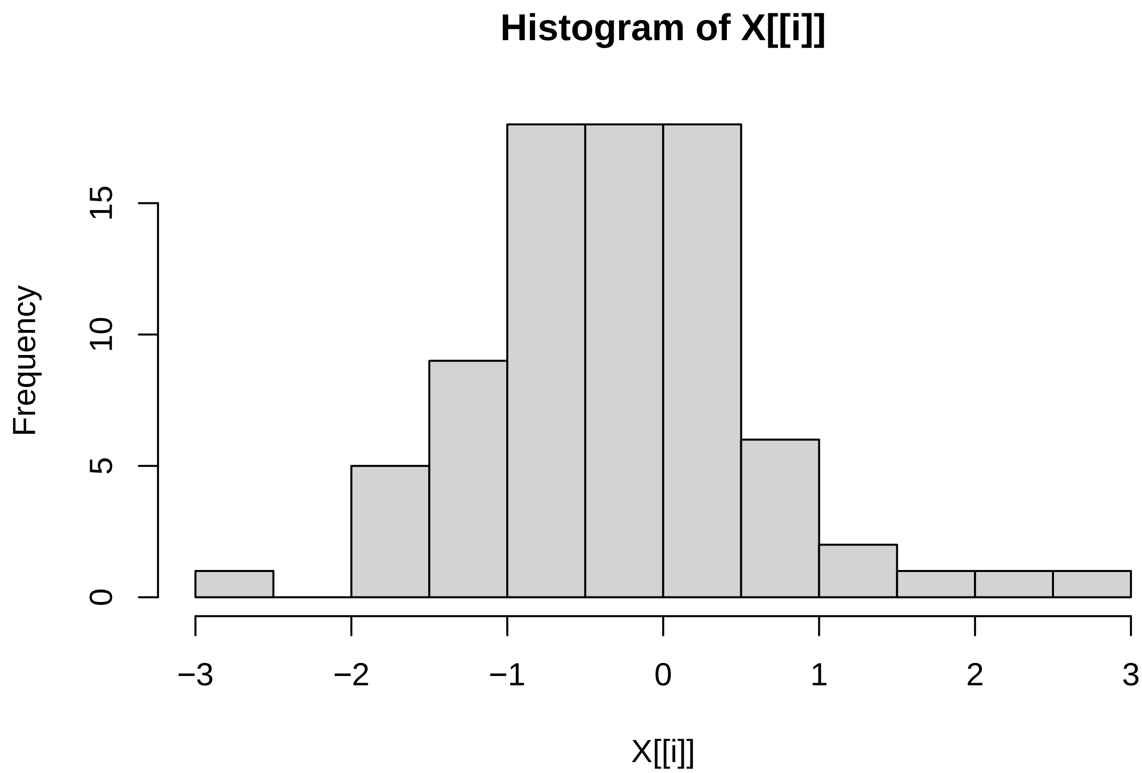

Histogram of X[[i]]
Frequency
0
5
10
15
−4
−2
0
2
X[[i]]

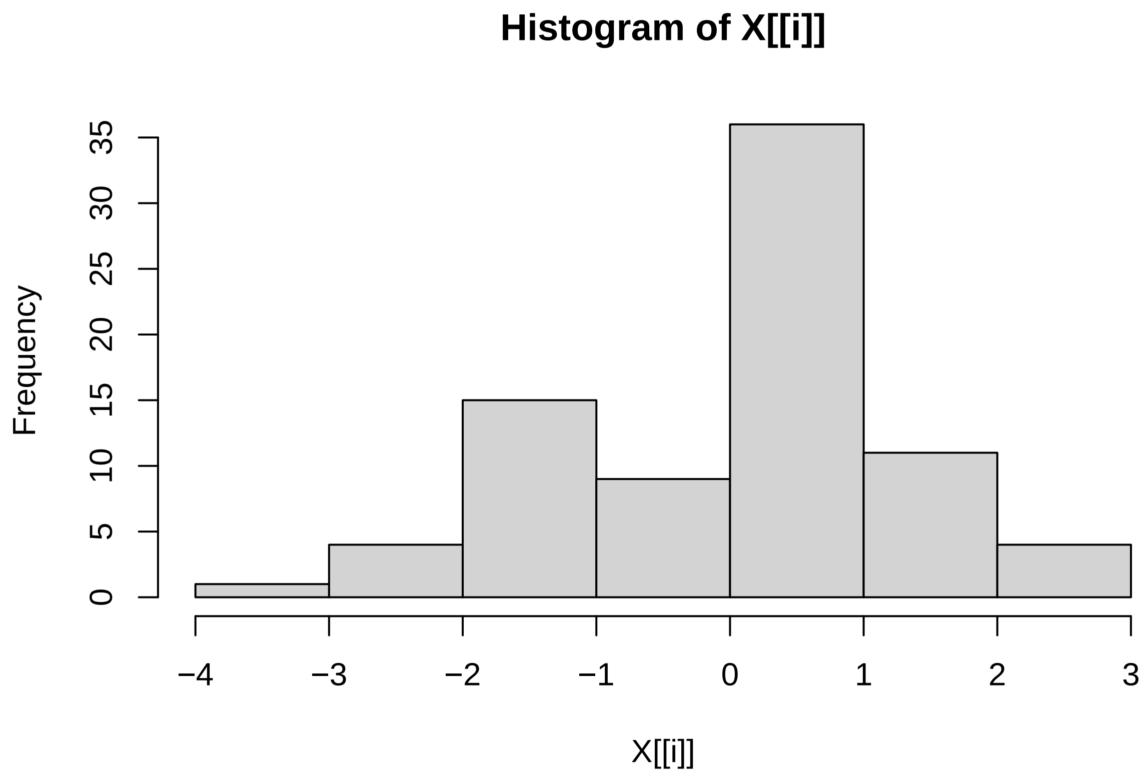

Histogram of X[[i]]
Frequency
0
5
10
15
20
25
−2
−1
0
1
2
3
4
X[[i]]

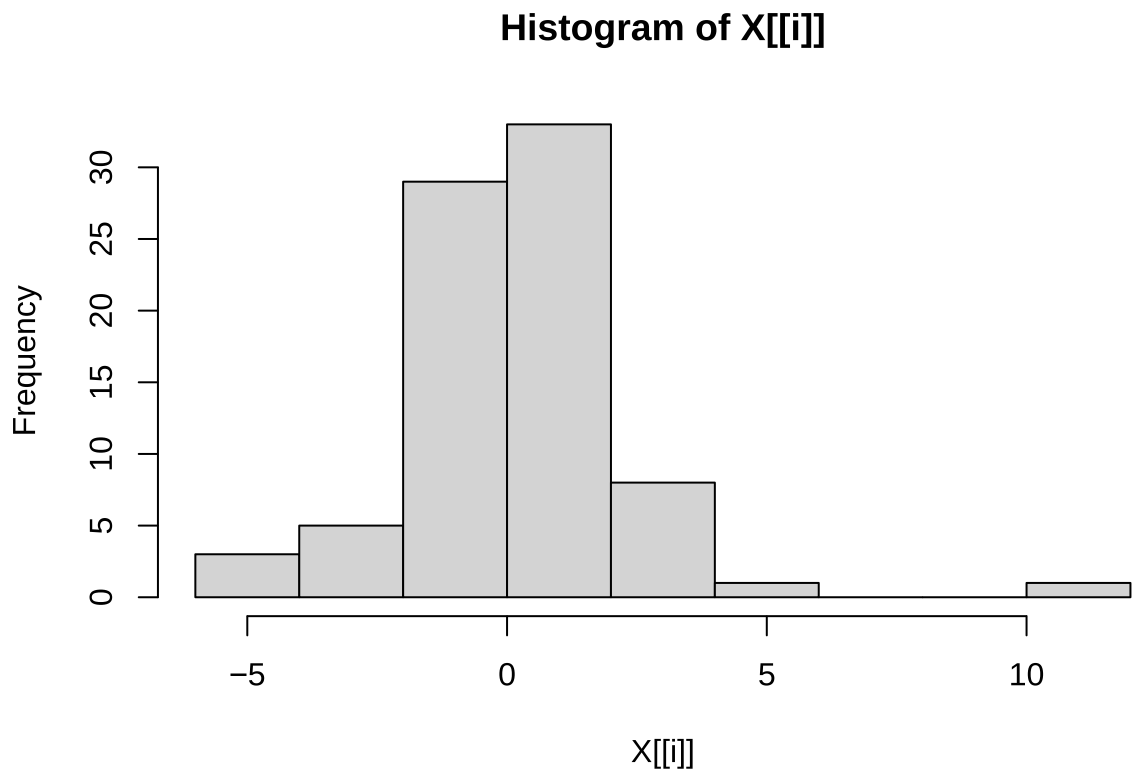

Histogram of X[[i]]
Frequency
0
5
10
15
−2
−1
0
1
2
3
X[[i]]

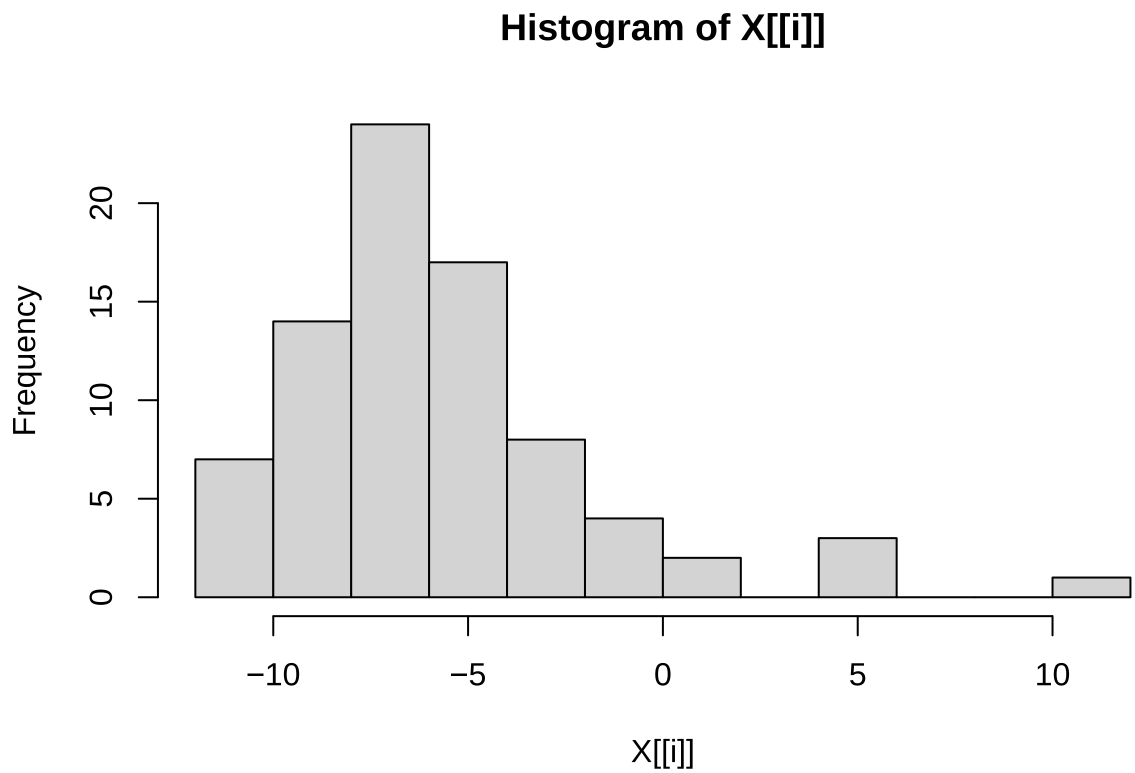

Histogram of X[[i]]
Frequency
0
5
10
15
20
−4
−2
0
2
4
X[[i]]

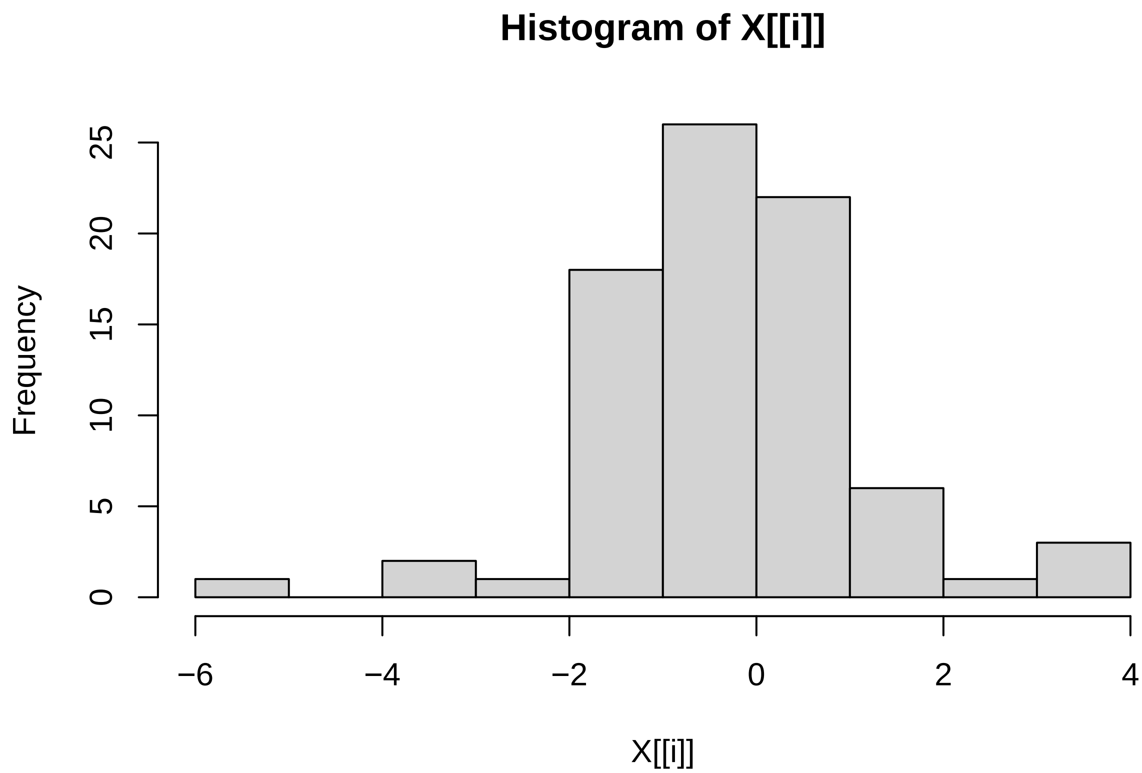

Histogram of X[[i]]
Frequency
0
5
10
15
20
25
30
−4
−2
0
2
X[[i]]

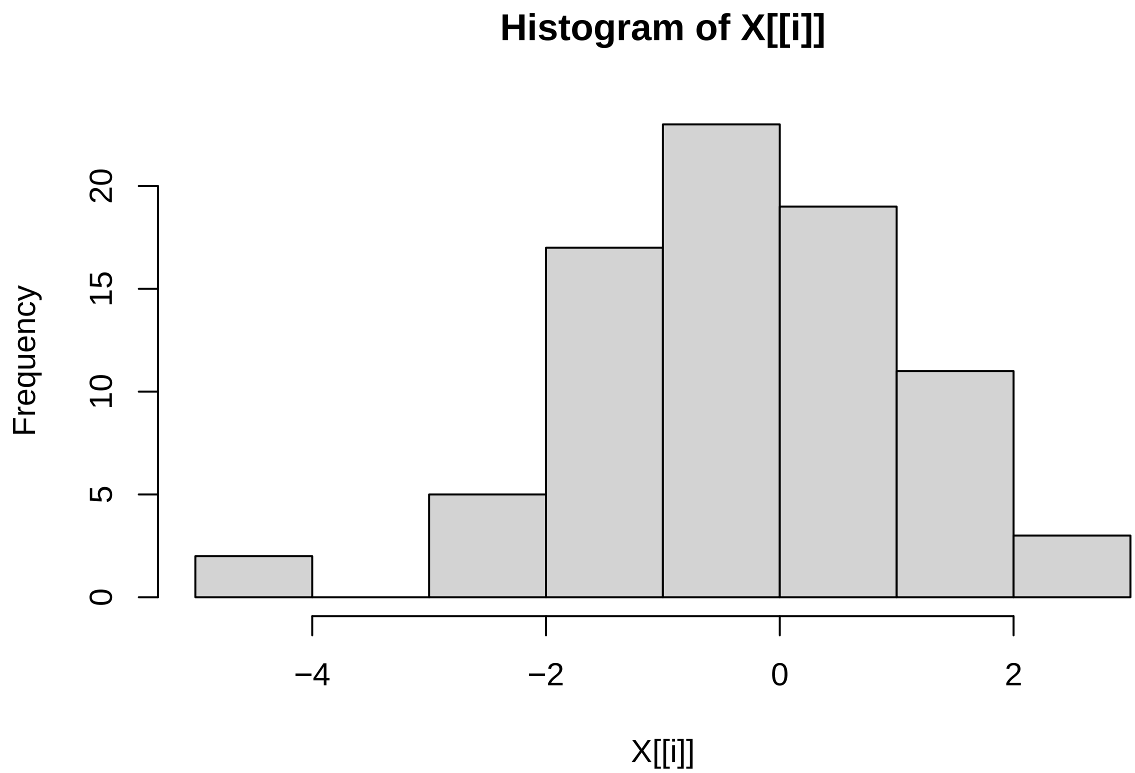

Histogram of X[[i]]
Frequency
0
5
10
15
−3
−2
−1
0
1
2
3
X[[i]]

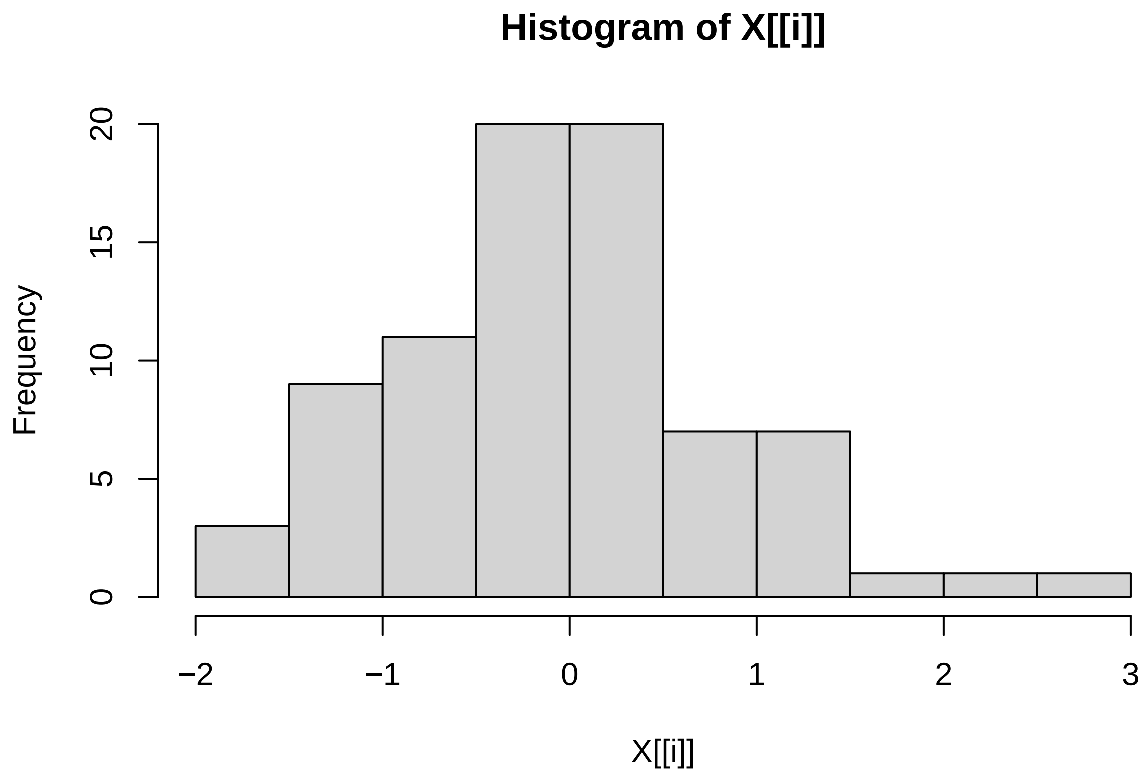

Histogram of X[[i]]
Frequency
0
5
10
15
20
25
30
35
−4
−3
−2
−1
0
1
2
3
X[[i]]

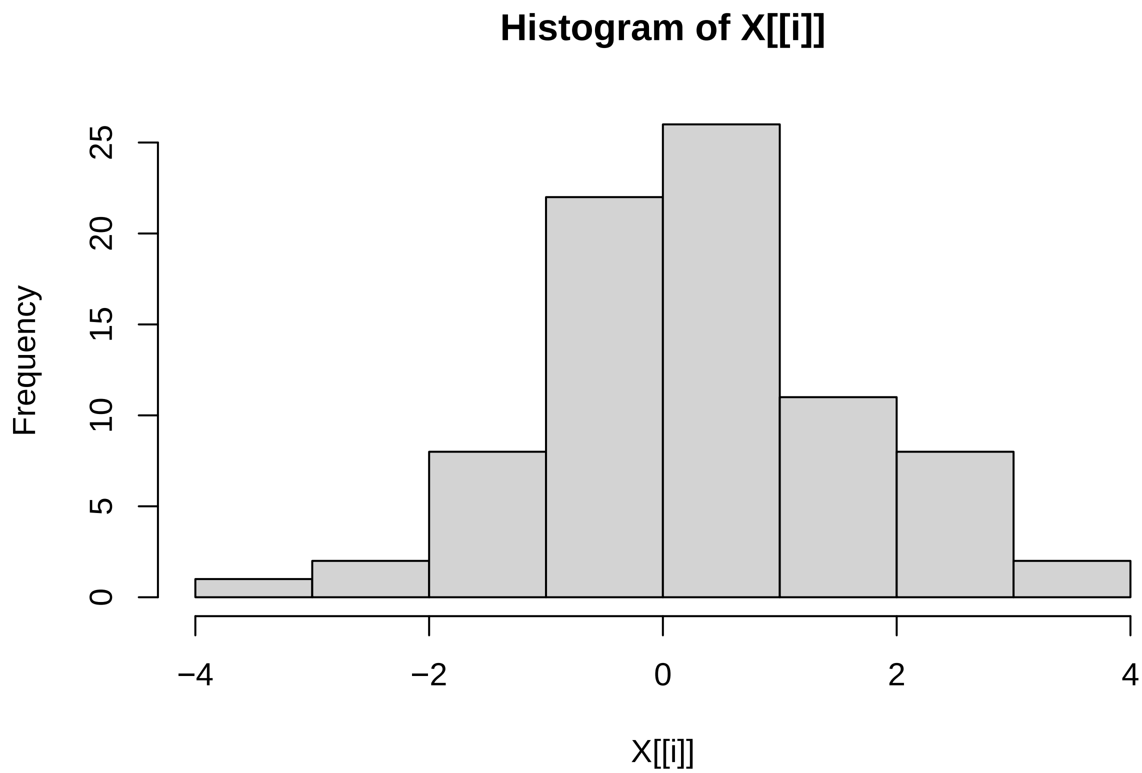

Histogram of X[[i]]
Frequency
0
5
10
15
20
25
30
−5
0
5
10
X[[i]]

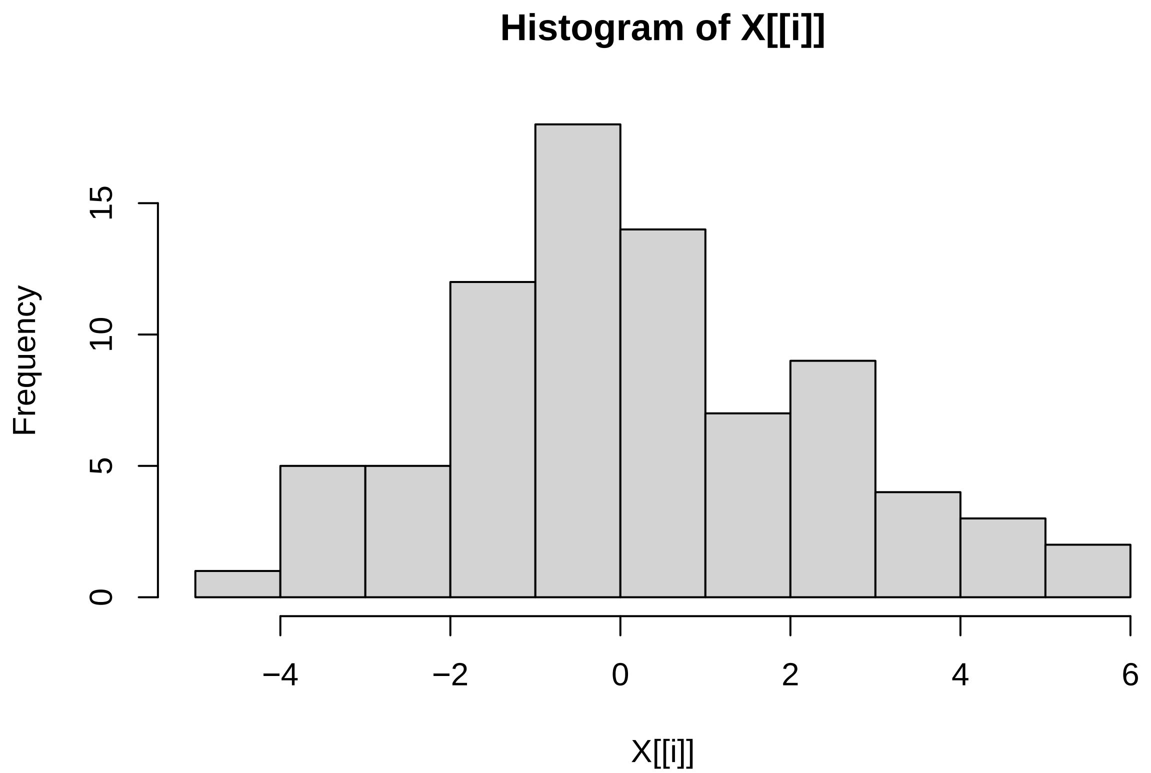

Histogram of X[[i]]
Frequency
0
5
10
15
20
−10
−5
0
5
10
X[[i]]


Histogram of X[[i]]
Frequency
0
5
10
15
20
25
−6
−4
−2
0
2
4
X[[i]]


Histogram of X[[i]]
Frequency
0
5
10
15
20
−4
−2
0
2
X[[i]]


Histogram of X[[i]]
Frequency
0
5
10
15
20
−2
−1
0
1
2
3
X[[i]]


Histogram of X[[i]]
Frequency
0
5
10
15
20
25
−4
−2
0
2
4
X[[i]]




```
## $NP_038479
## $breaks
## [1] -4 -3 -2 -1  0  1  2  3  4
##
## $counts
## [1]  2  6 22 22 16  7  4  1
##
## $density
## [1] 0.0250 0.0750 0.2750 0.2750 0.2000 0.0875 0.0500 0.0125
##
## $mids
## [1] -3.5 -2.5 -1.5 -0.5  0.5  1.5  2.5  3.5
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_001258898
## $breaks
## [1] -1.5 -1.0 -0.5  0.0  0.5  1.0  1.5  2.0
##
```

```
## $counts
## [1] 10 18 11 18 15  5  3
##
## $density
## [1] 0.250 0.450 0.275 0.450 0.375 0.125 0.075
##
## $mids
## [1] -1.25 -0.75 -0.25  0.25  0.75  1.25  1.75
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_542785
## $breaks
## [1] -10  -8  -6  -4  -2   0   2   4   6
##
## $counts
## [1]  2  1  9 10 17 24 12  5
##
## $density
## [1] 0.01250 0.00625 0.05625 0.06250 0.10625 0.15000 0.07500 0.03125
##
## $mids
## [1] -9 -7 -5 -3 -1  1  3  5
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_002005
## $breaks
##  [1] -5 -4 -3 -2 -1  0  1  2  3  4
##
## $counts
## [1]  2  3 13 16 21 11  9  3  2
##
## $density
## [1] 0.0250 0.0375 0.1625 0.2000 0.2625 0.1375 0.1125 0.0375 0.0250
##
## $mids
## [1] -4.5 -3.5 -2.5 -1.5 -0.5  0.5  1.5  2.5  3.5
##
## $xname
```

```
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $XP_003846537
## $breaks
##  [1] -2.5 -2.0 -1.5 -1.0 -0.5  0.0  0.5  1.0  1.5  2.0  2.5
##
## $counts
##  [1]  1  0  5 13 28 14  9  3  4  3
##
## $density
##  [1] 0.025 0.000 0.125 0.325 0.700 0.350 0.225 0.075 0.100 0.075
##
## $mids
##  [1] -2.25 -1.75 -1.25 -0.75 -0.25  0.25  0.75  1.25  1.75  2.25
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_660208
## $breaks
## [1] -1.5 -1.0 -0.5  0.0  0.5  1.0  1.5  2.0
##
## $counts
## [1]  6 14 20 19 14  5  2
##
## $density
## [1] 0.150 0.350 0.500 0.475 0.350 0.125 0.050
##
## $mids
## [1] -1.25 -0.75 -0.25  0.25  0.75  1.25  1.75
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_004439
## $breaks
```

```
## [1] -6 -4 -2  0  2  4  6  8 10
##
## $counts
## [1] 17 32 15  5  5  4  0  2
##
## $density
## [1] 0.10625 0.20000 0.09375 0.03125 0.03125 0.02500 0.00000 0.01250
##
## $mids
## [1] -5 -3 -1  1  3  5  7  9
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_004388
## $breaks
## [1] -1.5 -1.0 -0.5  0.0  0.5  1.0  1.5  2.0  2.5
##
## $counts
## [1]  6 13 26 16 11  5  2  1
##
## $density
## [1] 0.150 0.325 0.650 0.400 0.275 0.125 0.050 0.025
##
## $mids
## [1] -1.25 -0.75 -0.25  0.25  0.75  1.25  1.75  2.25
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_001229372
## $breaks
##  [1] -8 -6 -4 -2  0  2  4  6  8 10
##
## $counts
## [1]  3 13 31 17  8  4  1  1  2
##
## $density
## [1] 0.01875 0.08125 0.19375 0.10625 0.05000 0.02500 0.00625 0.00625 0.01250
##
## $mids
## [1] -7 -5 -3 -1  1  3  5  7  9
```

```
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_005130
## $breaks
##  [1] -10  -8  -6  -4  -2   0   2   4   6   8
##
## $counts
## [1]  1  2 15 18 23  9  7  4  1
##
## $density
## [1] 0.00625 0.01250 0.09375 0.11250 0.14375 0.05625 0.04375 0.02500 0.00625
##
## $mids
## [1] -9 -7 -5 -3 -1  1  3  5  7
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_004243
## $breaks
##  [1] -5 -4 -3 -2 -1  0  1  2  3  4  5  6
##
## $counts
##  [1]  1 10 17 15 16  5  6  4  2  3  1
##
## $density
##  [1] 0.0125 0.1250 0.2125 0.1875 0.2000 0.0625 0.0750 0.0500 0.0250 0.0375
## [11] 0.0125
##
## $mids
##  [1] -4.5 -3.5 -2.5 -1.5 -0.5  0.5  1.5  2.5  3.5  4.5  5.5
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
```

```
##
## $NP_003144
## $breaks
##  [1] -2.0 -1.5 -1.0 -0.5  0.0  0.5  1.0  1.5  2.0  2.5  3.0
##
## $counts
##  [1]  1  4 12 14 19 18  8  3  0  1
##
## $density
##  [1] 0.025 0.100 0.300 0.350 0.475 0.450 0.200 0.075 0.000 0.025
##
## $mids
##  [1] -1.75 -1.25 -0.75 -0.25  0.25  0.75  1.25  1.75  2.25  2.75
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_001171551
## $breaks
##  [1] -2.0 -1.5 -1.0 -0.5  0.0  0.5  1.0  1.5  2.0  2.5  3.0
##
## $counts
##  [1]  1  5 10 14 21 17  7  4  0  1
##
## $density
##  [1] 0.025 0.125 0.250 0.350 0.525 0.425 0.175 0.100 0.000 0.025
##
## $mids
##  [1] -1.75 -1.25 -0.75 -0.25  0.25  0.75  1.25  1.75  2.25  2.75
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_072096
## $breaks
##  [1] -3.0 -2.5 -2.0 -1.5 -1.0 -0.5  0.0  0.5  1.0  1.5
##
## $counts
## [1]  1  0  1  3 18 20 19 15  3
##
## $density
## [1] 0.025 0.000 0.025 0.075 0.450 0.500 0.475 0.375 0.075
```

```
##
## $mids
## [1] -2.75 -2.25 -1.75 -1.25 -0.75 -0.25  0.25  0.75  1.25
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_005484
## $breaks
## [1] -2.0 -1.5 -1.0 -0.5  0.0  0.5  1.0  1.5  2.0
##
## $counts
## [1]  1  3 19 22 18 10  6  1
##
## $density
## [1] 0.025 0.075 0.475 0.550 0.450 0.250 0.150 0.025
##
## $mids
## [1] -1.75 -1.25 -0.75 -0.25  0.25  0.75  1.25  1.75
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_061170
## $breaks
##  [1] -5 -4 -3 -2 -1  0  1  2  3  4  5  6
##
## $counts
##  [1]  1  7 12 21 17  8  2  4  6  1  1
##
## $density
##  [1] 0.0125 0.0875 0.1500 0.2625 0.2125 0.1000 0.0250 0.0500 0.0750 0.0125
## [11] 0.0125
##
## $mids
##  [1] -4.5 -3.5 -2.5 -1.5 -0.5  0.5  1.5  2.5  3.5  4.5  5.5
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
```

```
##
## attr(,"class")
## [1] "histogram"
##
## $NP_653304
## $breaks
## [1] -5 -4 -3 -2 -1  0  1  2  3
##
## $counts
## [1]  1  0 19 14 18 15 10  3
##
## $density
## [1] 0.0125 0.0000 0.2375 0.1750 0.2250 0.1875 0.1250 0.0375
##
## $mids
## [1] -4.5 -3.5 -2.5 -1.5 -0.5  0.5  1.5  2.5
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_653081
## $breaks
##  [1] -2.0 -1.5 -1.0 -0.5  0.0  0.5  1.0  1.5  2.0  2.5  3.0  3.5  4.0
##
## $counts
##  [1]  3  6 11 25 18 10  2  3  1  0  0  1
##
## $density
##  [1] 0.075 0.150 0.275 0.625 0.450 0.250 0.050 0.075 0.025 0.000 0.000 0.025
##
## $mids
##  [1] -1.75 -1.25 -0.75 -0.25  0.25  0.75  1.25  1.75  2.25  2.75  3.25  3.75
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_057164
## $breaks
##  [1] -2.0 -1.5 -1.0 -0.5  0.0  0.5  1.0  1.5  2.0  2.5  3.0  3.5
##
## $counts
##  [1]  4  8 16 14  7  7 14  8  0  1  1
```

```
##
## $density
##  [1] 0.100 0.200 0.400 0.350 0.175 0.175 0.350 0.200 0.000 0.025 0.025
##
## $mids
##  [1] -1.75 -1.25 -0.75 -0.25  0.25  0.75  1.25  1.75  2.25  2.75  3.25
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_004453
## $breaks
##  [1] -5 -4 -3 -2 -1  0  1  2  3  4  5
##
## $counts
##  [1]  2  3  8 15 21 16  4  6  4  1
##
## $density
##  [1] 0.0250 0.0375 0.1000 0.1875 0.2625 0.2000 0.0500 0.0750 0.0500 0.0125
##
## $mids
##  [1] -4.5 -3.5 -2.5 -1.5 -0.5  0.5  1.5  2.5  3.5  4.5
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_003212
## $breaks
## [1] -5 -4 -3 -2 -1  0  1  2  3
##
## $counts
## [1]  1  1  7 11 30 15 10  5
##
## $density
## [1] 0.0125 0.0125 0.0875 0.1375 0.3750 0.1875 0.1250 0.0625
##
## $mids
## [1] -4.5 -3.5 -2.5 -1.5 -0.5  0.5  1.5  2.5
##
## $xname
## [1] "X[[i]]"
##
```

```
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_060866
## $breaks
##  [1] -3.0 -2.5 -2.0 -1.5 -1.0 -0.5  0.0  0.5  1.0  1.5  2.0  2.5  3.0
##
## $counts
##  [1]  1  0  5  9 18 18 18  6  2  1  1  1
##
## $density
##  [1] 0.025 0.000 0.125 0.225 0.450 0.450 0.450 0.150 0.050 0.025 0.025 0.025
##
## $mids
##  [1] -2.75 -2.25 -1.75 -1.25 -0.75 -0.25  0.25  0.75  1.25  1.75  2.25  2.75
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_001160163
## $breaks
## [1] -4 -3 -2 -1  0  1  2  3
##
## $counts
## [1]  1  4 15  9 36 11  4
##
## $density
## [1] 0.0125 0.0500 0.1875 0.1125 0.4500 0.1375 0.0500
##
## $mids
## [1] -3.5 -2.5 -1.5 -0.5  0.5  1.5  2.5
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_003875
## $breaks
##  [1] -6 -4 -2  0  2  4  6  8 10 12
##
```

```
## $counts
## [1]  3  5 29 33  8  1  0  0  1
##
## $density
## [1] 0.01875 0.03125 0.18125 0.20625 0.05000 0.00625 0.00000 0.00000 0.00625
##
## $mids
## [1] -5 -3 -1  1  3  5  7  9 11
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_002677
## $breaks
##  [1] -12 -10  -8  -6  -4  -2   0   2   4   6   8  10  12
##
## $counts
##  [1]  7 14 24 17  8  4  2  0  3  0  0  1
##
## $density
##  [1] 0.04375 0.08750 0.15000 0.10625 0.05000 0.02500 0.01250 0.00000 0.01875
## [10] 0.00000 0.00000 0.00625
##
## $mids
##  [1] -11  -9  -7  -5  -3  -1   1   3   5   7   9  11
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_001135891
## $breaks
##  [1] -6 -5 -4 -3 -2 -1  0  1  2  3  4
##
## $counts
##  [1]  1  0  2  1 18 26 22  6  1  3
##
## $density
##  [1] 0.0125 0.0000 0.0250 0.0125 0.2250 0.3250 0.2750 0.0750 0.0125 0.0375
##
## $mids
##  [1] -5.5 -4.5 -3.5 -2.5 -1.5 -0.5  0.5  1.5  2.5  3.5
##
```

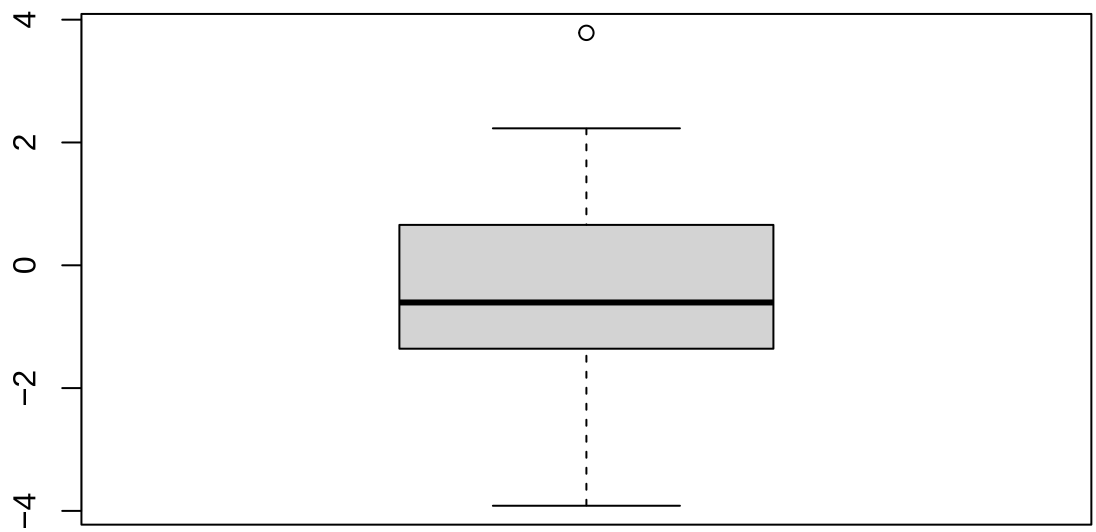
```
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_004522
## $breaks
## [1] -5 -4 -3 -2 -1  0  1  2  3
##
## $counts
## [1]  2  0  5 17 23 19 11  3
##
## $density
## [1] 0.0250 0.0000 0.0625 0.2125 0.2875 0.2375 0.1375 0.0375
##
## $mids
## [1] -4.5 -3.5 -2.5 -1.5 -0.5  0.5  1.5  2.5
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_003767
## $breaks
##  [1] -2.0 -1.5 -1.0 -0.5  0.0  0.5  1.0  1.5  2.0  2.5  3.0
##
## $counts
##  [1]  3  9 11 20 20  7  7  1  1  1
##
## $density
##  [1] 0.075 0.225 0.275 0.500 0.500 0.175 0.175 0.025 0.025 0.025
##
## $mids
##  [1] -1.75 -1.25 -0.75 -0.25  0.25  0.75  1.25  1.75  2.25  2.75
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_848597
```

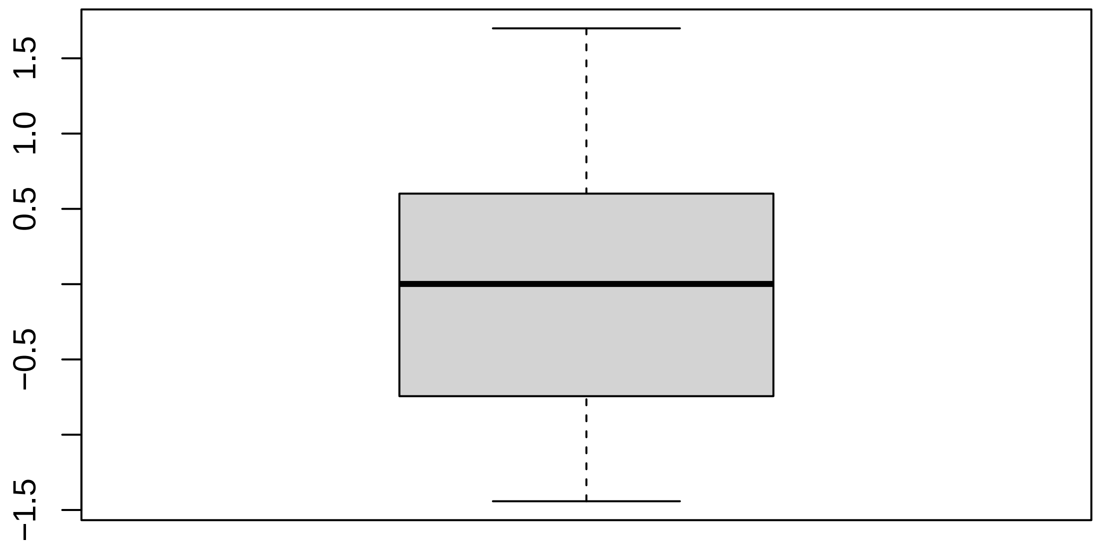
```
## $breaks
## [1] -4 -3 -2 -1  0  1  2  3  4
##
## $counts
## [1]  1  2  8 22 26 11  8  2
##
## $density
## [1] 0.0125 0.0250 0.1000 0.2750 0.3250 0.1375 0.1000 0.0250
##
## $mids
## [1] -3.5 -2.5 -1.5 -0.5  0.5  1.5  2.5  3.5
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
##
## $NP_005970
## $breaks
##  [1] -5 -4 -3 -2 -1  0  1  2  3  4  5  6
##
## $counts
##  [1]  1  5  5 12 18 14  7  9  4  3  2
##
## $density
##  [1] 0.0125 0.0625 0.0625 0.1500 0.2250 0.1750 0.0875 0.1125 0.0500 0.0375
## [11] 0.0250
##
## $mids
##  [1] -4.5 -3.5 -2.5 -1.5 -0.5  0.5  1.5  2.5  3.5  4.5  5.5
##
## $xname
## [1] "X[[i]]"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
```

Detection of outliers and data imputation

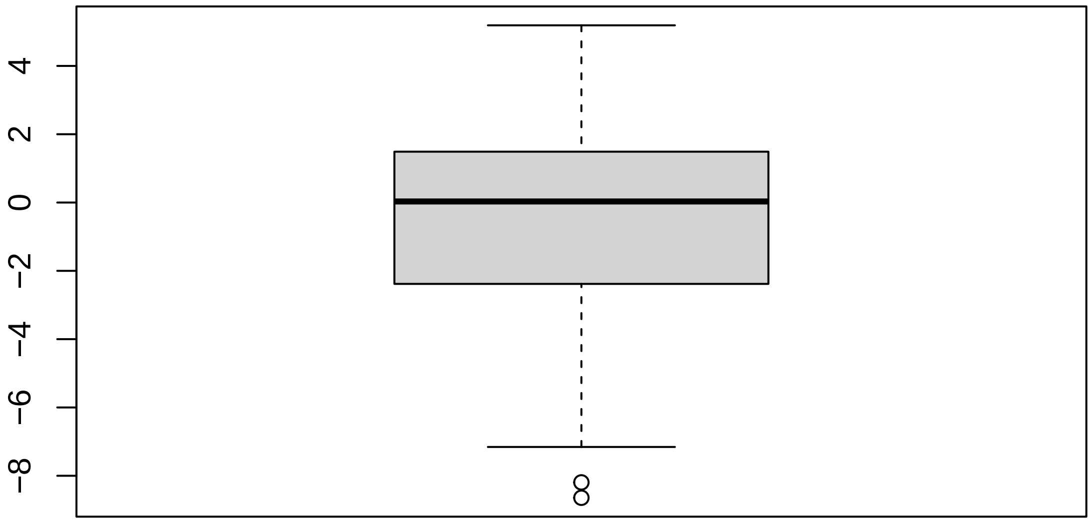
- On observing the box plot of 30 column, I got to know that it has a few outliers
- I have also created the function which can identify the presence of outliers in each varaible
- I removed these outliers and imputed them with median value

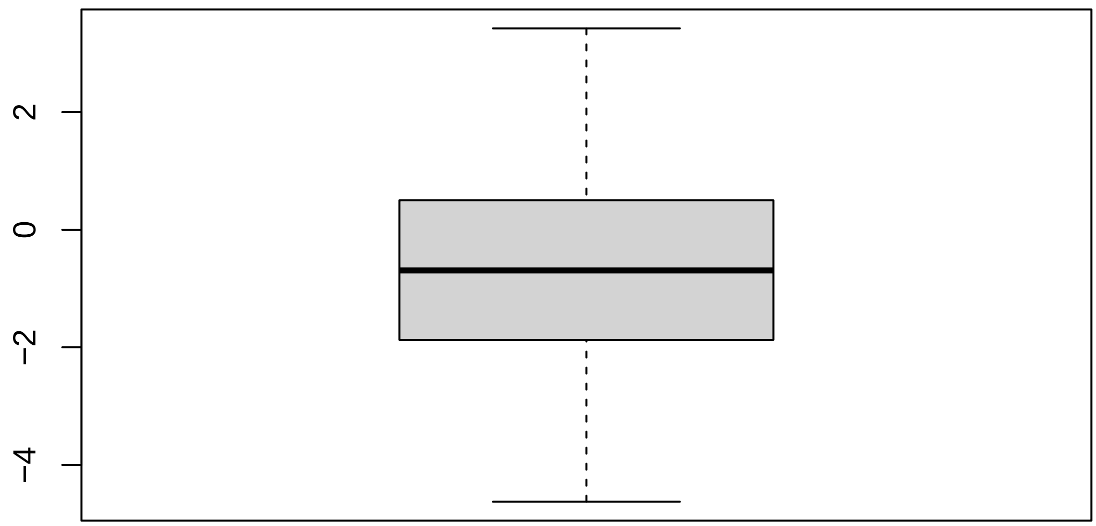
```
lapply(final_data[, 2:ncol(final_data)], boxplot)
```

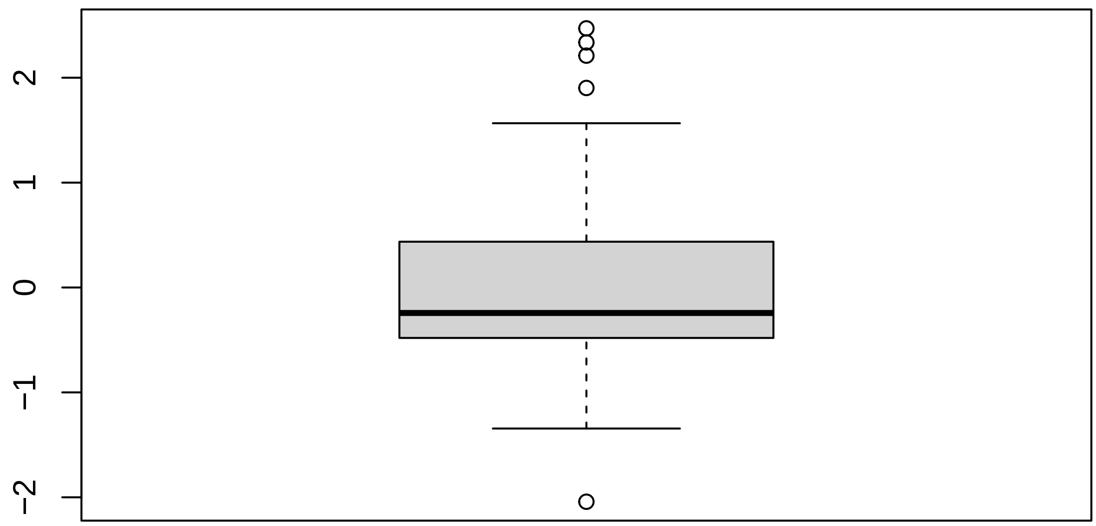

4
2
0
−2
−4

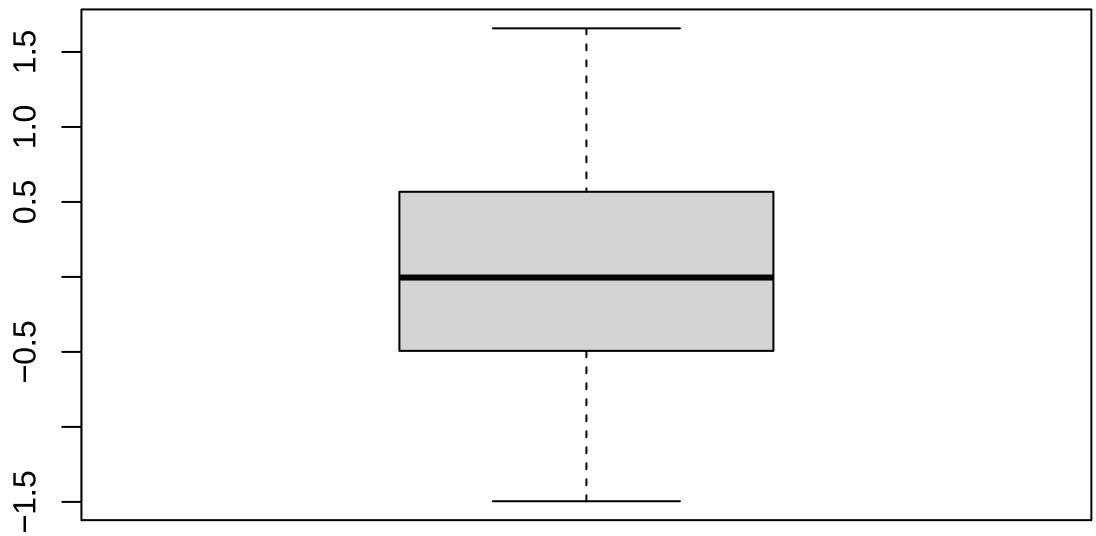


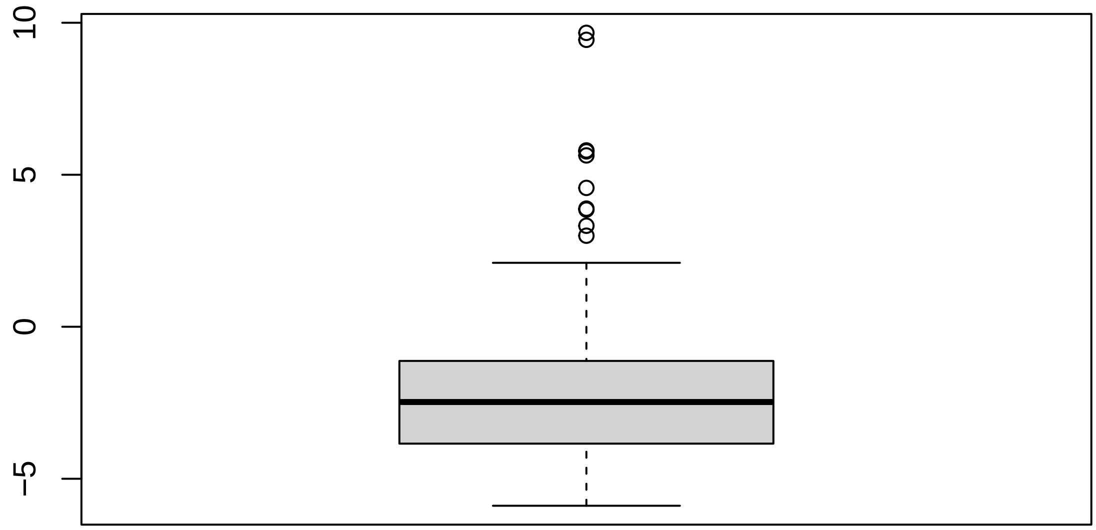
1.5
1.0
0.5
−0.5
−1.5


4
2
0
−2
−4
−6
−8

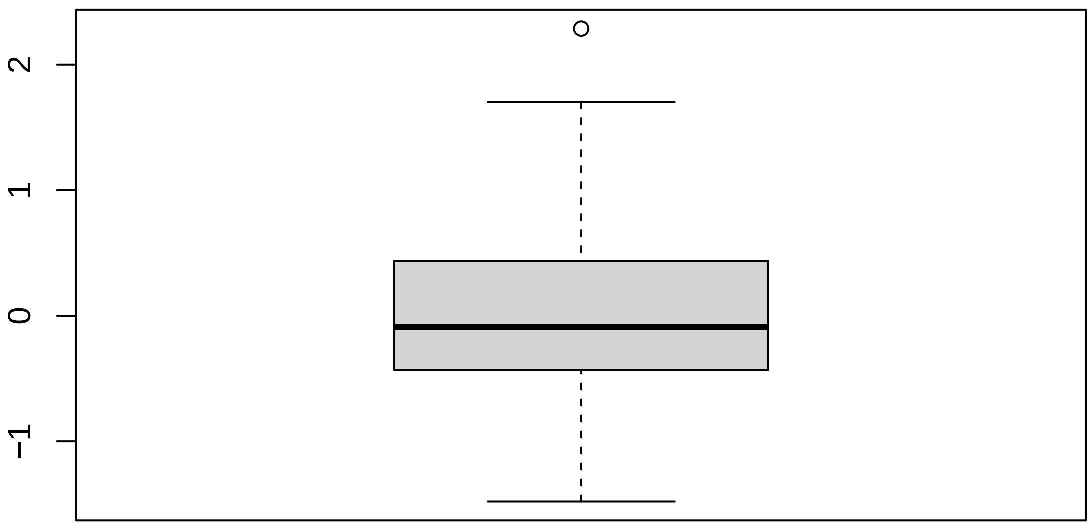

2
0
−2
−4


2
1
0
−1
−2

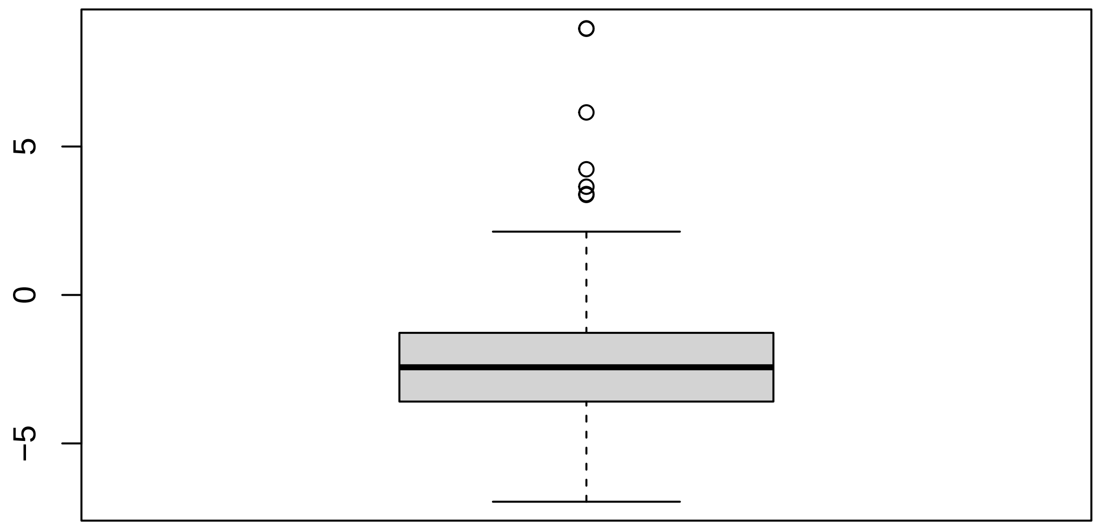

1.5
1.0
0.5
−0.5
−1.5

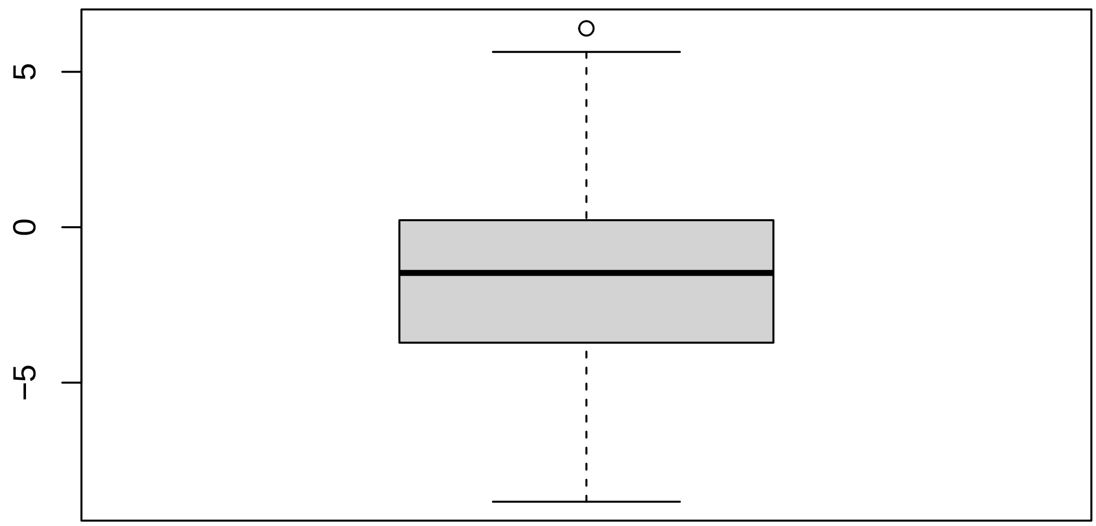


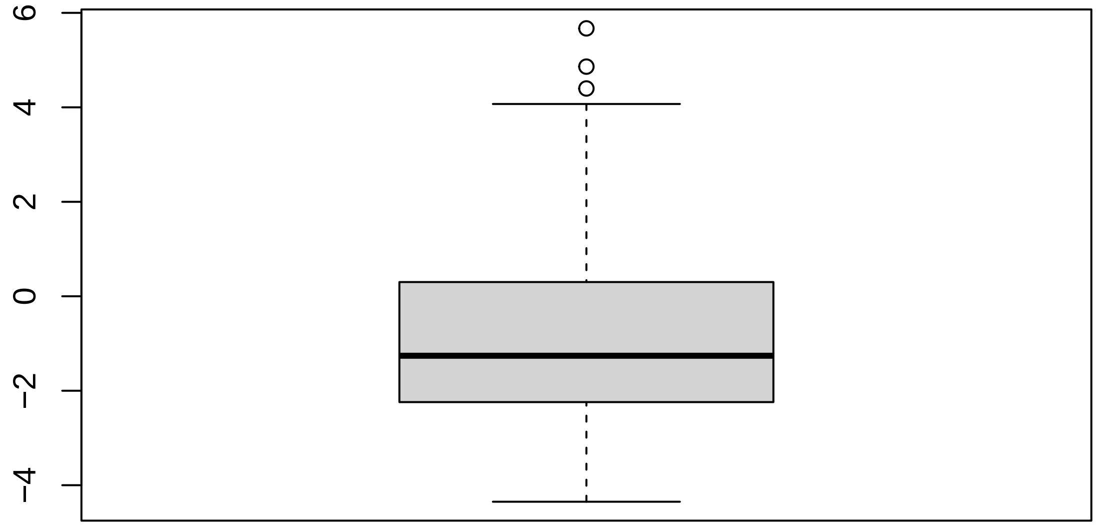
10
5
0
−5

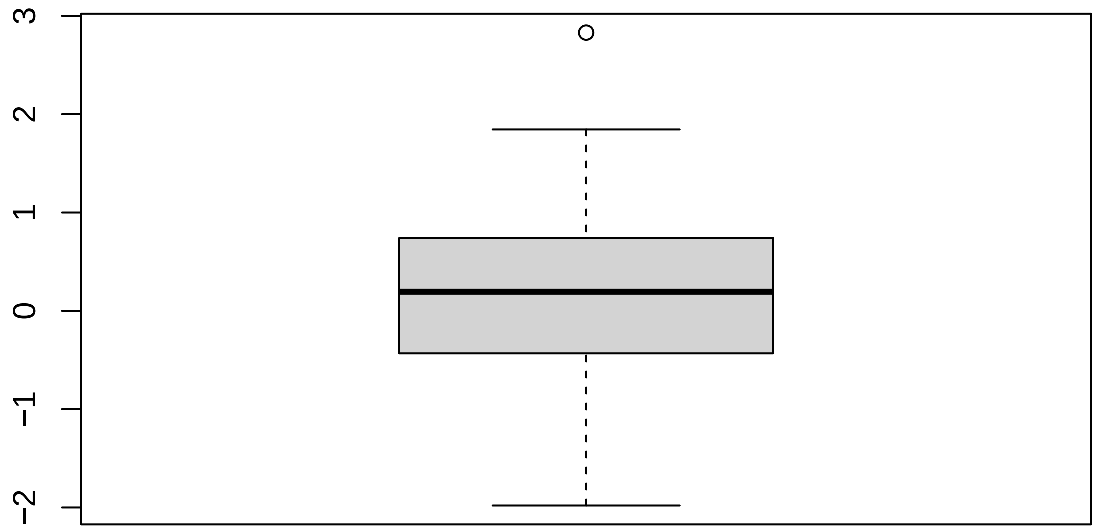


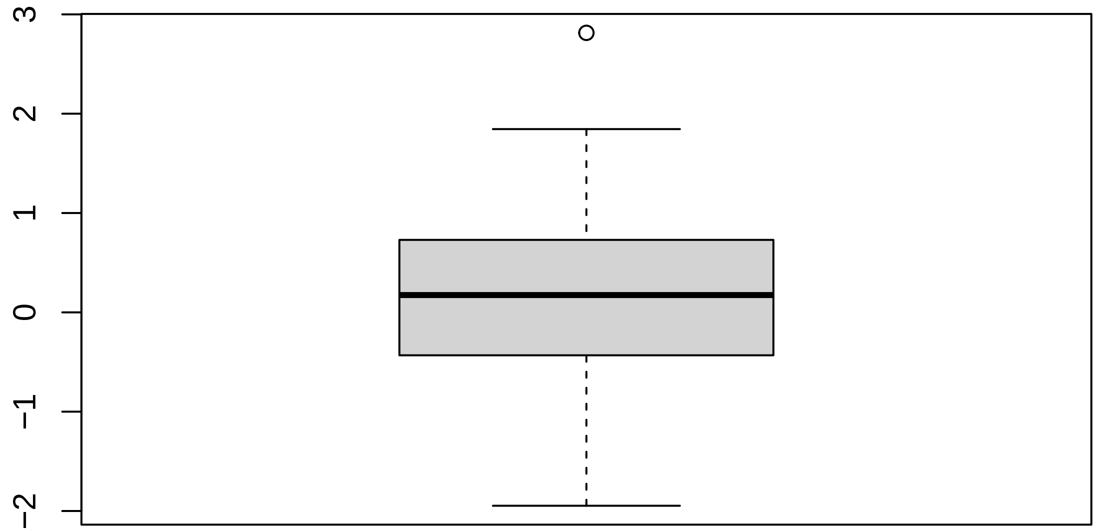
2
1
0
−1

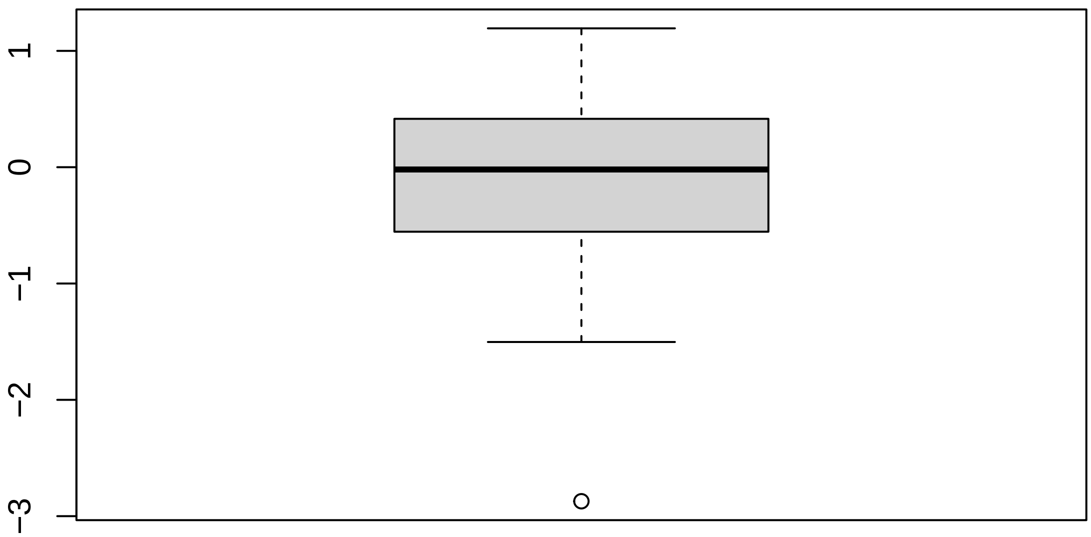

5
0
−5

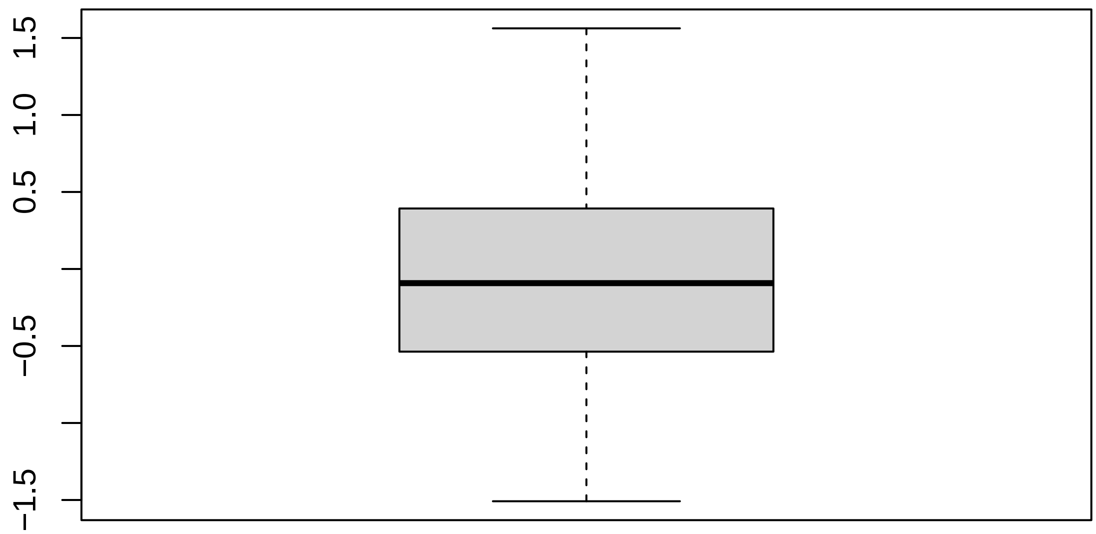

5
0
−5

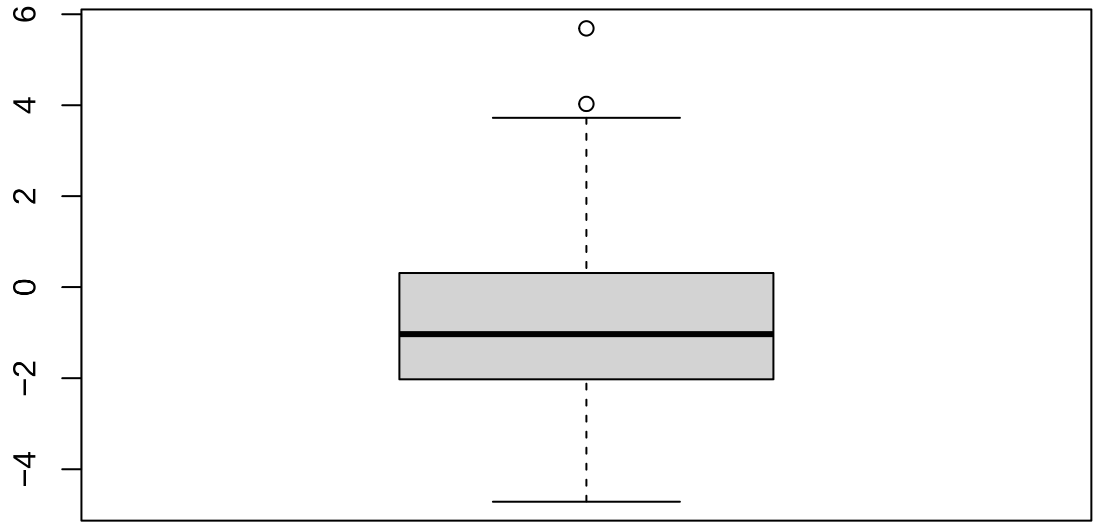

6
4
2
0
−2
−4


3
2
1
0
−1
−2

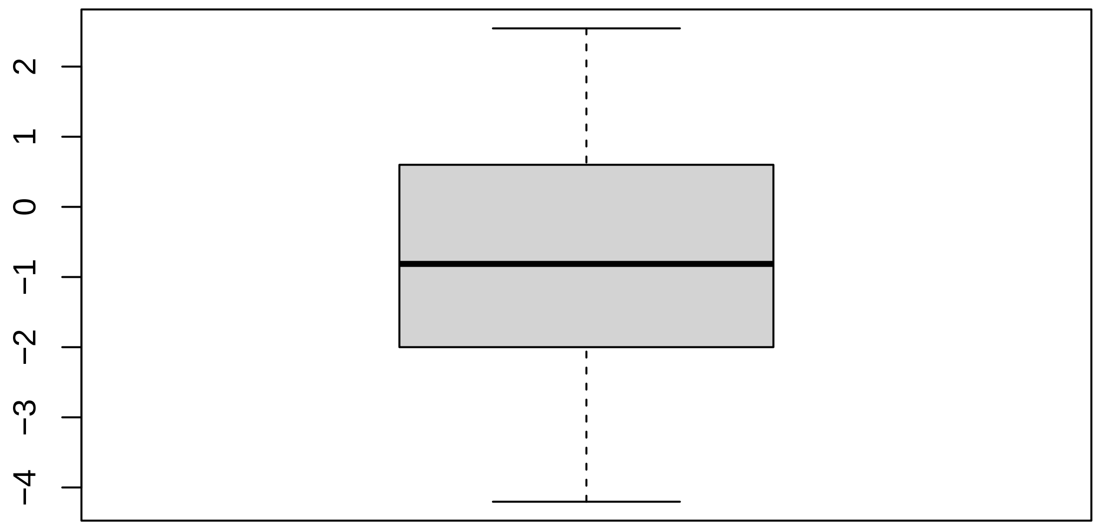

3
2
1
0
−1
−2

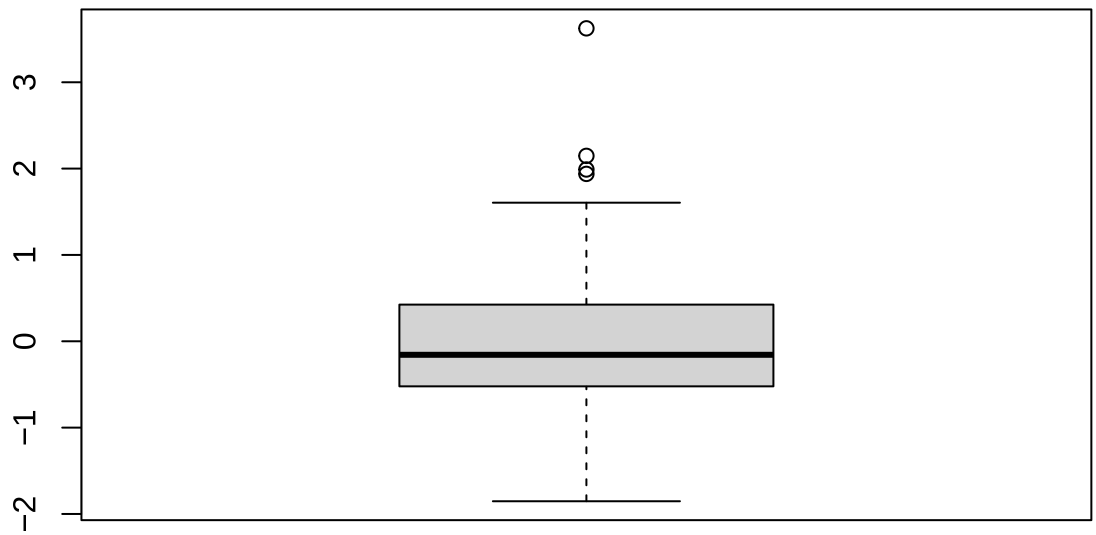

1
0
−1
−2
−3


1.5
1.0
0.5
−0.5
−1.5

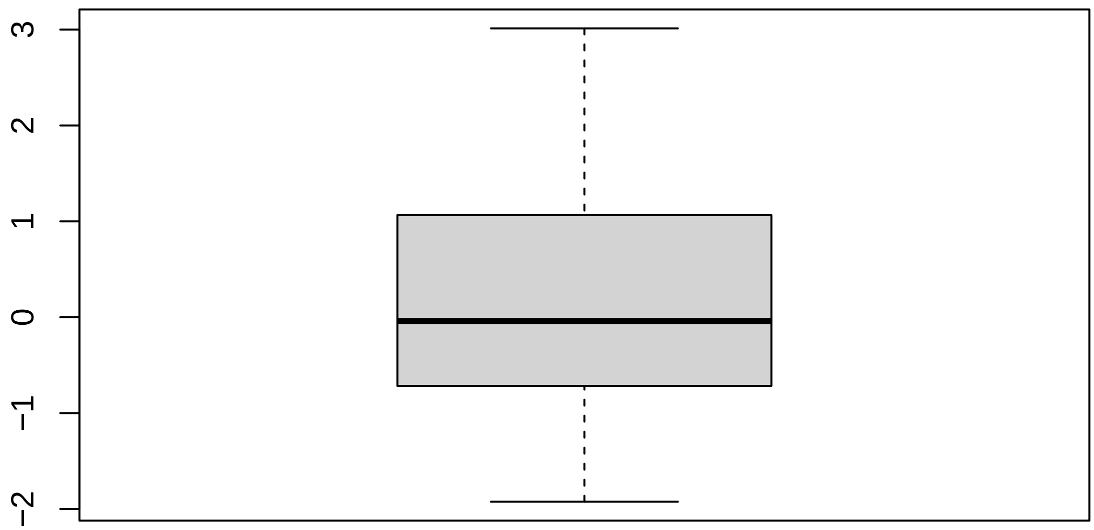


6
4
2
0
−2
−4

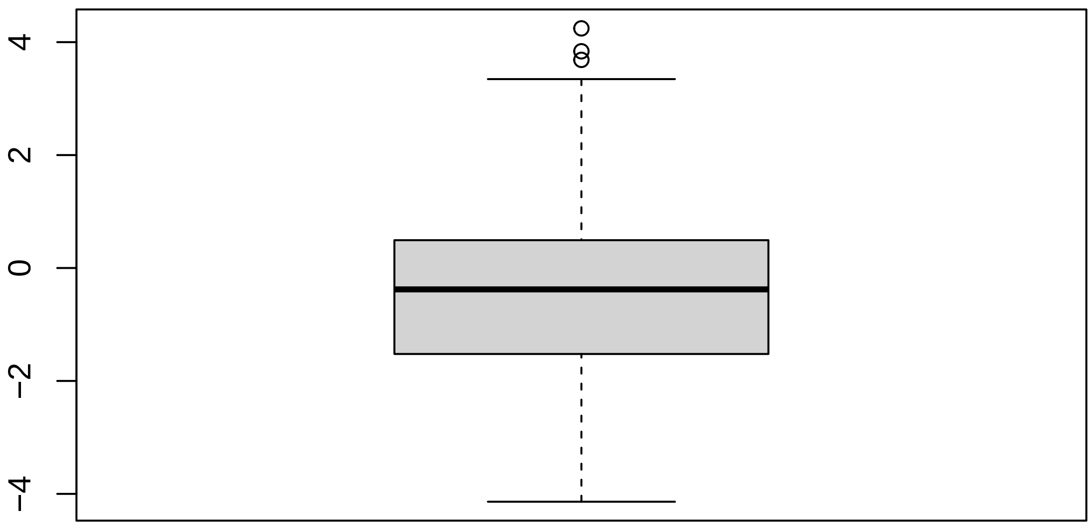

2
1
0
−1
−2
−3
−4

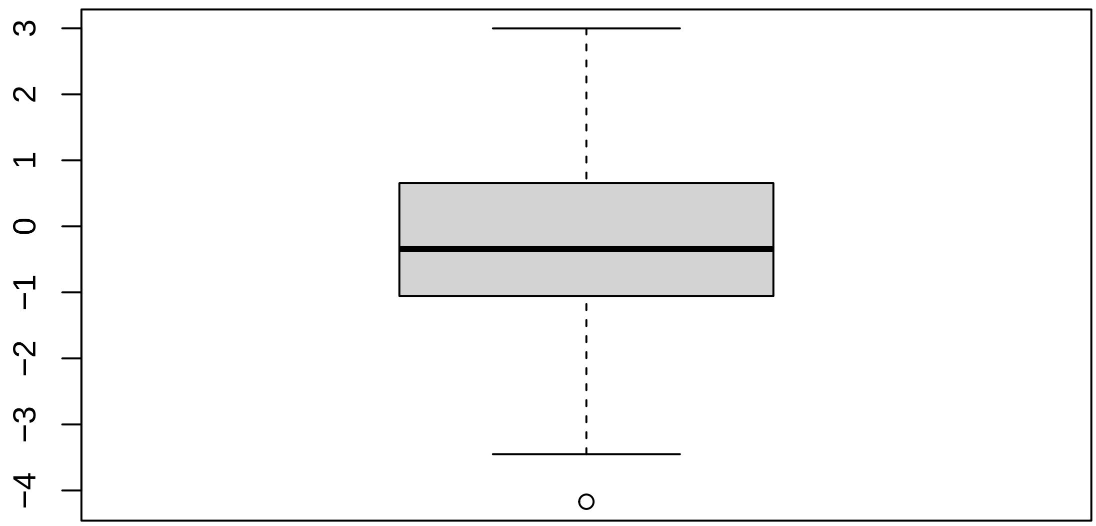


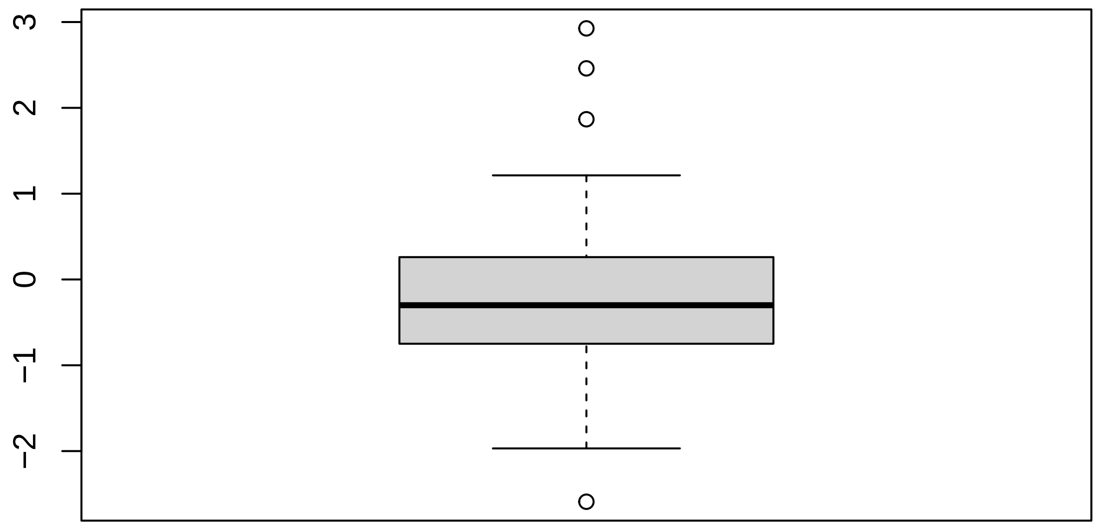
3
2
1
0
−1
−2

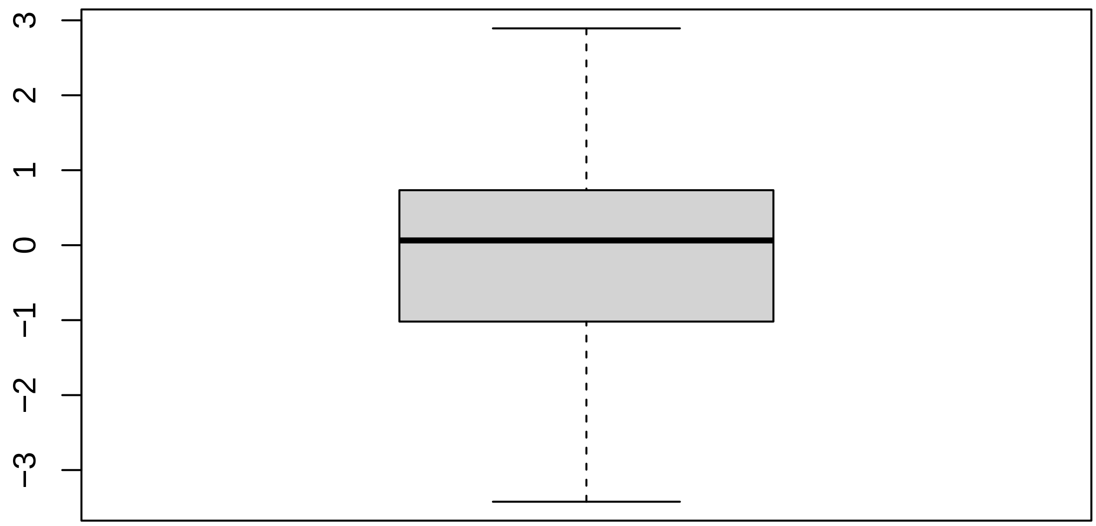


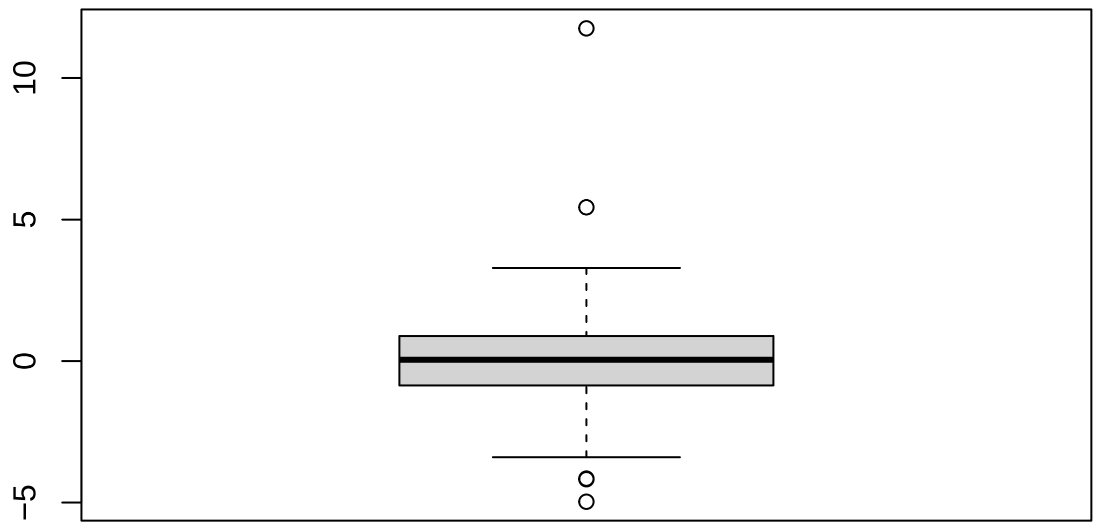
3
2
1
0
−1
−2

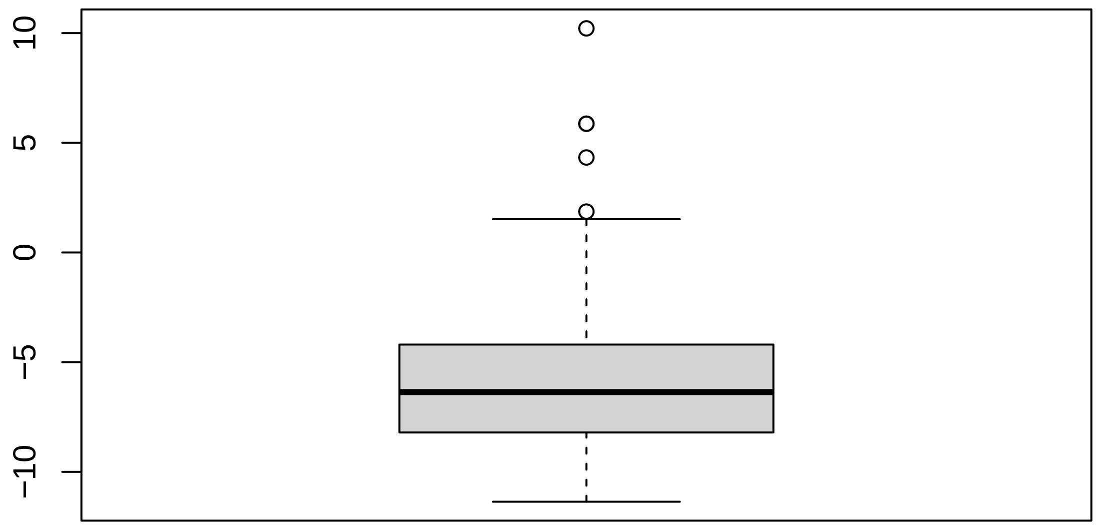

4
2
0
−2
−4

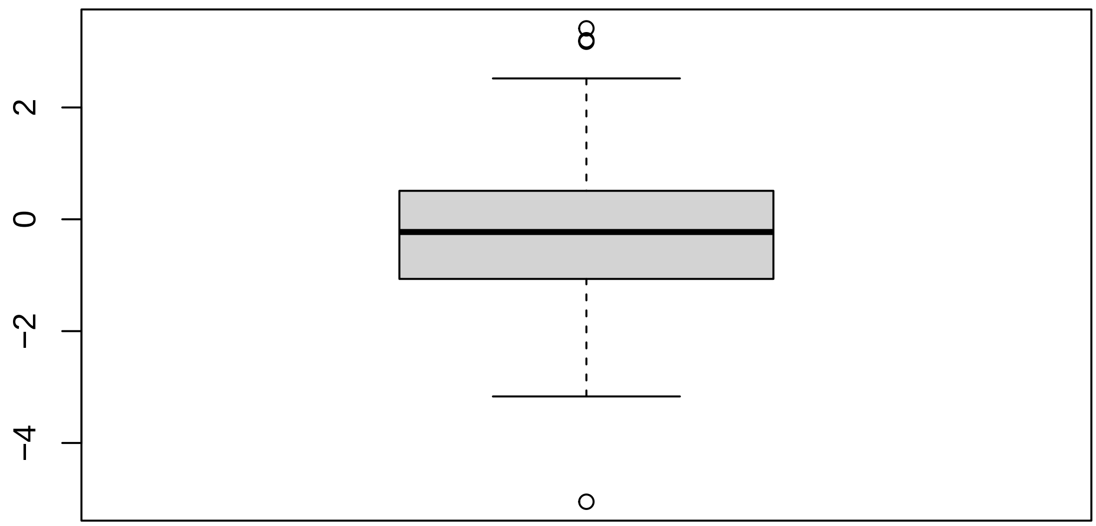

3
2
1
0
−1
−2
−3
−4

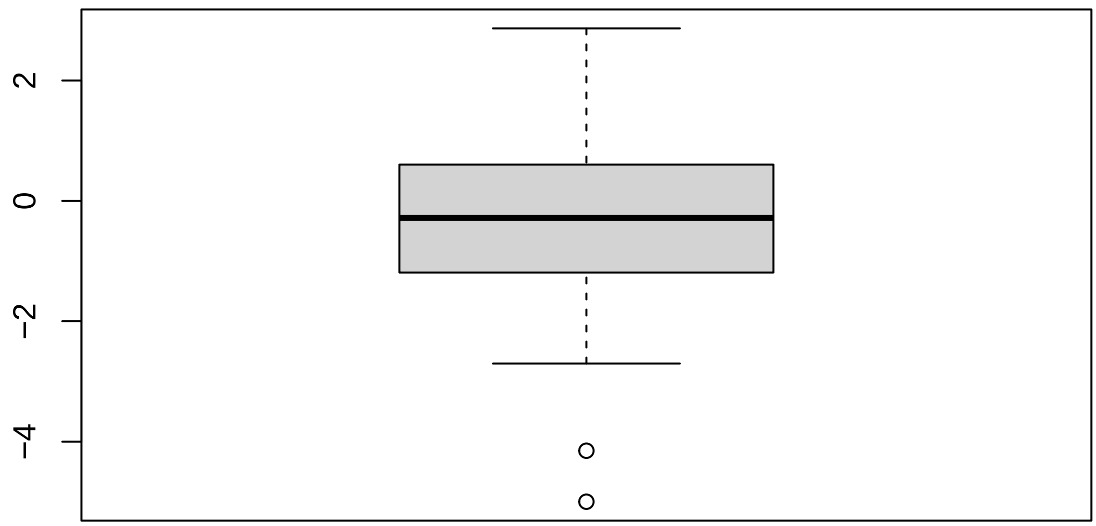

3
2
1
0
−1
−2

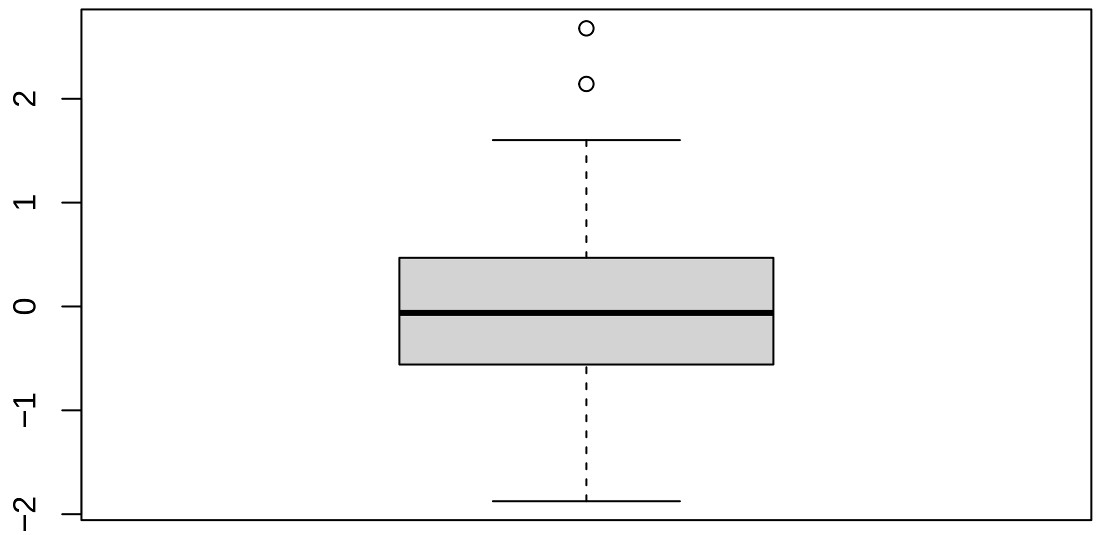

3
2
1
0
−1
−2
−3


10
5
0
−5

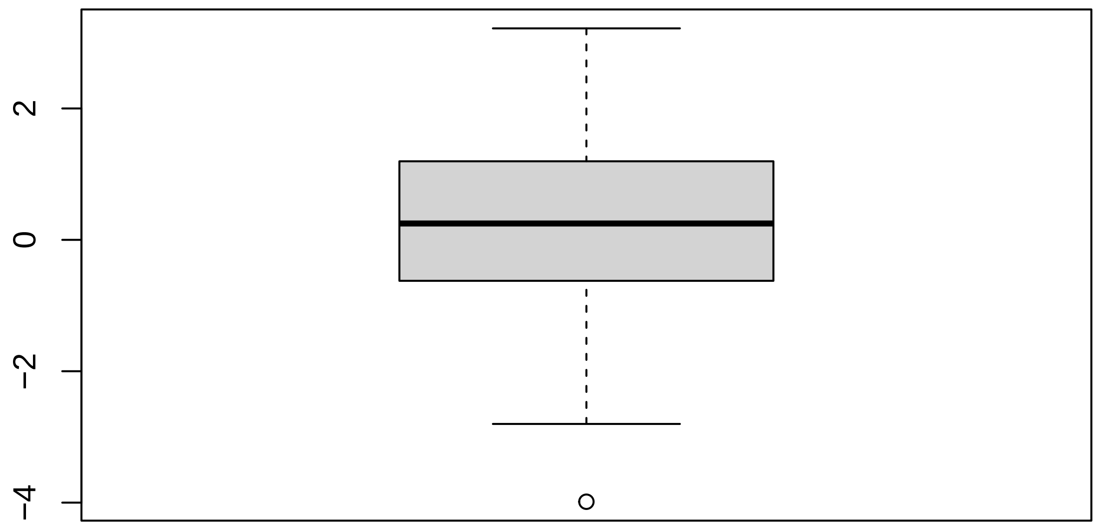

10
5
0
−5
−10

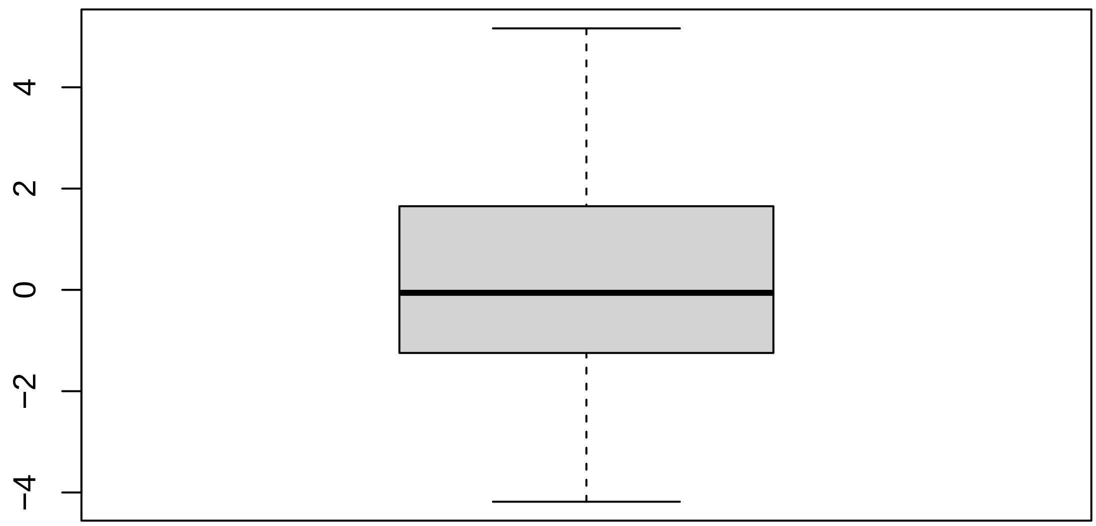

2
0
−2
−4


2
0
−2
−4



2
1
0
−1
−2


2
0
−2
−4




```
## $NP_038479
## $NP_038479$stats
##             [,1]
## [1,] -3.9159043
## [2,] -1.3588005
## [3,] -0.6057669
## [4,]  0.6575331
## [5,]  2.2302073
##
## $NP_038479$n
## [1] 80
##
## $NP_038479$conf
##             [,1]
## [1,] -0.9619510
## [2,] -0.2495829
##
## $NP_038479$out
## [1] 3.785229
##
## $NP_038479$group
## [1] 1
##
## $NP_038479$names
## [1] "1"
##
```

```
##
## $NP_001258898
## $NP_001258898$stats
##               [,1]
## [1,] -1.441904379
## [2,] -0.744144882
## [3,]  0.001291721
## [4,]  0.601259769
## [5,]  1.698927450
##
## $NP_001258898$n
## [1] 80
##
## $NP_001258898$conf
##             [,1]
## [1,] -0.2363732
## [2,]  0.2389566
##
## $NP_001258898$out
## numeric(0)
##
## $NP_001258898$group
## numeric(0)
##
## $NP_001258898$names
## [1] "1"
##
##
## $NP_542785
## $NP_542785$stats
##              [,1]
## [1,] -7.15625291
## [2,] -2.38215725
## [3,]  0.03094425
## [4,]  1.48903278
## [5,]  5.18818807
##
## $NP_542785$n
## [1] 80
##
## $NP_542785$conf
##             [,1]
## [1,] -0.6528990
## [2,]  0.7147875
##
## $NP_542785$out
## [1] -8.643742 -8.192980
##
## $NP_542785$group
## [1] 1 1
##
## $NP_542785$names
## [1] "1"
##
```

```
##
## $NP_002005
## $NP_002005$stats
##             [,1]
## [1,] -4.6253957
## [2,] -1.8720616
## [3,] -0.6925908
## [4,]  0.5003105
## [5,]  3.4240101
##
## $NP_002005$n
## [1] 80
##
## $NP_002005$conf
##             [,1]
## [1,] -1.1116688
## [2,] -0.2735127
##
## $NP_002005$out
## numeric(0)
##
## $NP_002005$group
## numeric(0)
##
## $NP_002005$names
## [1] "1"
##
##
## $XP_003846537
## $XP_003846537$stats
##             [,1]
## [1,] -1.3445653
## [2,] -0.4809037
## [3,] -0.2429975
## [4,]  0.4367871
## [5,]  1.5662875
##
## $XP_003846537$n
## [1] 80
##
## $XP_003846537$conf
##              [,1]
## [1,] -0.40510701
## [2,] -0.08088803
##
## $XP_003846537$out
## [1]  2.336572  1.902276  2.470569  2.210577 -2.042273
##
## $XP_003846537$group
## [1] 1 1 1 1 1
##
## $XP_003846537$names
## [1] "1"
##
```

```
##
## $NP_660208
## $NP_660208$stats
##              [,1]
## [1,] -1.495746821
## [2,] -0.493137518
## [3,] -0.004159959
## [4,]  0.567662746
## [5,]  1.657515110
##
## $NP_660208$n
## [1] 80
##
## $NP_660208$conf
##            [,1]
## [1,] -0.1915497
## [2,]  0.1832297
##
## $NP_660208$out
## numeric(0)
##
## $NP_660208$group
## numeric(0)
##
## $NP_660208$names
## [1] "1"
##
##
## $NP_004439
## $NP_004439$stats
##           [,1]
## [1,] -5.887760
## [2,] -3.844681
## [3,] -2.475620
## [4,] -1.124023
## [5,]  2.103030
##
## $NP_004439$n
## [1] 80
##
## $NP_004439$conf
##           [,1]
## [1,] -2.956223
## [2,] -1.995018
##
## $NP_004439$out
##  [1] 9.668177 9.438237 2.995443 3.853287 5.635589 3.886441 3.322970 5.767942
##  [9] 5.800973 4.567836
##
## $NP_004439$group
##  [1] 1 1 1 1 1 1 1 1 1 1
##
## $NP_004439$names
## [1] "1"
```

```
##
##
## $NP_004388
## $NP_004388$stats
##             [,1]
## [1,] -1.4793025
## [2,] -0.4315964
## [3,] -0.0896896
## [4,]  0.4370189
## [5,]  1.7005950
##
## $NP_004388$n
## [1] 80
##
## $NP_004388$conf
##              [,1]
## [1,] -0.24312994
## [2,]  0.06375073
##
## $NP_004388$out
## [1] 2.286965
##
## $NP_004388$group
## [1] 1
##
## $NP_004388$names
## [1] "1"
##
##
## $NP_001229372
## $NP_001229372$stats
##            [,1]
## [1,] -6.963267
## [2,] -3.590168
## [3,] -2.435468
## [4,] -1.275306
## [5,]  2.133122
##
## $NP_001229372$n
## [1] 80
##
## $NP_001229372$conf
##            [,1]
## [1,] -2.844387
## [2,] -2.026549
##
## $NP_001229372$out
## [1] 8.978604 8.965470 6.148162 3.646817 3.369828 3.398403 4.232799
##
## $NP_001229372$group
## [1] 1 1 1 1 1 1 1
##
## $NP_001229372$names
## [1] "1"
```

```
##
##
## $NP_005130
## $NP_005130$stats
##            [,1]
## [1,] -8.8307556
## [2,] -3.7147704
## [3,] -1.4701347
## [4,]  0.2255714
## [5,]  5.6405463
##
## $NP_005130$n
## [1] 80
##
## $NP_005130$conf
##            [,1]
## [1,] -2.1661936
## [2,] -0.7740758
##
## $NP_005130$out
## [1] 6.397391
##
## $NP_005130$group
## [1] 1
##
## $NP_005130$names
## [1] "1"
##
##
## $NP_004243
## $NP_004243$stats
##            [,1]
## [1,] -4.3493525
## [2,] -2.2404093
## [3,] -1.2588643
## [4,]  0.3011927
## [5,]  4.0708722
##
## $NP_004243$n
## [1] 80
##
## $NP_004243$conf
##            [,1]
## [1,] -1.7078367
## [2,] -0.8098919
##
## $NP_004243$out
## [1] 4.399083 4.861847 5.671446
##
## $NP_004243$group
## [1] 1 1 1
##
## $NP_004243$names
## [1] "1"
```

```
##
##
## $NP_003144
## $NP_003144$stats
##            [,1]
## [1,] -1.9798402
## [2,] -0.4325426
## [3,]  0.1947012
## [4,]  0.7404052
## [5,]  1.8449029
##
## $NP_003144$n
## [1] 80
##
## $NP_003144$conf
##             [,1]
## [1,] -0.01249928
## [2,]  0.40190170
##
## $NP_003144$out
## [1] 2.830061
##
## $NP_003144$group
## [1] 1
##
## $NP_003144$names
## [1] "1"
##
##
## $NP_001171551
## $NP_001171551$stats
##            [,1]
## [1,] -1.9470415
## [2,] -0.4322866
## [3,]  0.1742170
## [4,]  0.7294963
## [5,]  1.8449029
##
## $NP_001171551$n
## [1] 80
##
## $NP_001171551$conf
##             [,1]
## [1,] -0.03101126
## [2,]  0.37944520
##
## $NP_001171551$out
## [1] 2.813958
##
## $NP_001171551$group
## [1] 1
##
## $NP_001171551$names
## [1] "1"
```

```
##
##
## $NP_072096
## $NP_072096$stats
##             [,1]
## [1,] -1.50276929
## [2,] -0.55484927
## [3,] -0.01969573
## [4,]  0.41592377
## [5,]  1.19362341
##
## $NP_072096$n
## [1] 80
##
## $NP_072096$conf
##            [,1]
## [1,] -0.1911822
## [2,]  0.1517907
##
## $NP_072096$out
## [1] -2.871865
##
## $NP_072096$group
## [1] 1
##
## $NP_072096$names
## [1] "1"
##
##
## $NP_005484
## $NP_005484$stats
##             [,1]
## [1,] -1.50816552
## [2,] -0.53675374
## [3,] -0.09190035
## [4,]  0.39283208
## [5,]  1.56245999
##
## $NP_005484$n
## [1] 80
##
## $NP_005484$conf
##             [,1]
## [1,] -0.25611110
## [2,]  0.07231039
##
## $NP_005484$out
## numeric(0)
##
## $NP_005484$group
## numeric(0)
##
## $NP_005484$names
## [1] "1"
```

```
##
##
## $NP_061170
## $NP_061170$stats
##            [,1]
## [1,] -4.712975
## [2,] -2.025168
## [3,] -1.033795
## [4,]  0.311528
## [5,]  3.724644
##
## $NP_061170$n
## [1] 80
##
## $NP_061170$conf
##             [,1]
## [1,] -1.4465707
## [2,] -0.6210191
##
## $NP_061170$out
## [1] 4.029373 5.689747
##
## $NP_061170$group
## [1] 1 1
##
## $NP_061170$names
## [1] "1"
##
##
## $NP_653304
## $NP_653304$stats
##             [,1]
## [1,] -4.2030116
## [2,] -1.9997588
## [3,] -0.8129121
## [4,]  0.6002230
## [5,]  2.5447948
##
## $NP_653304$n
## [1] 80
##
## $NP_653304$conf
##             [,1]
## [1,] -1.2721972
## [2,] -0.3536269
##
## $NP_653304$out
## numeric(0)
##
## $NP_653304$group
## numeric(0)
##
## $NP_653304$names
## [1] "1"
```

```
##
##
## $NP_653081
## $NP_653081$stats
##            [,1]
## [1,] -1.8526870
## [2,] -0.5220216
## [3,] -0.1564469
## [4,]  0.4245559
## [5,]  1.6049629
##
## $NP_653081$n
## [1] 80
##
## $NP_653081$conf
##             [,1]
## [1,] -0.32365917
## [2,]  0.01076545
##
## $NP_653081$out
## [1] 2.147486 1.989637 3.624280 1.938567
##
## $NP_653081$group
## [1] 1 1 1 1
##
## $NP_653081$names
## [1] "1"
##
##
## $NP_057164
## $NP_057164$stats
##             [,1]
## [1,] -1.92397415
## [2,] -0.71653848
## [3,] -0.03968425
## [4,]  1.06566335
## [5,]  3.01239495
##
## $NP_057164$n
## [1] 80
##
## $NP_057164$conf
##            [,1]
## [1,] -0.3545091
## [2,]  0.2751406
##
## $NP_057164$out
## numeric(0)
##
## $NP_057164$group
## numeric(0)
##
## $NP_057164$names
## [1] "1"
```

```
##
##
## $NP_004453
## $NP_004453$stats
##            [,1]
## [1,] -4.1386672
## [2,] -1.5225765
## [3,] -0.3784592
## [4,]  0.4924532
## [5,]  3.3454346
##
## $NP_004453$n
## [1] 80
##
## $NP_004453$conf
##             [,1]
## [1,] -0.73441287
## [2,] -0.02250543
##
## $NP_004453$out
## [1] 3.686225 3.837949 4.243675
##
## $NP_004453$group
## [1] 1 1 1
##
## $NP_004453$names
## [1] "1"
##
##
## $NP_003212
## $NP_003212$stats
##            [,1]
## [1,] -3.4500588
## [2,] -1.0539582
## [3,] -0.3422749
## [4,]  0.6543596
## [5,]  2.9986201
##
## $NP_003212$n
## [1] 80
##
## $NP_003212$conf
##             [,1]
## [1,] -0.64404820
## [2,] -0.04050166
##
## $NP_003212$out
## [1] -4.1699
##
## $NP_003212$group
## [1] 1
##
## $NP_003212$names
## [1] "1"
```

```
##
##
## $NP_060866
## $NP_060866$stats
##            [,1]
## [1,] -1.9687931
## [2,] -0.7490088
## [3,] -0.3001057
## [4,]  0.2604499
## [5,]  1.2134275
##
## $NP_060866$n
## [1] 80
##
## $NP_060866$conf
##            [,1]
## [1,] -0.4784260
## [2,] -0.1217855
##
## $NP_060866$out
## [1] -2.589974  2.460358  1.867033  2.926207
##
## $NP_060866$group
## [1] 1 1 1 1
##
## $NP_060866$names
## [1] "1"
##
##
## $NP_001160163
## $NP_001160163$stats
##             [,1]
## [1,] -3.42210803
## [2,] -1.01917050
## [3,]  0.06316141
## [4,]  0.73348041
## [5,]  2.89217103
##
## $NP_001160163$n
## [1] 80
##
## $NP_001160163$conf
##            [,1]
## [1,] -0.2464433
## [2,]  0.3727661
##
## $NP_001160163$out
## numeric(0)
##
## $NP_001160163$group
## numeric(0)
##
## $NP_001160163$names
## [1] "1"
```

```
##
##
## $NP_003875
## $NP_003875$stats
##             [,1]
## [1,] -3.39803927
## [2,] -0.86429123
## [3,]  0.04810062
## [4,]  0.88773048
## [5,]  3.29279523
##
## $NP_003875$n
## [1] 80
##
## $NP_003875$conf
##            [,1]
## [1,] -0.2613929
## [2,]  0.3575941
##
## $NP_003875$out
## [1] -4.970156  5.432549 11.755122 -4.153530 -4.176455
##
## $NP_003875$group
## [1] 1 1 1 1 1
##
## $NP_003875$names
## [1] "1"
##
##
## $NP_002677
## $NP_002677$stats
##            [,1]
## [1,] -11.361115
## [2,]  -8.205643
## [3,]  -6.362650
## [4,]  -4.197724
## [5,]   1.516256
##
## $NP_002677$n
## [1] 80
##
## $NP_002677$conf
##           [,1]
## [1,] -7.070647
## [2,] -5.654654
##
## $NP_002677$out
## [1]  4.331248  1.864520  5.868250 10.215922  5.871759
##
## $NP_002677$group
## [1] 1 1 1 1 1
##
## $NP_002677$names
## [1] "1"
```

```
##
##
## $NP_001135891
## $NP_001135891$stats
##            [,1]
## [1,] -3.1680635
## [2,] -1.0661463
## [3,] -0.2271340
## [4,]  0.5092675
## [5,]  2.5193274
##
## $NP_001135891$n
## [1] 80
##
## $NP_001135891$conf
##             [,1]
## [1,] -0.50542981
## [2,]  0.05116191
##
## $NP_001135891$out
## [1] -5.050298  3.201698  3.175491  3.414158
##
## $NP_001135891$group
## [1] 1 1 1 1
##
## $NP_001135891$names
## [1] "1"
##
##
## $NP_004522
## $NP_004522$stats
##            [,1]
## [1,] -2.7021650
## [2,] -1.1902918
## [3,] -0.2807051
## [4,]  0.6040038
## [5,]  2.8653784
##
## $NP_004522$n
## [1] 80
##
## $NP_004522$conf
##             [,1]
## [1,] -0.59766633
## [2,]  0.03625606
##
## $NP_004522$out
## [1] -4.150392 -4.996855
##
## $NP_004522$group
## [1] 1 1
##
## $NP_004522$names
## [1] "1"
```

```
##
##
## $NP_003767
## $NP_003767$stats
##              [,1]
## [1,] -1.87517546
## [2,] -0.55882109
## [3,] -0.06146679
## [4,]  0.46892980
## [5,]  1.60169464
##
## $NP_003767$n
## [1] 80
##
## $NP_003767$conf
##             [,1]
## [1,] -0.2430183
## [2,]  0.1200848
##
## $NP_003767$out
## [1] 2.142263 2.677884
##
## $NP_003767$group
## [1] 1 1
##
## $NP_003767$names
## [1] "1"
##
##
## $NP_848597
## $NP_848597$stats
##             [,1]
## [1,] -2.8023343
## [2,] -0.6238947
## [3,]  0.2488007
## [4,]  1.1953659
## [5,]  3.2187065
##
## $NP_848597$n
## [1] 80
##
## $NP_848597$conf
##              [,1]
## [1,] -0.07257056
## [2,]  0.57017190
##
## $NP_848597$out
## [1] -3.986077
##
## $NP_848597$group
## [1] 1
##
## $NP_848597$names
## [1] "1"
```

```
##
##
## $NP_005970
## $NP_005970$stats
##              [,1]
## [1,] -4.18213251
## [2,] -1.24546089
## [3,] -0.05750858
## [4,]  1.65100594
## [5,]  5.16274745
##
## $NP_005970$n
## [1] 80
##
## $NP_005970$conf
##             [,1]
## [1,] -0.5691676
## [2,]  0.4541505
##
## $NP_005970$out
## numeric(0)
##
## $NP_005970$group
## numeric(0)
##
## $NP_005970$names
## [1] "1"
```

```
# function for detection of outliers in each column
outliers <- function(x)
{
  for(i in 1:ncol(x))
  {
    sd_i <- sd(x[,i])
    mean_i <- mean(x[,i])

    out = x[x[,i] > 3*sd_i+mean_i | x[,i] < mean_i-3*sd_i, ]
    if(nrow(out) > 0)
    {
      print(colnames(x)[i])
      paste("The outliers are -", out)
    }else
    {
      print(paste("No outliers for",colnames(x)[i]))
    }
  }
}
```

```
# Detecting outliers in the dataset
outliers(final_data[,c(2:ncol(final_data))])
```

```
## [1] "NP_038479"
## [1] "No outliers for NP_001258898"
```

```
## [1] "No outliers for NP_542785"
## [1] "No outliers for NP_002005"
## [1] "No outliers for XP_003846537"
## [1] "No outliers for NP_660208"
## [1] "NP_004439"
## [1] "No outliers for NP_004388"
## [1] "NP_001229372"
## [1] "No outliers for NP_005130"
## [1] "No outliers for NP_004243"
## [1] "NP_003144"
## [1] "NP_001171551"
## [1] "NP_072096"
## [1] "No outliers for NP_005484"
## [1] "No outliers for NP_061170"
## [1] "No outliers for NP_653304"
## [1] "NP_653081"
## [1] "No outliers for NP_057164"
## [1] "No outliers for NP_004453"
## [1] "No outliers for NP_003212"
## [1] "NP_060866"
## [1] "No outliers for NP_001160163"
## [1] "NP_003875"
## [1] "NP_002677"
## [1] "NP_001135891"
## [1] "NP_004522"
## [1] "NP_003767"
## [1] "NP_848597"
## [1] "No outliers for NP_005970"
```

```
# replacing outliers with median imputation
outlier <- function(x) {
 x[x < quantile(x,0.25) - 1.5 * IQR(x) | x > quantile(x,0.75) + 1.5 * IQR(x)] <- median(x)
 x
}
```

```
data_out <- as.data.frame(lapply(final_data[,c(2:ncol(final_data))], outlier))
data_norm <- data_out
data_norm$PAM50.mRNA <- final_data$PAM50.mRNA
```

Feature Engineering -

I have not derived new features. - converted the PAM50.mRNA as a factor type as this is a response variable. for this I have used factor()

```
# changing the names
data_norm$PAM50.mRNA[which(data_norm$PAM50.mRNA == "Basal-like")] = "Basal.like"
data_norm$PAM50.mRNA[which(data_norm$PAM50.mRNA == "HER2-enriched")] = "HER2.enriched"
data_norm$PAM50.mRNA[which(data_norm$PAM50.mRNA == "Luminal A")] = "Luminal.A"
data_norm$PAM50.mRNA[which(data_norm$PAM50.mRNA == "Luminal B")] = "Luminal.B"
```

```
# converting PAM50.mRNA to a factor type
data_norm$PAM50.mRNA <- factor(data_norm$PAM50.mRNA)
```

Correlation/Collinearity analysis

- Numerical data is required for calculating correlation, so I have used only numerical variables to interpret the correlation
- Correlation plot is shown for whole data
- I have shown the plot of correlation between numeric features
- I also tried pairs.panels function for correlation but since there are more than 15 features. Plots are not clearly visible pairs.panels(data_n)
- Thefore, build a plot with top ten features
- I cannot apply chi-square test as the datapoints should be non-zero and non-negative

```
#Creating a correlation plot of whole dataset
cormat <- round(cor(data_norm[,1:30]),2)
cormat
```

```
##              NP_038479 NP_001258898 NP_542785 NP_002005 XP_003846537 NP_660208
## NP_038479         1.00        -0.41      0.20     -0.14         0.33     -0.05
## NP_001258898     -0.41         1.00     -0.04      0.33        -0.30     -0.13
## NP_542785         0.20        -0.04      1.00     -0.34         0.07     -0.35
## NP_002005        -0.14         0.33     -0.34      1.00         0.09      0.18
## XP_003846537      0.33        -0.30      0.07      0.09         1.00      0.06
## NP_660208        -0.05        -0.13     -0.35      0.18         0.06      1.00
## NP_004439         0.13         0.05      0.07      0.06        -0.05     -0.03
## NP_004388        -0.45         0.56      0.07      0.03        -0.22     -0.10
## NP_001229372      0.09         0.06      0.13      0.00         0.00     -0.07
## NP_005130         0.05        -0.04      0.42     -0.49        -0.09     -0.18
## NP_004243         0.01         0.12     -0.39      0.64         0.17      0.24
## NP_003144         0.36        -0.51      0.16     -0.24         0.19      0.13
## NP_001171551      0.35        -0.53      0.16     -0.25         0.19      0.14
## NP_072096         0.12        -0.16     -0.29      0.07        -0.04      0.52
## NP_005484        -0.36         0.34     -0.15      0.02        -0.18     -0.08
## NP_061170        -0.01        -0.04      0.06      0.01         0.17     -0.08
## NP_653304        -0.25         0.53      0.09      0.17        -0.05     -0.21
## NP_653081         0.05         0.18      0.15      0.09         0.02     -0.28
## NP_057164         0.11        -0.51     -0.01      0.06         0.26      0.35
## NP_004453        -0.13         0.32      0.07      0.07        -0.19     -0.25
## NP_003212        -0.22         0.23      0.23     -0.08        -0.05     -0.38
## NP_060866        -0.02         0.18     -0.32      0.32        -0.01      0.28
## NP_001160163     -0.40         0.46     -0.03     -0.11        -0.37     -0.05
## NP_003875         0.34        -0.30     -0.18     -0.01         0.15      0.09
## NP_002677        -0.04         0.09     -0.03      0.02        -0.14      0.13
## NP_001135891     -0.03         0.18     -0.17      0.34         0.04     -0.04
## NP_004522         0.00        -0.08     -0.33      0.27         0.08      0.26
## NP_003767        -0.19         0.06     -0.30      0.36        -0.11      0.25
## NP_848597         0.38        -0.36     -0.03      0.18         0.26      0.23
## NP_005970         0.27        -0.41      0.10     -0.15         0.21      0.28
##              NP_004439 NP_004388 NP_001229372 NP_005130 NP_004243 NP_003144
## NP_038479         0.13     -0.45         0.09      0.05      0.01      0.36
## NP_001258898      0.05      0.56         0.06     -0.04      0.12     -0.51
## NP_542785         0.07      0.07         0.13      0.42     -0.39      0.16
## NP_002005         0.06      0.03         0.00     -0.49      0.64     -0.24
## XP_003846537     -0.05     -0.22         0.00     -0.09      0.17      0.19
## NP_660208        -0.03     -0.10        -0.07     -0.18      0.24      0.13
```

```
## NP_004439         1.00      0.06         0.78      0.01      0.05     -0.04
## NP_004388         0.06      1.00         0.19      0.16     -0.09     -0.48
## NP_001229372      0.78      0.19         1.00      0.09     -0.04     -0.04
## NP_005130         0.01      0.16         0.09      1.00     -0.49      0.05
## NP_004243         0.05     -0.09        -0.04     -0.49      1.00     -0.04
## NP_003144        -0.04     -0.48        -0.04      0.05     -0.04      1.00
## NP_001171551     -0.05     -0.48        -0.05      0.05     -0.04      1.00
## NP_072096        -0.01     -0.17        -0.10     -0.10      0.15      0.17
## NP_005484         0.13      0.30         0.17      0.02      0.02     -0.37
## NP_061170         0.06     -0.02         0.13     -0.17      0.13     -0.10
## NP_653304         0.15      0.67         0.22      0.02      0.10     -0.58
## NP_653081         0.05      0.25         0.16      0.22      0.14     -0.23
## NP_057164        -0.13     -0.36        -0.17     -0.01      0.15      0.49
## NP_004453         0.17      0.22         0.29     -0.05      0.06     -0.28
## NP_003212         0.10      0.28         0.13      0.20     -0.15     -0.17
## NP_060866         0.03      0.12         0.07     -0.28      0.37     -0.17
## NP_001160163      0.01      0.38         0.07      0.11     -0.20     -0.33
## NP_003875        -0.13     -0.21        -0.13     -0.13      0.11      0.23
## NP_002677         0.38      0.23         0.41      0.12      0.03     -0.02
## NP_001135891     -0.13      0.00        -0.14     -0.16      0.27     -0.16
## NP_004522         0.01     -0.16        -0.12     -0.21      0.38      0.14
## NP_003767         0.23      0.07         0.15     -0.27      0.41     -0.24
## NP_848597         0.10     -0.26         0.13     -0.05      0.23      0.20
## NP_005970        -0.16     -0.20        -0.10      0.14      0.00      0.47
##              NP_001171551 NP_072096 NP_005484 NP_061170 NP_653304 NP_653081
## NP_038479            0.35      0.12     -0.36     -0.01     -0.25      0.05
## NP_001258898        -0.53     -0.16      0.34     -0.04      0.53      0.18
## NP_542785            0.16     -0.29     -0.15      0.06      0.09      0.15
## NP_002005           -0.25      0.07      0.02      0.01      0.17      0.09
## XP_003846537         0.19     -0.04     -0.18      0.17     -0.05      0.02
## NP_660208            0.14      0.52     -0.08     -0.08     -0.21     -0.28
## NP_004439           -0.05     -0.01      0.13      0.06      0.15      0.05
## NP_004388           -0.48     -0.17      0.30     -0.02      0.67      0.25
## NP_001229372        -0.05     -0.10      0.17      0.13      0.22      0.16
## NP_005130            0.05     -0.10      0.02     -0.17      0.02      0.22
## NP_004243           -0.04      0.15      0.02      0.13      0.10      0.14
## NP_003144            1.00      0.17     -0.37     -0.10     -0.58     -0.23
## NP_001171551         1.00      0.18     -0.37     -0.08     -0.59     -0.23
## NP_072096            0.18      1.00     -0.14     -0.18     -0.29     -0.19
## NP_005484           -0.37     -0.14      1.00      0.18      0.26      0.04
## NP_061170           -0.08     -0.18      0.18      1.00      0.13      0.18
## NP_653304           -0.59     -0.29      0.26      0.13      1.00      0.40
## NP_653081           -0.23     -0.19      0.04      0.18      0.40      1.00
## NP_057164            0.50      0.31     -0.33     -0.13     -0.50     -0.19
## NP_004453           -0.29     -0.25      0.36      0.25      0.24      0.22
## NP_003212           -0.18     -0.32      0.24     -0.01      0.23      0.16
## NP_060866           -0.18      0.11      0.14      0.14      0.16      0.04
## NP_001160163        -0.32      0.03      0.33     -0.02      0.30      0.14
## NP_003875            0.22      0.06     -0.30     -0.15     -0.18     -0.08
## NP_002677            0.00      0.10      0.23      0.04      0.06      0.18
## NP_001135891        -0.16     -0.03     -0.06      0.01      0.13      0.14
## NP_004522            0.15      0.13      0.18      0.14     -0.23     -0.08
## NP_003767           -0.21      0.07     -0.08      0.14      0.18      0.09
## NP_848597            0.22      0.27     -0.28     -0.15     -0.23      0.10
```

```
## NP_005970          0.48       0.28      -0.22      -0.16      -0.43      -0.11
##             NP_057164 NP_004453 NP_003212 NP_060866 NP_001160163 NP_003875
## NP_038479         0.11     -0.13     -0.22     -0.02        -0.40      0.34
## NP_001258898     -0.51      0.32      0.23      0.18         0.46     -0.30
## NP_542785        -0.01      0.07      0.23     -0.32        -0.03     -0.18
## NP_002005         0.06      0.07     -0.08      0.32        -0.11     -0.01
## XP_003846537      0.26     -0.19     -0.05     -0.01        -0.37      0.15
## NP_660208         0.35     -0.25     -0.38      0.28        -0.05      0.09
## NP_004439        -0.13      0.17      0.10      0.03         0.01     -0.13
## NP_004388        -0.36      0.22      0.28      0.12         0.38     -0.21
## NP_001229372     -0.17      0.29      0.13      0.07         0.07     -0.13
## NP_005130        -0.01     -0.05      0.20     -0.28         0.11     -0.13
## NP_004243         0.15      0.06     -0.15      0.37        -0.20      0.11
## NP_003144         0.49     -0.28     -0.17     -0.17        -0.33      0.23
## NP_001171551      0.50     -0.29     -0.18     -0.18        -0.32      0.22
## NP_072096         0.31     -0.25     -0.32      0.11         0.03      0.06
## NP_005484        -0.33      0.36      0.24      0.14         0.33     -0.30
## NP_061170        -0.13      0.25     -0.01      0.14        -0.02     -0.15
## NP_653304        -0.50      0.24      0.23      0.16         0.30     -0.18
## NP_653081        -0.19      0.22      0.16      0.04         0.14     -0.08
## NP_057164         1.00     -0.47     -0.24     -0.16        -0.37      0.14
## NP_004453        -0.47      1.00     -0.01      0.20         0.26     -0.25
## NP_003212        -0.24     -0.01      1.00     -0.14        -0.08     -0.16
## NP_060866        -0.16      0.20     -0.14      1.00        -0.01      0.14
## NP_001160163     -0.37      0.26     -0.08     -0.01         1.00     -0.38
## NP_003875         0.14     -0.25     -0.16      0.14        -0.38      1.00
## NP_002677        -0.06      0.20      0.07      0.06         0.20     -0.12
## NP_001135891     -0.09      0.03     -0.09      0.22         0.19     -0.04
## NP_004522         0.22      0.02     -0.19      0.20        -0.07     -0.01
## NP_003767         0.04      0.08     -0.17      0.23        -0.05      0.01
## NP_848597         0.36     -0.29     -0.17      0.06        -0.35      0.20
## NP_005970         0.56     -0.45     -0.21     -0.15        -0.20      0.25
##             NP_002677 NP_001135891 NP_004522 NP_003767 NP_848597 NP_005970
## NP_038479        -0.04        -0.03      0.00     -0.19      0.38      0.27
## NP_001258898      0.09         0.18     -0.08      0.06     -0.36     -0.41
## NP_542785        -0.03        -0.17     -0.33     -0.30     -0.03      0.10
## NP_002005         0.02         0.34      0.27      0.36      0.18     -0.15
## XP_003846537     -0.14         0.04      0.08     -0.11      0.26      0.21
## NP_660208         0.13        -0.04      0.26      0.25      0.23      0.28
## NP_004439         0.38        -0.13      0.01      0.23      0.10     -0.16
## NP_004388         0.23         0.00     -0.16      0.07     -0.26     -0.20
## NP_001229372      0.41        -0.14     -0.12      0.15      0.13     -0.10
## NP_005130         0.12        -0.16     -0.21     -0.27     -0.05      0.14
## NP_004243         0.03         0.27      0.38      0.41      0.23      0.00
## NP_003144        -0.02        -0.16      0.14     -0.24      0.20      0.47
## NP_001171551      0.00        -0.16      0.15     -0.21      0.22      0.48
## NP_072096         0.10        -0.03      0.13      0.07      0.27      0.28
## NP_005484         0.23        -0.06      0.18     -0.08     -0.28     -0.22
## NP_061170         0.04         0.01      0.14      0.14     -0.15     -0.16
## NP_653304         0.06         0.13     -0.23      0.18     -0.23     -0.43
## NP_653081         0.18         0.14     -0.08      0.09      0.10     -0.11
## NP_057164        -0.06        -0.09      0.22      0.04      0.36      0.56
## NP_004453         0.20         0.03      0.02      0.08     -0.29     -0.45
## NP_003212         0.07        -0.09     -0.19     -0.17     -0.17     -0.21
```

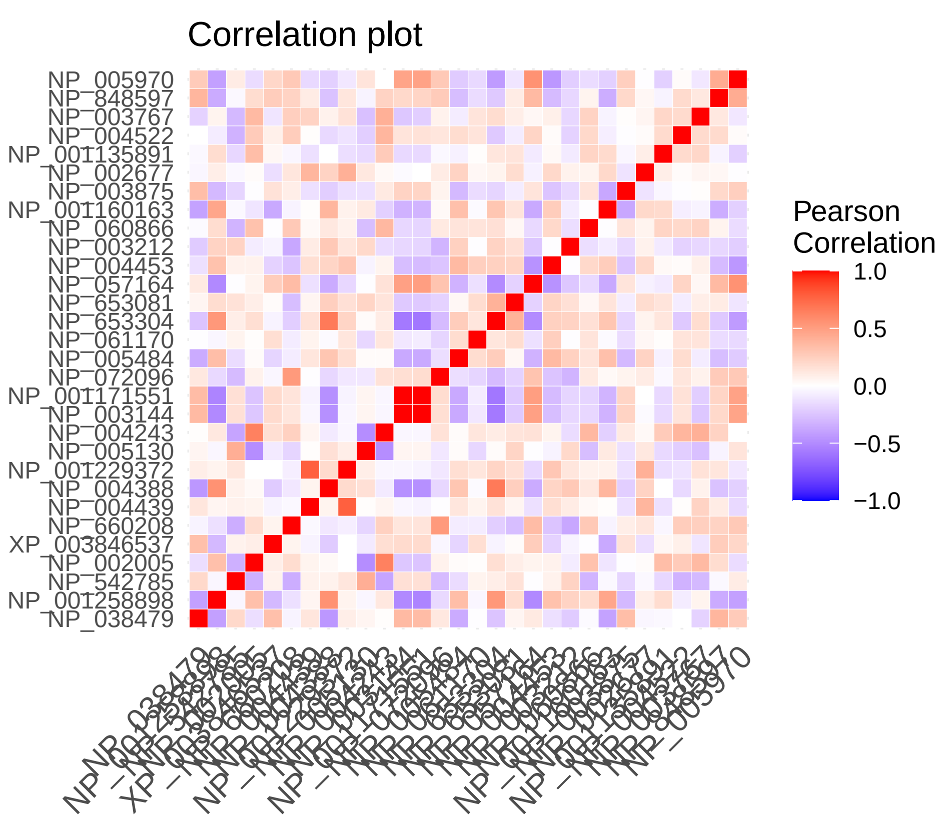
```
## NP_060866          0.06         0.22       0.20       0.23       0.06      -0.15
## NP_001160163       0.20         0.19      -0.07      -0.05      -0.35      -0.20
## NP_003875         -0.12        -0.04      -0.01       0.01       0.20       0.25
## NP_002677          1.00         0.09       0.02       0.05       0.04      -0.01
## NP_001135891       0.09         1.00       0.19       0.21      -0.05      -0.20
## NP_004522          0.02         0.19       1.00       0.19       0.19       0.02
## NP_003767          0.05         0.21       0.19       1.00       0.12      -0.10
## NP_848597          0.04        -0.05       0.19       0.12       1.00       0.43
## NP_005970         -0.01        -0.20       0.02      -0.10       0.43       1.00
```

We can say that the proteins are not highly correlated

```
melted_cormat <- reshape2::melt(cormat)
```

Visualizing the correlation plot

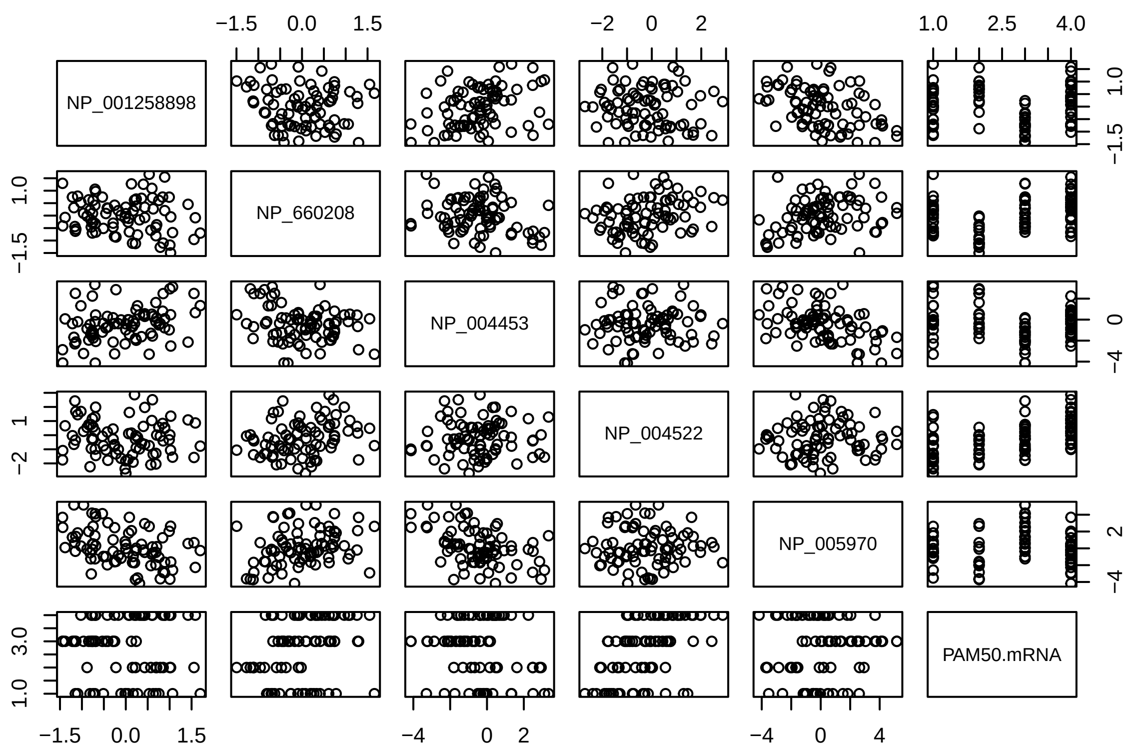
```
ggplot(data = melted_cormat, aes(Var2, Var1, fill = value))+
 geom_tile(color = "white")+
 scale_fill_gradient2(low = "blue", high = "red", mid = "white",
   midpoint = 0, limit = c(-1,1), space = "Lab",
   name="Pearson\nCorrelation") +
  theme_minimal()+
 theme(axis.text.x = element_text(angle = 45, vjust = 1,
    size = 12, hjust = 1))+
 coord_fixed()+xlab("")+ylab("")+ggtitle("Correlation plot")
```



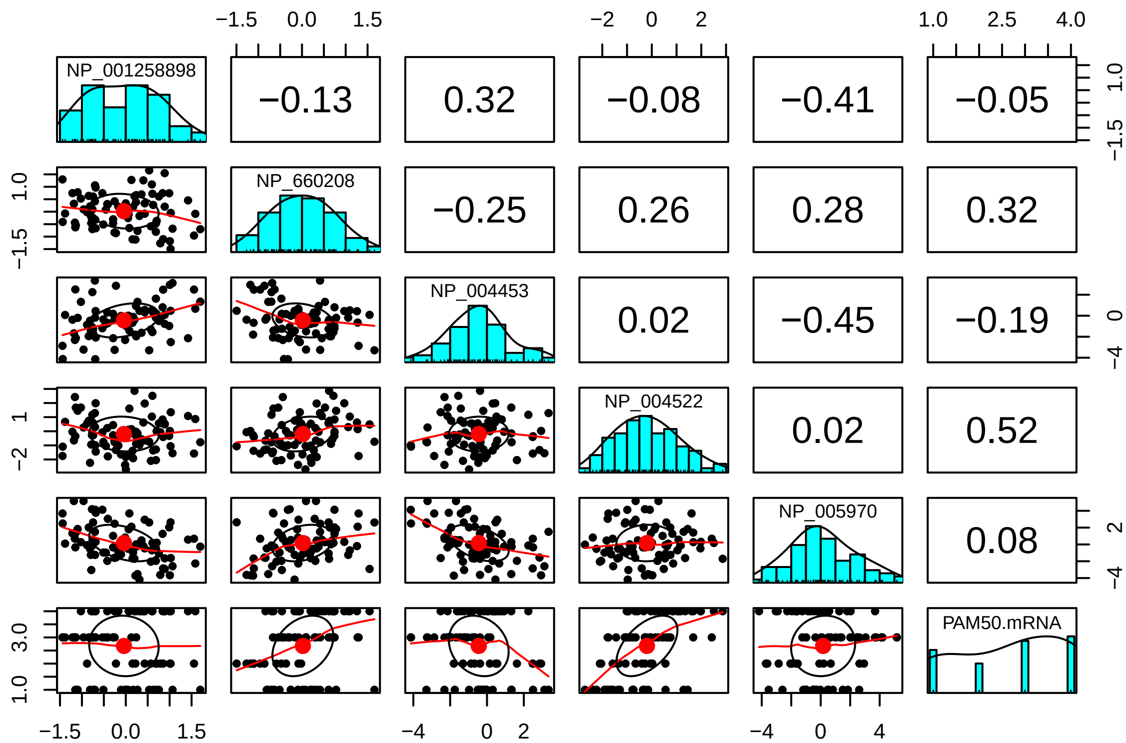
Top 5 variables and response variable

```
top_variables <- c("PAM50.mRNA", "NP_660208", "NP_005970", "NP_004453", "NP_004522", "NP_001258898")
#"NP_001160163", "NP_003767", "NP_542785", "NP_060866", "NP_004388"
data_viz= data_norm[,(names(data_norm) %in% top_variables)]
```

```
pairs(data_viz)
```

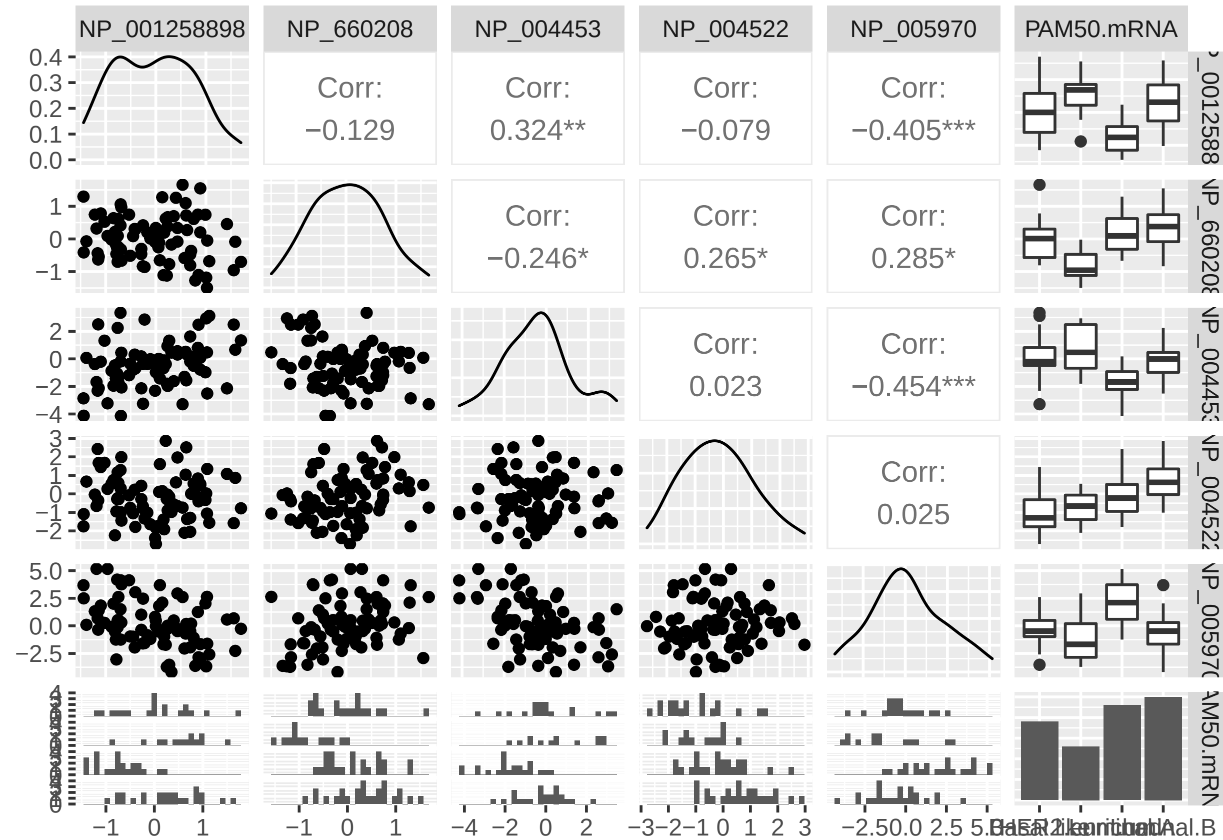



```
pairs.panels(data_viz)
```




```r
ggpairs(data_viz)
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



The variable names are displayed on the outer edges of the matrix. The boxes along the diagonals display the density plot for each variable. The boxes in the lower left corner display the scatterplot between each variable. The boxes in the upper right corner display the Pearson correlation coefficient between each variable. The variables are not correlated but according to the distribution they have normal distribution

4. Model Construction & Evaluation

- which algorithms will you use and why? naive bayes, knn, decision trees, rules, log regression, multi regression, lasso, ridge, neural net, svm, clustering
- is the algorithm compatible with the features you have in the data set?

As this is a multi-class classification, I am going to use SVM, Neural Networks, Decison tree and Naive Baye's. 1. SVM : I chose this algorithm as it does complex data transformations depending on the selected kernel function and based on that transformations, it tries to maximize the separation boundaries between the data points depending on the labels or classes defined. SVM works well for binary classification. But, For multi-class classification, the same principle for binary classfication is utilized after breaking down the multiclassification problem into multiple binary classification problems. The main reason behind choosing this alogirthm is it works well with expression data. As I am dealing with the protein expression data, this algorithm will work well and compatiable with the features in the data-set. The kernel function is used where the complexity of the problem is high and data is linearly separable. where it adds multiple polynomial features at a very high degree this way it prevents the computational complexity or burden that comes along adding multiple features to data. The dependencies of the variable are always taken into consideration

2. Neural Networks : I chose this algorithm as this works well with complex datset. The output layer contains one neuron per class rather than just one neuron. If the dataset contains four classes, then the output layer has four neurons. Therefore, it works well with multi class classfication problems.

3. Random Forests : I chose this algorithm as this a classifier is a systematic approach for multiclass classification. It poses a set of questions to the dataset (related to its attributes/features). The benefit of this method is that it can handle missing values and maintains accuracy for missing data. It won't over fit the model. t handles dataset with higher dimensionality

4. Naive bayes : I chose naive bayes algorithm as this is highly compatiable for protein expression datset and the calculations of the probabilities for each class are simplified to make their calculations tractable.

- how do you compare and evaluate the performance of the algorithms? R-Squared? MAD, MSE, RMSE? AIC? AUC? why are they that way?

As this is a classification problem, Classification Metrics are :Confusion Matrix, Precision, Recall, F1-score and AUC I chose these metrics as it is a well-balanced datasetand these metrics works well.

- how do you choose training vs validation data? why? Data splitting is done in 70:20 ratio. Partition is created using createDataPartition function. As it is a well balanced datset.

- can you and should you use k-fold cross-validation? - k-Fold Cross Validation is done for the whole dataset - I have used k = 10 which means 10 folds take place along with 10 repetitions - For testing the data, I have used 3 models to test the k-fold CV

- how would you build a stacked ensemble model? is it a better model? can you use boosting or bagging? or build a stacked learner?

- how will you communicate the results of your algorithms? I have used confusionMatrix function to interpret the results of the algorithm

Creation of training & validation subsets

- Data splitting is done in 70:20 ratio
- Partition is created using createDataPartition function

Construction of at least three related models

- I built 4 models which are as follows:
  - Support Vector Machine (svm())
  - Neural Network (neuralnet())
  - Naive Bayes (naive_bayes())
  - Random Forest (randomForest())

Evaluation of fit of models with holdout method

- For model evaluation,I have calculated accuracy of each model using the confusionMatrix function. I have also compared the sensitivity, specificity, precision, recall and AUC of classification models

For a balanced dataset, we use a confusion matrix and the derived performance metrics; accuracy, precision, recall, F1-score and AUC

```
#creating test/train split index
set.seed(1000)
samp <- createDataPartition(data_norm$PAM50.mRNA, p = 0.7, list = FALSE)
train <- data_norm[samp, ]
test<- data_norm[-samp, ]
```

```r
#exploring training dataset
head(train)
```

```
##    NP_038479 NP_001258898   NP_542785  NP_002005 XP_003846537   NP_660208
## 1 -0.3708959  -0.01456473  0.05890562 -2.1305106   -0.4957955 -0.09170859
## 2 -1.6044748  -0.51053492  3.17273051 -0.9688522   -0.6711132 -0.51388030
## 3 -3.0516640   0.53387720  3.71857004 -0.3435704   -0.3498830  1.65751511
## 4 -1.0663490   1.69892745  2.96770134 -3.2821848   -0.4373841 -0.70126018
## 5 -0.3009396  -1.09705962  0.03501174 -1.2946781   -0.3376402  0.78031558
## 6  0.6787788  -0.70384668 -1.91679672 -2.7445377   -0.4103540  0.41280109
##   NP_004439  NP_004388 NP_001229372  NP_005130 NP_004243 NP_003144 NP_001171551
## 1 -4.419112  0.1691111    -3.004808  2.2373013 -3.717470 0.1948258    0.1948258
## 2 -5.187379  0.4863889    -3.273820 -2.2066435 -2.905828 0.9748146    0.9547423
## 3 -3.099008 -0.7349499    -2.969601 -0.4698218 -3.076914 0.3539689    0.3508126
## 4 -3.130366  0.7843981    -2.859260  3.8894601 -3.180972 0.3397851    0.3470145
## 5 -2.062567 -0.1823685    -1.774609 -0.2388310 -1.785901 1.5453813    1.5990205
## 6 -3.322351 -0.2659006    -2.127745 -0.6167161 -1.937433 1.4835906    1.5432063
##    NP_072096   NP_005484   NP_061170  NP_653304  NP_653081  NP_057164
## 1 -0.5215101 -0.96600568 -1.41417478  0.5548304 -0.2753844 -0.6243686
## 2 -0.5506795 -0.29643048 -2.19660738 -0.8751815  0.2890113  0.6034772
## 3  0.8747561  0.29399945 -3.01378855 -1.5334903 -1.4072388  1.8279546
## 4 -1.2145533 -0.11205750 -1.51096203  0.1301301  0.3723177 -0.1771228
## 5  0.2693307  0.62504394  0.48671103 -1.4414803  0.6448058  1.4155177
## 6  0.3623570  0.07115731 -0.06412445 -2.9967579 -0.3690816  0.6375064
##    NP_004453    NP_003212    NP_060866 NP_001160163   NP_003875 NP_002677
## 1 -2.3105130  0.007476375 -1.399480707  1.340963113  0.04810062 -7.684869
## 2 -0.3499566 -0.376719645 -1.457277986  0.740637896  1.71079864 -8.877335
## 3 -3.2915417 -0.476134402  0.335031167  2.493930969 -3.12110229 -7.479934
## 4  1.3374534  0.159048035 -0.451843095  1.055503657 -0.82416136 -7.963274
## 5 -0.2021304 -1.819778494 -0.600190397  1.886978849  0.83677799 -4.388818
## 6  3.3454346 -2.334106568  0.002369978  0.002369978 -0.66257428 -3.342988
##   NP_001135891  NP_004522  NP_003767  NP_848597  NP_005970 PAM50.mRNA
## 1    0.9038146 -2.3839833 -0.3892635  0.3819222  0.8193237 Basal.like
## 2   -1.2933543 -0.7514024 -1.0558322 -0.7346755 -0.9655069 Basal.like
## 3   -0.4603530 -0.7412624 -1.0095468 -0.1952249  2.6107136 Basal.like
## 4   -1.7784528 -0.7771697 -0.7446371  0.2277281 -0.2638766 Basal.like
## 5    0.6306902  1.4493952 -0.5521973  1.9688493  1.8389858 Basal.like
## 6   -1.0913487  1.2864003  0.2889839 -0.5502216  1.5019339 Basal.like
```

```r
dim(train)
```

```
## [1] 59 31
```

```r
head(test)
```

```
##     NP_038479 NP_001258898  NP_542785 NP_002005 XP_003846537   NP_660208
## 7  -1.6621615    0.6862870  1.2085340 -1.994803   -0.4081033 -0.80727303
## 12 -1.0424112   -0.1083678 -1.0174124 -1.919639   -0.5742532  0.01208057
## 14 -1.3904136   -0.7426185  1.6022647 -2.311497   -0.8640801 -0.25677221
## 17  0.9718405    0.1667926  1.4009461 -3.102765   -0.6610396  0.19337440
## 18 -1.9684279    0.7547515  1.3304690 -4.288958   -0.2695313  0.60993907
## 23 -2.0569715    0.2201496 -0.3960125 -2.099070   -0.8055116 -1.11933337
```

```
##    NP_004439   NP_004388 NP_001229372  NP_005130 NP_004243  NP_003144
## 7  -5.421010 -0.05217698    -4.053853 -1.0833654 -3.112478 -0.9070655
## 12 -1.396939 -0.08968960    -1.969637  3.2369163 -0.967415 -0.4265335
## 14 -1.532119  0.38764892    -0.766236 -0.3748599 -4.349352  0.9274781
## 17 -3.383772 -0.27750263    -2.685051  4.9629030 -3.679969 -0.6914187
## 18 -4.140614  1.20684870    -5.323837  0.7264954 -3.681453 -0.9794653
## 23 -2.795601 -0.11280757    -2.902759  3.5956468 -2.114378  0.5645881
##    NP_001171551  NP_072096   NP_005484  NP_061170  NP_653304   NP_653081
## 7    -0.9070655 -0.4779580  0.48670214 -0.8804541  0.1241230  0.35031915
## 12   -0.4333513  0.2938844 -0.20609014 -0.5850009  2.3551430  0.05071496
## 14    0.9072345  0.3910229 -0.72574885 -1.5624841 -2.3182450 -0.26014614
## 17   -0.6800265 -0.3306662  0.36805459 -3.4103538 -0.6154708 -0.23193388
## 18   -0.9335491  1.0302482  0.65232319  0.5710870  1.2598288 -0.58741219
## 23    0.5684152 -0.8131658 -0.05540115 -4.7129749 -0.7902033 -0.29650809
##     NP_057164   NP_004453  NP_003212  NP_060866 NP_001160163   NP_003875
## 7  -0.7074806 -0.19188638  1.3183057  0.2571795   2.08670742 -0.07878830
## 12  0.1188933 -0.02428122  0.8756729 -0.9151449  -1.36284939  2.66194558
## 14  0.4146404 -1.74805043 -0.3141291 -0.7729839   0.72504218  0.04810062
## 17 -1.1850801 -0.11421462 -0.1825677 -0.6686344   0.87690557 -1.37115250
## 18 -1.8271476 -0.49911195 -0.4143437 -1.1030856   2.35475182 -0.94061315
## 23 -0.4074938 -1.80055616  2.9986201 -0.5414421   0.06316141 -0.41897511
##    NP_002677 NP_001135891  NP_004522    NP_003767  NP_848597  NP_005970
## 7  -7.080890    0.4667437 -1.2896031 -1.359457807 -1.7752596 -0.4746316
## 12 -3.814997   -0.2879042 -1.6423806  1.077935362 -1.1696774 -1.1787679
## 14 -5.732665   -1.7446765 -0.2837637  0.006394535  0.6676853  0.5226062
## 17 -9.444415   -0.8850859 -1.9103826 -1.731905061 -0.1977573 -0.9724260
## 18 -9.745913   -1.5481188  0.5569589 -1.254962003 -0.5838802 -1.0818935
## 23 -3.737066    0.4957004 -0.2807051 -0.503171187 -0.6639091 -3.7141033
##       PAM50.mRNA
## 7     Basal.like
## 12    Basal.like
## 14    Basal.like
## 17    Basal.like
## 18    Basal.like
## 23 HER2.enriched
```

```
dim(test)
```

```
## [1] 21 31
```

Model building

As this is a multi-class classification, I am implement 4 models - SVM, Neural Networks, Naive Baye's and Random forests

SVM linear classifier

Support Vector Machines are generalized extension of a maximal margin classifier, SVM are intended for the binary classification setting when there are two classes. However, this designed intention does not disqualify from using the SVM method with cases of more than two classes. SVM determines the best line separator by identifying closest points in Convex hull, a hyperplane bisects the closest point to the convex hull. The support vector classifies a test observation depending on which side of a plane it lies; this is based on boundaries-support vectors. SVM method allows some observations to be on the incorrect side of the margin and in some cases the incorrect side of the hyperplane in the interest of performing better in classifying the remaining observations further away from the hydroplane. This is known as a soft margin classifier; training observations can violate this area. Advantages of using a SVM model are; can be adapted to work well with nonlinear boundaries, uses kernels, less overfitting of data, performs well with clear margin of separation among data. The kernel function is used where the complexity of the problem is high and data is linearly separable. where it adds multiple polynomial features at a very high degree this way it prevents the computational complexity or burden that comes along adding multiple features to data. The dependencies of the variable are always taken into consideration

```
svm_model1 <- svm(PAM50.mRNA~., data= train, type="C-classification", kernel = 'linear')
svm_model1
```

```
##
## Call:
## svm(formula = PAM50.mRNA ~ ., data = train, type = "C-classification",
##     kernel = "linear")
##
##
## Parameters:
##    SVM-Type:  C-classification
##  SVM-Kernel:  linear
##        cost:  1
##
## Number of Support Vectors:  41
```

```
svm_pred <- predict(svm_model1, newdata = test)
confusionMatrix(svm_pred, factor(data_norm$PAM50.mRNA[-samp]), mode = "everything")
```

```
## Confusion Matrix and Statistics
##
##                Reference
## Prediction      Basal.like HER2.enriched Luminal.A Luminal.B
##   Basal.like             5             0         0         2
##   HER2.enriched          0             2         0         0
##   Luminal.A              0             0         6         1
##   Luminal.B              0             1         0         4
##
## Overall Statistics
##
##                Accuracy : 0.8095
##                  95% CI : (0.5809, 0.9455)
##     No Information Rate : 0.3333
##     P-Value [Acc > NIR] : 1.026e-05
##
##                   Kappa : 0.7399
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Basal.like Class: HER2.enriched Class: Luminal.A
```

```
## Sensitivity                    1.0000             0.66667          1.0000
## Specificity                    0.8750             1.00000          0.9333
## Pos Pred Value                 0.7143             1.00000          0.8571
## Neg Pred Value                 1.0000             0.94737          1.0000
## Precision                      0.7143             1.00000          0.8571
## Recall                         1.0000             0.66667          1.0000
## F1                             0.8333             0.80000          0.9231
## Prevalence                     0.2381             0.14286          0.2857
## Detection Rate                 0.2381             0.09524          0.2857
## Detection Prevalence           0.3333             0.09524          0.3333
## Balanced Accuracy              0.9375             0.83333          0.9667
##                        Class: Luminal.B
## Sensitivity                   0.5714
## Specificity                   0.9286
## Pos Pred Value                0.8000
## Neg Pred Value                0.8125
## Precision                     0.8000
## Recall                        0.5714
## F1                            0.6667
## Prevalence                    0.3333
## Detection Rate                0.1905
## Detection Prevalence          0.2381
## Balanced Accuracy             0.7500
```

```
accuracy_svm <-confusionMatrix(test$PAM50.mRNA, svm_pred)$overall["Accuracy"]
```

Model evaluation for SVM:

1. Accuracy : The overall model accuracy of SVM model is 81%
2. Precision,Recall,F1 : The Precision,Recall,F1 for Basal.like class is 0.7143, 1.0000, 0.8333 The Precision,Recall,F1 for HER2.enriched class is 1.00000, 0.33333 , 0.80000
   The Precision,Recall,F1 for Luminal.A class is 0.8571, 1.0000, 0.9231 The Precision,Recall,F1 for Luminal.B class is 0.8000, 0.5714, 0.6667
3. Sensitivity and Specificity: The Sensitivity and Specificity for Basal.like class is 1.0000 and 0.8750 The Sensitivity and Specificity for HER2.enriched class is 0.66667 and 1.00000 The Sensitivity and Specificity for Luminal.A is 1.0000 and 0.9333 The Sensitivity and Specificity for Luminal.B class is 0.5714 and 0.9286
4. The Kappa statistic: The kappa value for this model is 0.7399 which states that it is a good agreement.

Macro-averaged Metrics : The per-class metrics can be averaged over all the classes resulting in macro-averaged precision, recall and F-1.

```
# macro-averaged precision
precision_svm <- c(0.7143, 1.00000,0.8571, 0.8000)
macro_precision_svm <- mean(precision_svm)
# macro-averaged recall
recall_svm <- c(1.0000, 0.66667, 1.0000, 0.5714)
macro_recall_svm <- mean(recall_svm)
# macro-averaged F-1
```

```
F1_svm<- c(0.8333,0.80000, 0.9231, 0.6667)
macroF1_svm <- mean(F1_svm)
macro_avg_svm <- data.frame( macro_precision_svm, macro_recall_svm, macroF1_svm)
macro_avg_svm
```

```
##   macro_precision_svm macro_recall_svm macroF1_svm
## 1             0.84285        0.8095175    0.805775
```

AUC for SVM

```
svm_auc <- multiclass.roc(test$PAM50.mRNA, as.ordered(svm_pred))
auc(svm_auc)
```

```
## Multi-class area under the curve: 0.7897
```

The AUC of SVM model is : 0.7897

```
Name_metrics <- c("Accuracy", "Precision", "Recall", "F-1", "AUC", "Kappa")
values_svm <- c(0.8095 , 0.84285,   0.8095175,  0.805775,0.7897, 0.7399  )
metrics_svm <- data.frame(Name_metrics, values_svm)
print (metrics_svm)
```

```
##   Name_metrics values_svm
## 1     Accuracy  0.8095000
## 2    Precision  0.8428500
## 3       Recall  0.8095175
## 4          F-1  0.8057750
## 5          AUC  0.7897000
## 6        Kappa  0.7399000
```

Neural Networks

Inspired by biological neural networks, the Neural Network method is a supervised machine learning algorithm which consists of units arranged in layers which coverts an input vector (independent variable) into a prediction/classification. "The algorithm learns a function by training on a dataset without prior knowledge about the dataset."

```
# I have tried out many hidden layers but got optimal results with hidden layer = 5
neuralnet_model2 <- train(PAM50.mRNA~., data= train, hidden = 5, method = "nnet")
```

```
## # weights:  39
## initial  value 90.443203
## iter  10 value 33.522949
## iter  20 value 29.081551
## iter  30 value 25.631000
## iter  40 value 25.517964
## iter  50 value 25.395198
## iter  60 value 25.275651
## iter  70 value 25.125594
## iter  80 value 25.083164
```

```
## iter  90 value 25.080909
## iter 100 value 25.080875
## final  value 25.080875
## stopped after 100 iterations
## # weights:  109
## initial  value 95.605172
## iter  10 value 31.720806
## iter  20 value 21.847426
## iter  30 value 18.902135
## iter  40 value 16.921231
## iter  50 value 16.448415
## iter  60 value 14.611412
## iter  70 value 14.256358
## iter  80 value 13.929841
## iter  90 value 4.909790
## iter 100 value 4.500195
## final  value 4.500195
## stopped after 100 iterations
## # weights:  179
## initial  value 115.225552
## iter  10 value 16.288091
## iter  20 value 4.194251
## iter  30 value 0.250901
## iter  40 value 0.023452
## iter  50 value 0.010547
## iter  60 value 0.002400
## iter  70 value 0.000788
## iter  80 value 0.000229
## iter  90 value 0.000140
## final  value 0.000085
## converged
## # weights:  39
## initial  value 99.122639
## iter  10 value 55.167500
## iter  20 value 44.898518
## iter  30 value 41.116677
## iter  40 value 40.029601
## iter  50 value 38.251906
## iter  60 value 36.067643
## iter  70 value 34.828719
## iter  80 value 34.678452
## final  value 34.678386
## converged
## # weights:  109
## initial  value 125.755935
## iter  10 value 49.563245
## iter  20 value 30.684360
## iter  30 value 17.693543
## iter  40 value 13.908672
## iter  50 value 13.614344
## iter  60 value 13.433069
## iter  70 value 13.086003
## iter  80 value 11.668672
## iter  90 value 11.218409
```

```
## iter 100 value 11.214485
## final  value 11.214485
## stopped after 100 iterations
## # weights:  179
## initial  value 91.656334
## iter  10 value 33.201743
## iter  20 value 12.681427
## iter  30 value 9.869531
## iter  40 value 9.214958
## iter  50 value 9.131412
## iter  60 value 9.066018
## iter  70 value 8.996023
## iter  80 value 8.895696
## iter  90 value 8.776035
## iter 100 value 8.769974
## final  value 8.769974
## stopped after 100 iterations
## # weights:  39
## initial  value 87.201502
## iter  10 value 41.199495
## iter  20 value 38.238237
## iter  30 value 37.143784
## iter  40 value 35.524119
## iter  50 value 35.018233
## iter  60 value 34.042314
## iter  70 value 28.907243
## iter  80 value 26.316429
## iter  90 value 25.263122
## iter 100 value 23.316918
## final  value 23.316918
## stopped after 100 iterations
## # weights:  109
## initial  value 83.188527
## iter  10 value 28.268240
## iter  20 value 21.936391
## iter  30 value 20.065398
## iter  40 value 18.630963
## iter  50 value 17.970056
## iter  60 value 13.959872
## iter  70 value 12.926596
## iter  80 value 12.745194
## iter  90 value 11.182971
## iter 100 value 10.897900
## final  value 10.897900
## stopped after 100 iterations
## # weights:  179
## initial  value 88.663771
## iter  10 value 11.817962
## iter  20 value 4.425132
## iter  30 value 4.356586
## iter  40 value 4.330111
## iter  50 value 3.455265
## iter  60 value 1.619995
## iter  70 value 1.546960
```

```
## iter  80 value 1.538855
## iter  90 value 1.520211
## iter 100 value 0.157552
## final  value 0.157552
## stopped after 100 iterations
## # weights:  39
## initial  value 94.783065
## iter  10 value 53.592345
## iter  20 value 47.413612
## iter  30 value 47.405922
## final  value 47.405898
## converged
## # weights:  109
## initial  value 87.084715
## iter  10 value 26.023255
## iter  20 value 10.114774
## iter  30 value 6.342580
## iter  40 value 2.451392
## iter  50 value 0.385445
## iter  60 value 0.004774
## final  value 0.000074
## converged
## # weights:  179
## initial  value 97.163515
## iter  10 value 2.318107
## iter  20 value 0.034487
## iter  30 value 0.003940
## iter  40 value 0.000306
## final  value 0.000056
## converged
## # weights:  39
## initial  value 86.806419
## iter  10 value 75.907903
## iter  20 value 54.688468
## iter  30 value 50.443480
## iter  40 value 46.229664
## iter  50 value 45.961644
## final  value 45.958668
## converged
## # weights:  109
## initial  value 85.421652
## iter  10 value 36.382018
## iter  20 value 18.181113
## iter  30 value 13.355138
## iter  40 value 12.954718
## iter  50 value 12.933512
## iter  60 value 12.932679
## iter  70 value 12.932642
## final  value 12.932639
## converged
## # weights:  179
## initial  value 83.841104
## iter  10 value 18.837481
## iter  20 value 11.161662
```

```
## iter  30 value 9.930130
## iter  40 value 9.566609
## iter  50 value 9.197280
## iter  60 value 9.032886
## iter  70 value 9.028200
## final  value 9.028183
## converged
## # weights:  39
## initial  value 84.493812
## iter  10 value 48.961837
## iter  20 value 47.120962
## iter  30 value 47.082685
## iter  40 value 47.041195
## iter  50 value 44.496694
## iter  60 value 41.900776
## iter  70 value 41.830720
## iter  80 value 41.820574
## iter  90 value 41.813915
## iter 100 value 39.622200
## final  value 39.622200
## stopped after 100 iterations
## # weights:  109
## initial  value 88.138094
## iter  10 value 21.747293
## iter  20 value 15.048828
## iter  30 value 4.739654
## iter  40 value 3.025010
## iter  50 value 0.210109
## iter  60 value 0.137009
## iter  70 value 0.124200
## iter  80 value 0.115496
## iter  90 value 0.102141
## iter 100 value 0.098121
## final  value 0.098121
## stopped after 100 iterations
## # weights:  179
## initial  value 91.373849
## iter  10 value 20.036539
## iter  20 value 16.034971
## iter  30 value 13.476093
## iter  40 value 8.681280
## iter  50 value 8.207184
## iter  60 value 8.188263
## iter  70 value 6.974597
## iter  80 value 0.151427
## iter  90 value 0.116454
## iter 100 value 0.109773
## final  value 0.109773
## stopped after 100 iterations
## # weights:  39
## initial  value 86.274487
## iter  10 value 54.969200
## iter  20 value 46.295371
## iter  30 value 43.451786
```

```
## iter  40 value 35.825469
## iter  50 value 30.188165
## iter  60 value 29.345780
## iter  70 value 29.332040
## iter  80 value 29.150480
## iter  90 value 27.963031
## iter 100 value 26.884173
## final  value 26.884173
## stopped after 100 iterations
## # weights:  109
## initial  value 80.318196
## iter  10 value 33.230696
## iter  20 value 29.954567
## iter  30 value 21.628038
## iter  40 value 19.174917
## iter  50 value 19.114320
## iter  60 value 19.108960
## iter  70 value 17.916887
## iter  80 value 17.492408
## iter  90 value 17.491062
## iter 100 value 16.469337
## final  value 16.469337
## stopped after 100 iterations
## # weights:  179
## initial  value 116.205737
## iter  10 value 25.710360
## iter  20 value 0.588619
## iter  30 value 0.001871
## iter  40 value 0.000492
## final  value 0.000041
## converged
## # weights:  39
## initial  value 85.707050
## iter  10 value 59.869708
## iter  20 value 50.880603
## iter  30 value 47.953242
## iter  40 value 47.821941
## iter  50 value 47.708402
## iter  60 value 45.499533
## iter  70 value 44.250235
## iter  80 value 44.003961
## final  value 44.003956
## converged
## # weights:  109
## initial  value 82.029705
## iter  10 value 43.266080
## iter  20 value 18.106270
## iter  30 value 14.673940
## iter  40 value 14.289562
## iter  50 value 14.087079
## iter  60 value 14.022807
## iter  70 value 14.002406
## iter  80 value 13.996983
## iter  90 value 13.817015
```

```
## iter 100 value 13.636175
## final  value 13.636175
## stopped after 100 iterations
## # weights:  179
## initial  value 98.834823
## iter  10 value 36.380523
## iter  20 value 16.515008
## iter  30 value 12.663731
## iter  40 value 10.549273
## iter  50 value 10.060107
## iter  60 value 9.870984
## iter  70 value 9.487019
## iter  80 value 9.401886
## iter  90 value 9.366593
## iter 100 value 9.363588
## final  value 9.363588
## stopped after 100 iterations
## # weights:  39
## initial  value 92.269604
## iter  10 value 45.213232
## iter  20 value 33.655342
## iter  30 value 25.408527
## iter  40 value 21.498229
## iter  50 value 19.126444
## iter  60 value 18.590005
## iter  70 value 17.211918
## iter  80 value 15.679628
## iter  90 value 15.526128
## iter 100 value 15.486981
## final  value 15.486981
## stopped after 100 iterations
## # weights:  109
## initial  value 86.556071
## iter  10 value 21.126144
## iter  20 value 12.730770
## iter  30 value 8.742250
## iter  40 value 5.295686
## iter  50 value 5.189398
## iter  60 value 2.870990
## iter  70 value 2.670458
## iter  80 value 2.568535
## iter  90 value 2.551348
## iter 100 value 2.543453
## final  value 2.543453
## stopped after 100 iterations
## # weights:  179
## initial  value 85.899796
## iter  10 value 19.404934
## iter  20 value 1.100866
## iter  30 value 0.267923
## iter  40 value 0.246658
## iter  50 value 0.208982
## iter  60 value 0.191440
## iter  70 value 0.169343
```

```
## iter  80 value 0.153520
## iter  90 value 0.129620
## iter 100 value 0.107696
## final  value 0.107696
## stopped after 100 iterations
## # weights:  39
## initial  value 85.430115
## iter  10 value 57.225354
## iter  20 value 53.384902
## iter  30 value 51.057077
## iter  40 value 50.925104
## iter  50 value 50.922126
## iter  60 value 50.921837
## iter  70 value 50.920673
## final  value 50.920351
## converged
## # weights:  109
## initial  value 85.167665
## iter  10 value 43.130540
## iter  20 value 23.554206
## iter  30 value 21.552249
## iter  40 value 20.072041
## iter  50 value 19.914727
## iter  60 value 19.902638
## iter  70 value 19.891377
## iter  80 value 16.626852
## iter  90 value 13.128356
## iter 100 value 12.955756
## final  value 12.955756
## stopped after 100 iterations
## # weights:  179
## initial  value 88.286280
## iter  10 value 4.681288
## iter  20 value 0.043541
## iter  30 value 0.018550
## iter  40 value 0.003462
## iter  50 value 0.001255
## final  value 0.000069
## converged
## # weights:  39
## initial  value 94.891027
## iter  10 value 55.411517
## iter  20 value 48.375786
## iter  30 value 46.518448
## iter  40 value 46.394271
## iter  50 value 46.219650
## iter  60 value 45.602791
## iter  70 value 45.547223
## final  value 45.547177
## converged
## # weights:  109
## initial  value 87.111745
## iter  10 value 30.400489
## iter  20 value 19.456495
```

```
## iter  30 value 14.712802
## iter  40 value 13.830381
## iter  50 value 13.701561
## iter  60 value 13.696985
## iter  70 value 13.696311
## iter  80 value 13.696173
## final  value 13.696161
## converged
## # weights:  179
## initial  value 104.196537
## iter  10 value 39.403897
## iter  20 value 17.959820
## iter  30 value 12.788810
## iter  40 value 10.185183
## iter  50 value 9.919076
## iter  60 value 9.778906
## iter  70 value 9.770507
## iter  80 value 9.770228
## iter  90 value 9.770166
## final  value 9.770163
## converged
## # weights:  39
## initial  value 88.889867
## iter  10 value 52.154530
## iter  20 value 47.815507
## iter  30 value 46.865824
## iter  40 value 46.568644
## iter  50 value 46.541225
## iter  60 value 45.922501
## iter  70 value 45.329131
## iter  80 value 45.327348
## iter  90 value 45.317741
## iter 100 value 45.311484
## final  value 45.311484
## stopped after 100 iterations
## # weights:  109
## initial  value 95.002202
## iter  10 value 28.105194
## iter  20 value 0.797318
## iter  30 value 0.283174
## iter  40 value 0.243165
## iter  50 value 0.213412
## iter  60 value 0.179481
## iter  70 value 0.158125
## iter  80 value 0.147890
## iter  90 value 0.138696
## iter 100 value 0.133682
## final  value 0.133682
## stopped after 100 iterations
## # weights:  179
## initial  value 94.277604
## iter  10 value 13.652133
## iter  20 value 4.123864
## iter  30 value 3.446456
```

```
## iter  40 value 3.020496
## iter  50 value 2.823374
## iter  60 value 2.772622
## iter  70 value 0.522470
## iter  80 value 0.237647
## iter  90 value 0.208239
## iter 100 value 0.139159
## final  value 0.139159
## stopped after 100 iterations
## # weights:  39
## initial  value 94.460149
## iter  10 value 51.389012
## iter  20 value 43.140962
## iter  30 value 33.502189
## iter  40 value 27.847599
## iter  50 value 26.824443
## iter  60 value 26.640600
## iter  70 value 26.619348
## iter  80 value 26.597036
## iter  90 value 26.590045
## iter 100 value 26.575277
## final  value 26.575277
## stopped after 100 iterations
## # weights:  109
## initial  value 90.391599
## iter  10 value 7.930567
## iter  20 value 3.633502
## iter  30 value 3.526730
## iter  40 value 3.443888
## iter  50 value 2.982633
## iter  60 value 0.006821
## iter  70 value 0.002643
## iter  80 value 0.000379
## iter  90 value 0.000223
## iter 100 value 0.000128
## final  value 0.000128
## stopped after 100 iterations
## # weights:  179
## initial  value 87.133673
## iter  10 value 12.481079
## iter  20 value 3.318230
## iter  30 value 1.831807
## iter  40 value 0.056883
## iter  50 value 0.013627
## iter  60 value 0.006736
## iter  70 value 0.003365
## iter  80 value 0.001944
## iter  90 value 0.001451
## iter 100 value 0.000798
## final  value 0.000798
## stopped after 100 iterations
## # weights:  39
## initial  value 88.563420
## iter  10 value 47.640507
```

```
## iter  20 value 44.315735
## iter  30 value 42.430785
## iter  40 value 41.526490
## iter  50 value 41.412117
## iter  60 value 40.455560
## iter  70 value 40.143907
## final  value 40.139625
## converged
## # weights:  109
## initial  value 85.979869
## iter  10 value 37.610561
## iter  20 value 18.706558
## iter  30 value 14.114685
## iter  40 value 13.069311
## iter  50 value 12.948879
## iter  60 value 12.924478
## iter  70 value 12.920273
## iter  80 value 12.843843
## iter  90 value 12.714622
## iter 100 value 12.711120
## final  value 12.711120
## stopped after 100 iterations
## # weights:  179
## initial  value 87.609021
## iter  10 value 29.697635
## iter  20 value 11.896680
## iter  30 value 9.670379
## iter  40 value 9.141076
## iter  50 value 9.085234
## iter  60 value 9.072865
## iter  70 value 9.072378
## iter  80 value 9.072302
## final  value 9.072299
## converged
## # weights:  39
## initial  value 84.685863
## iter  10 value 61.851769
## iter  20 value 42.560284
## iter  30 value 41.078396
## iter  40 value 40.657067
## iter  50 value 40.600519
## iter  60 value 40.594214
## iter  70 value 40.592003
## iter  80 value 40.580621
## iter  90 value 37.142350
## iter 100 value 35.353003
## final  value 35.353003
## stopped after 100 iterations
## # weights:  109
## initial  value 86.006150
## iter  10 value 12.014673
## iter  20 value 8.523674
## iter  30 value 4.504624
## iter  40 value 3.986184
```

```
## iter  50 value 3.940254
## iter  60 value 3.464024
## iter  70 value 3.362368
## iter  80 value 3.345236
## iter  90 value 3.301024
## iter 100 value 3.275278
## final  value 3.275278
## stopped after 100 iterations
## # weights:  179
## initial  value 91.636387
## iter  10 value 19.423609
## iter  20 value 2.315661
## iter  30 value 0.213472
## iter  40 value 0.181507
## iter  50 value 0.164156
## iter  60 value 0.143868
## iter  70 value 0.129505
## iter  80 value 0.119273
## iter  90 value 0.107597
## iter 100 value 0.100645
## final  value 0.100645
## stopped after 100 iterations
## # weights:  39
## initial  value 96.098385
## iter  10 value 39.375213
## iter  20 value 37.798208
## iter  30 value 37.538787
## iter  40 value 35.200981
## iter  50 value 33.220585
## iter  60 value 33.181587
## iter  70 value 33.164335
## iter  80 value 33.125487
## iter  90 value 33.021383
## iter 100 value 32.883628
## final  value 32.883628
## stopped after 100 iterations
## # weights:  109
## initial  value 100.613408
## iter  10 value 34.385032
## iter  20 value 22.629568
## iter  30 value 22.206673
## iter  40 value 22.099804
## iter  50 value 18.525970
## iter  60 value 18.522409
## final  value 18.522345
## converged
## # weights:  179
## initial  value 109.623683
## iter  10 value 18.936297
## iter  20 value 3.276659
## iter  30 value 2.780370
## iter  40 value 2.772626
## iter  50 value 2.772606
## final  value 2.772589
```

```
## converged
## # weights:  39
## initial  value 100.819689
## iter  10 value 66.110514
## iter  20 value 51.872886
## iter  30 value 47.839847
## iter  40 value 46.910595
## iter  50 value 44.475972
## iter  60 value 42.359488
## iter  70 value 42.182041
## iter  80 value 42.178825
## iter  90 value 41.954433
## iter 100 value 41.022153
## final  value 41.022153
## stopped after 100 iterations
## # weights:  109
## initial  value 83.972304
## iter  10 value 31.973653
## iter  20 value 18.513537
## iter  30 value 14.075397
## iter  40 value 13.374546
## iter  50 value 12.785221
## iter  60 value 11.878226
## iter  70 value 11.744054
## final  value 11.743838
## converged
## # weights:  179
## initial  value 75.849269
## iter  10 value 32.628312
## iter  20 value 14.725494
## iter  30 value 10.022148
## iter  40 value 9.189537
## iter  50 value 9.130171
## iter  60 value 9.080929
## iter  70 value 8.908773
## iter  80 value 8.841742
## final  value 8.841481
## converged
## # weights:  39
## initial  value 85.799499
## iter  10 value 43.617362
## iter  20 value 34.249951
## iter  30 value 31.305164
## iter  40 value 30.361464
## iter  50 value 30.290953
## iter  60 value 29.599607
## iter  70 value 28.454963
## iter  80 value 26.964606
## iter  90 value 26.504183
## iter 100 value 26.233920
## final  value 26.233920
## stopped after 100 iterations
## # weights:  109
## initial  value 84.346112
```

```
## iter  10 value 31.238751
## iter  20 value 24.851702
## iter  30 value 17.040986
## iter  40 value 16.468365
## iter  50 value 14.804783
## iter  60 value 14.706728
## iter  70 value 14.691470
## iter  80 value 11.901883
## iter  90 value 7.924900
## iter 100 value 5.185011
## final  value 5.185011
## stopped after 100 iterations
## # weights:  179
## initial  value 135.816014
## iter  10 value 28.633434
## iter  20 value 3.210789
## iter  30 value 0.332123
## iter  40 value 0.287206
## iter  50 value 0.267787
## iter  60 value 0.241176
## iter  70 value 0.204326
## iter  80 value 0.161146
## iter  90 value 0.133226
## iter 100 value 0.123824
## final  value 0.123824
## stopped after 100 iterations
## # weights:  39
## initial  value 84.555277
## iter  10 value 52.401706
## iter  20 value 46.716274
## iter  30 value 44.489603
## iter  40 value 41.728293
## iter  50 value 41.441095
## iter  60 value 40.317774
## iter  70 value 40.163819
## iter  80 value 40.090193
## iter  90 value 40.084579
## iter 100 value 40.084029
## final  value 40.084029
## stopped after 100 iterations
## # weights:  109
## initial  value 84.461243
## iter  10 value 25.676559
## iter  20 value 10.681158
## iter  30 value 10.241056
## iter  40 value 9.941434
## iter  50 value 9.937546
## iter  60 value 9.937409
## final  value 9.937406
## converged
## # weights:  179
## initial  value 85.647588
## iter  10 value 1.113502
## iter  20 value 0.015207
```

```
## iter  30 value 0.001123
## iter  40 value 0.000121
## final  value 0.000095
## converged
## # weights:  39
## initial  value 84.493059
## iter  10 value 55.337174
## iter  20 value 49.473363
## iter  30 value 45.855050
## iter  40 value 45.236948
## iter  50 value 45.231476
## final  value 45.231474
## converged
## # weights:  109
## initial  value 88.576805
## iter  10 value 47.901369
## iter  20 value 19.973965
## iter  30 value 16.340185
## iter  40 value 14.075666
## iter  50 value 13.241925
## iter  60 value 13.230843
## final  value 13.230825
## converged
## # weights:  179
## initial  value 96.244694
## iter  10 value 36.815255
## iter  20 value 16.444696
## iter  30 value 13.402294
## iter  40 value 10.660775
## iter  50 value 9.741046
## iter  60 value 9.718537
## iter  70 value 9.717106
## iter  80 value 9.717017
## iter  90 value 9.717015
## final  value 9.717014
## converged
## # weights:  39
## initial  value 87.527507
## iter  10 value 59.470647
## iter  20 value 54.261550
## iter  30 value 50.852477
## iter  40 value 43.821573
## iter  50 value 37.665738
## iter  60 value 34.944475
## iter  70 value 32.372165
## iter  80 value 30.552119
## iter  90 value 29.890023
## iter 100 value 29.628402
## final  value 29.628402
## stopped after 100 iterations
## # weights:  109
## initial  value 95.897478
## iter  10 value 19.551051
## iter  20 value 6.736674
```

```
## iter  30 value 0.306956
## iter  40 value 0.151007
## iter  50 value 0.130962
## iter  60 value 0.125228
## iter  70 value 0.119796
## iter  80 value 0.114569
## iter  90 value 0.104433
## iter 100 value 0.097994
## final  value 0.097994
## stopped after 100 iterations
## # weights:  179
## initial  value 92.894485
## iter  10 value 7.813962
## iter  20 value 2.245462
## iter  30 value 2.056088
## iter  40 value 1.739702
## iter  50 value 1.564327
## iter  60 value 1.539055
## iter  70 value 0.191459
## iter  80 value 0.153090
## iter  90 value 0.143226
## iter 100 value 0.120820
## final  value 0.120820
## stopped after 100 iterations
## # weights:  39
## initial  value 82.045220
## iter  10 value 50.460103
## iter  20 value 40.359635
## iter  30 value 39.868212
## iter  40 value 39.801420
## iter  50 value 39.796008
## iter  60 value 39.777249
## iter  70 value 39.744564
## iter  80 value 39.715937
## final  value 39.700620
## converged
## # weights:  109
## initial  value 93.497383
## iter  10 value 23.968601
## iter  20 value 11.199831
## iter  30 value 9.462070
## iter  40 value 9.142694
## iter  50 value 9.125637
## iter  60 value 9.124723
## iter  70 value 9.124622
## iter  80 value 9.124597
## final  value 9.124593
## converged
## # weights:  179
## initial  value 89.102480
## iter  10 value 2.568511
## iter  20 value 0.004981
## iter  30 value 0.000125
## final  value 0.000087
```

```
## converged
## # weights:  39
## initial  value 90.422485
## iter  10 value 55.439180
## iter  20 value 51.210726
## iter  30 value 49.466750
## iter  40 value 47.377306
## iter  50 value 46.510887
## iter  60 value 46.510403
## iter  70 value 46.505202
## iter  80 value 45.837570
## iter  90 value 44.594694
## final  value 44.551711
## converged
## # weights:  109
## initial  value 84.935148
## iter  10 value 40.757184
## iter  20 value 19.629173
## iter  30 value 15.348745
## iter  40 value 12.681702
## iter  50 value 12.199866
## iter  60 value 12.185067
## iter  70 value 12.184624
## iter  80 value 12.184611
## iter  80 value 12.184611
## iter  80 value 12.184611
## final  value 12.184611
## converged
## # weights:  179
## initial  value 83.910426
## iter  10 value 34.998274
## iter  20 value 15.773805
## iter  30 value 12.113621
## iter  40 value 10.561321
## iter  50 value 10.240869
## iter  60 value 10.221188
## iter  70 value 10.218426
## iter  80 value 10.217704
## iter  90 value 10.217680
## final  value 10.217679
## converged
## # weights:  39
## initial  value 87.161684
## iter  10 value 48.919987
## iter  20 value 37.120230
## iter  30 value 33.619473
## iter  40 value 31.964313
## iter  50 value 31.846112
## iter  60 value 31.833067
## iter  70 value 31.788296
## iter  80 value 31.785319
## iter  90 value 31.771949
## iter 100 value 31.770205
## final  value 31.770205
```

```
## stopped after 100 iterations
## # weights:  109
## initial  value 84.472374
## iter  10 value 24.637282
## iter  20 value 6.256709
## iter  30 value 3.710129
## iter  40 value 2.301789
## iter  50 value 0.196754
## iter  60 value 0.154125
## iter  70 value 0.142200
## iter  80 value 0.124523
## iter  90 value 0.110449
## iter 100 value 0.101403
## final  value 0.101403
## stopped after 100 iterations
## # weights:  179
## initial  value 86.311468
## iter  10 value 19.606938
## iter  20 value 0.175800
## iter  30 value 0.140464
## iter  40 value 0.127027
## iter  50 value 0.105444
## iter  60 value 0.088970
## iter  70 value 0.081223
## iter  80 value 0.078218
## iter  90 value 0.073560
## iter 100 value 0.068932
## final  value 0.068932
## stopped after 100 iterations
## # weights:  39
## initial  value 95.240893
## iter  10 value 54.335887
## iter  20 value 44.230801
## iter  30 value 40.626475
## iter  40 value 40.607851
## final  value 40.607827
## converged
## # weights:  109
## initial  value 91.822970
## iter  10 value 33.620848
## iter  20 value 21.077220
## iter  30 value 17.886135
## iter  40 value 10.261788
## iter  50 value 5.746909
## iter  60 value 3.450583
## iter  70 value 3.343943
## iter  80 value 3.015293
## iter  90 value 3.014907
## iter 100 value 3.014293
## final  value 3.014293
## stopped after 100 iterations
## # weights:  179
## initial  value 78.654200
## iter  10 value 21.477523
```

```
## iter  20 value 5.268091
## iter  30 value 2.269101
## iter  40 value 0.116834
## iter  50 value 0.041772
## iter  60 value 0.002297
## iter  70 value 0.000695
## iter  80 value 0.000405
## final  value 0.000078
## converged
## # weights:  39
## initial  value 88.612030
## iter  10 value 49.622789
## iter  20 value 46.781365
## iter  30 value 45.469918
## iter  40 value 44.221383
## iter  50 value 43.291555
## iter  60 value 42.952889
## iter  70 value 42.777443
## iter  80 value 41.746366
## iter  90 value 41.701759
## final  value 41.701757
## converged
## # weights:  109
## initial  value 112.009100
## iter  10 value 39.822394
## iter  20 value 18.341515
## iter  30 value 13.739736
## iter  40 value 12.873716
## iter  50 value 12.801245
## iter  60 value 12.730344
## iter  70 value 12.373070
## iter  80 value 12.300504
## final  value 12.300475
## converged
## # weights:  179
## initial  value 90.899929
## iter  10 value 25.380800
## iter  20 value 11.075211
## iter  30 value 9.434821
## iter  40 value 9.309890
## iter  50 value 9.293179
## iter  60 value 9.292766
## final  value 9.292761
## converged
## # weights:  39
## initial  value 84.660999
## iter  10 value 49.398835
## iter  20 value 38.087474
## iter  30 value 32.891198
## iter  40 value 32.856073
## iter  50 value 32.853953
## iter  60 value 32.842141
## iter  70 value 32.841166
## iter  80 value 32.535814
```

```
## iter  90 value 26.878178
## iter 100 value 22.543424
## final  value 22.543424
## stopped after 100 iterations
## # weights:  109
## initial  value 81.280071
## iter  10 value 20.730092
## iter  20 value 12.601547
## iter  30 value 10.933330
## iter  40 value 10.309970
## iter  50 value 10.261066
## iter  60 value 10.249574
## iter  70 value 10.232252
## iter  80 value 10.220141
## iter  90 value 9.603298
## iter 100 value 5.631390
## final  value 5.631390
## stopped after 100 iterations
## # weights:  179
## initial  value 92.642853
## iter  10 value 18.447145
## iter  20 value 1.291731
## iter  30 value 0.247518
## iter  40 value 0.176579
## iter  50 value 0.147135
## iter  60 value 0.125422
## iter  70 value 0.111623
## iter  80 value 0.098209
## iter  90 value 0.090113
## iter 100 value 0.085956
## final  value 0.085956
## stopped after 100 iterations
## # weights:  39
## initial  value 84.634485
## iter  10 value 60.329517
## iter  20 value 48.805937
## iter  30 value 47.747798
## iter  40 value 47.676858
## iter  50 value 47.667324
## iter  60 value 47.666017
## iter  70 value 47.665841
## final  value 47.665820
## converged
## # weights:  109
## initial  value 76.844182
## iter  10 value 12.473045
## iter  20 value 6.860033
## iter  30 value 6.482738
## iter  40 value 6.228858
## iter  50 value 5.926822
## iter  60 value 5.830490
## iter  70 value 5.738519
## iter  80 value 5.499911
## iter  90 value 5.113787
```

```
## iter 100 value 5.040150
## final  value 5.040150
## stopped after 100 iterations
## # weights:  179
## initial  value 97.227967
## iter  10 value 28.335348
## iter  20 value 13.570519
## iter  30 value 0.172348
## iter  40 value 0.008744
## iter  50 value 0.001066
## iter  60 value 0.000187
## final  value 0.000086
## converged
## # weights:  39
## initial  value 99.102172
## iter  10 value 62.321742
## iter  20 value 43.079288
## iter  30 value 41.755140
## iter  40 value 41.708582
## iter  50 value 41.345610
## iter  60 value 39.218102
## iter  70 value 38.195904
## iter  80 value 37.834449
## iter  90 value 37.409385
## iter 100 value 37.207320
## final  value 37.207320
## stopped after 100 iterations
## # weights:  109
## initial  value 79.457797
## iter  10 value 42.195002
## iter  20 value 23.916126
## iter  30 value 14.692237
## iter  40 value 13.636215
## iter  50 value 13.571933
## iter  60 value 13.570770
## final  value 13.570758
## converged
## # weights:  179
## initial  value 80.324008
## iter  10 value 26.593789
## iter  20 value 13.256101
## iter  30 value 10.056126
## iter  40 value 9.635744
## iter  50 value 9.599798
## iter  60 value 9.598230
## iter  70 value 9.598190
## final  value 9.598190
## converged
## # weights:  39
## initial  value 106.372760
## iter  10 value 50.764720
## iter  20 value 45.703467
## iter  30 value 45.118499
## iter  40 value 44.996638
```

```
## iter  50 value 44.977079
## iter  60 value 44.163350
## iter  70 value 44.138066
## iter  80 value 43.771994
## iter  90 value 42.693493
## iter 100 value 41.801180
## final  value 41.801180
## stopped after 100 iterations
## # weights:  109
## initial  value 94.368265
## iter  10 value 37.537841
## iter  20 value 9.237348
## iter  30 value 5.607793
## iter  40 value 3.957762
## iter  50 value 3.582007
## iter  60 value 3.457202
## iter  70 value 3.422662
## iter  80 value 3.420760
## iter  90 value 3.118252
## iter 100 value 2.962920
## final  value 2.962920
## stopped after 100 iterations
## # weights:  179
## initial  value 77.328495
## iter  10 value 6.997263
## iter  20 value 6.087295
## iter  30 value 2.731081
## iter  40 value 2.697898
## iter  50 value 2.625033
## iter  60 value 0.303728
## iter  70 value 0.196101
## iter  80 value 0.179384
## iter  90 value 0.170934
## iter 100 value 0.143402
## final  value 0.143402
## stopped after 100 iterations
## # weights:  39
## initial  value 87.726434
## iter  10 value 56.789121
## iter  20 value 51.328945
## iter  30 value 50.727551
## iter  40 value 50.565547
## iter  50 value 50.544471
## iter  60 value 50.541772
## iter  70 value 50.514281
## iter  80 value 50.493113
## iter  90 value 50.492645
## final  value 50.492608
## converged
## # weights:  109
## initial  value 85.146082
## iter  10 value 17.247189
## iter  20 value 4.934125
## iter  30 value 1.789466
```

```
## iter  40 value 0.057120
## iter  50 value 0.001257
## iter  60 value 0.000343
## iter  70 value 0.000103
## iter  70 value 0.000091
## iter  70 value 0.000091
## final  value 0.000091
## converged
## # weights:  179
## initial  value 91.033007
## iter  10 value 31.708816
## iter  20 value 18.209857
## iter  30 value 13.518443
## iter  40 value 11.694392
## iter  50 value 6.317442
## iter  60 value 6.163341
## iter  70 value 5.388519
## iter  80 value 5.072793
## iter  90 value 4.812263
## iter 100 value 4.684259
## final  value 4.684259
## stopped after 100 iterations
## # weights:  39
## initial  value 90.979391
## iter  10 value 63.840346
## iter  20 value 52.615424
## iter  30 value 45.795996
## iter  40 value 43.481910
## iter  50 value 43.400406
## final  value 43.400337
## converged
## # weights:  109
## initial  value 94.210037
## iter  10 value 34.748607
## iter  20 value 17.477748
## iter  30 value 13.690121
## iter  40 value 13.313755
## iter  50 value 13.103820
## iter  60 value 12.300829
## iter  70 value 12.274187
## final  value 12.273916
## converged
## # weights:  179
## initial  value 107.781479
## iter  10 value 46.113231
## iter  20 value 19.705543
## iter  30 value 13.620713
## iter  40 value 11.207289
## iter  50 value 10.508541
## iter  60 value 10.257546
## iter  70 value 10.057342
## iter  80 value 9.993389
## iter  90 value 9.980312
## iter 100 value 9.979237
```

```
## final  value 9.979237
## stopped after 100 iterations
## # weights:  39
## initial  value 85.637996
## iter  10 value 51.653682
## iter  20 value 47.024852
## iter  30 value 46.141526
## iter  40 value 44.813804
## iter  50 value 43.907115
## iter  60 value 43.822581
## iter  70 value 41.708388
## iter  80 value 37.321295
## iter  90 value 37.050755
## iter 100 value 36.959947
## final  value 36.959947
## stopped after 100 iterations
## # weights:  109
## initial  value 101.922916
## iter  10 value 40.093598
## iter  20 value 26.172665
## iter  30 value 23.959575
## iter  40 value 22.213973
## iter  50 value 21.606453
## iter  60 value 20.312927
## iter  70 value 19.728491
## iter  80 value 19.199098
## iter  90 value 18.996476
## iter 100 value 18.489666
## final  value 18.489666
## stopped after 100 iterations
## # weights:  179
## initial  value 88.500525
## iter  10 value 16.236081
## iter  20 value 9.359549
## iter  30 value 9.170230
## iter  40 value 9.113127
## iter  50 value 9.100655
## iter  60 value 8.683624
## iter  70 value 7.757516
## iter  80 value 4.253156
## iter  90 value 1.718618
## iter 100 value 1.557530
## final  value 1.557530
## stopped after 100 iterations
## # weights:  39
## initial  value 85.504158
## iter  10 value 51.035108
## iter  20 value 39.313031
## iter  30 value 37.099374
## iter  40 value 32.067650
## iter  50 value 24.718688
## iter  60 value 23.051059
## iter  70 value 22.770872
## iter  80 value 22.262695
```

```
## iter  90 value 17.880586
## iter 100 value 17.030609
## final  value 17.030609
## stopped after 100 iterations
## # weights:  109
## initial  value 86.368387
## iter  10 value 19.955508
## iter  20 value 3.918924
## iter  30 value 3.866134
## iter  40 value 3.862093
## final  value 3.862085
## converged
## # weights:  179
## initial  value 93.404603
## iter  10 value 6.995081
## iter  20 value 0.032685
## iter  30 value 0.000865
## final  value 0.000054
## converged
## # weights:  39
## initial  value 88.314914
## iter  10 value 55.186139
## iter  20 value 48.766242
## iter  30 value 46.880364
## iter  40 value 44.863689
## iter  50 value 44.716557
## final  value 44.715521
## converged
## # weights:  109
## initial  value 84.554258
## iter  10 value 42.769099
## iter  20 value 23.746488
## iter  30 value 15.237052
## iter  40 value 13.910516
## iter  50 value 13.855195
## iter  60 value 13.498744
## iter  70 value 13.340045
## final  value 13.339054
## converged
## # weights:  179
## initial  value 89.700336
## iter  10 value 19.369542
## iter  20 value 14.319760
## iter  30 value 11.368265
## iter  40 value 10.238950
## iter  50 value 10.019604
## iter  60 value 9.545527
## iter  70 value 9.456907
## iter  80 value 9.454461
## final  value 9.454459
## converged
## # weights:  39
## initial  value 83.217860
## iter  10 value 72.301523
```

```
## iter  20 value 54.547624
## iter  30 value 52.650064
## iter  40 value 48.000311
## iter  50 value 43.628001
## iter  60 value 41.230736
## iter  70 value 40.589780
## iter  80 value 40.319703
## iter  90 value 40.260977
## iter 100 value 33.202884
## final  value 33.202884
## stopped after 100 iterations
## # weights:  109
## initial  value 88.484848
## iter  10 value 27.234702
## iter  20 value 21.714300
## iter  30 value 21.677894
## iter  40 value 21.668467
## iter  50 value 21.650414
## iter  60 value 17.602318
## iter  70 value 15.493875
## iter  80 value 13.471855
## iter  90 value 0.548009
## iter 100 value 0.319634
## final  value 0.319634
## stopped after 100 iterations
## # weights:  179
## initial  value 85.158137
## iter  10 value 12.325689
## iter  20 value 5.530979
## iter  30 value 5.478463
## iter  40 value 2.125036
## iter  50 value 0.324598
## iter  60 value 0.196629
## iter  70 value 0.176477
## iter  80 value 0.156429
## iter  90 value 0.135107
## iter 100 value 0.117466
## final  value 0.117466
## stopped after 100 iterations
## # weights:  39
## initial  value 86.135040
## iter  10 value 58.849612
## iter  20 value 58.394005
## iter  30 value 57.215602
## iter  40 value 57.133695
## iter  50 value 56.957008
## iter  60 value 56.945747
## iter  70 value 56.203676
## iter  80 value 56.199832
## final  value 56.199496
## converged
## # weights:  109
## initial  value 85.263801
## iter  10 value 27.988399
```

```
## iter  20 value 10.459205
## iter  30 value 7.577709
## iter  40 value 7.554635
## iter  50 value 7.553103
## iter  60 value 7.553016
## iter  70 value 7.552982
## iter  80 value 7.552955
## final  value 7.552946
## converged
## # weights:  179
## initial  value 83.454380
## iter  10 value 5.220893
## iter  20 value 0.029194
## iter  30 value 0.000437
## iter  40 value 0.000113
## final  value 0.000098
## converged
## # weights:  39
## initial  value 85.070266
## iter  10 value 54.291042
## iter  20 value 50.846707
## iter  30 value 48.493029
## iter  40 value 43.253338
## iter  50 value 40.909423
## iter  60 value 40.789941
## final  value 40.789597
## converged
## # weights:  109
## initial  value 94.846875
## iter  10 value 45.152128
## iter  20 value 20.695816
## iter  30 value 13.259740
## iter  40 value 12.642599
## iter  50 value 12.606915
## iter  60 value 12.605400
## final  value 12.605382
## converged
## # weights:  179
## initial  value 99.763452
## iter  10 value 25.733380
## iter  20 value 11.276527
## iter  30 value 9.864735
## iter  40 value 8.510892
## iter  50 value 8.339314
## iter  60 value 8.330291
## iter  70 value 8.330149
## final  value 8.330147
## converged
## # weights:  39
## initial  value 80.735696
## iter  10 value 38.502479
## iter  20 value 38.032847
## iter  30 value 36.681442
## iter  40 value 33.928468
```

```
## iter  50 value 31.669356
## iter  60 value 31.330768
## iter  70 value 31.319876
## iter  80 value 31.309714
## iter  90 value 31.302838
## iter 100 value 31.300966
## final  value 31.300966
## stopped after 100 iterations
## # weights:  109
## initial  value 88.127854
## iter  10 value 48.603377
## iter  20 value 24.800636
## iter  30 value 21.634162
## iter  40 value 15.363698
## iter  50 value 14.444290
## iter  60 value 11.549834
## iter  70 value 10.599064
## iter  80 value 10.538604
## iter  90 value 10.484701
## iter 100 value 10.336191
## final  value 10.336191
## stopped after 100 iterations
## # weights:  179
## initial  value 82.382368
## iter  10 value 3.335850
## iter  20 value 0.139071
## iter  30 value 0.126641
## iter  40 value 0.119501
## iter  50 value 0.110842
## iter  60 value 0.100903
## iter  70 value 0.092511
## iter  80 value 0.084827
## iter  90 value 0.079327
## iter 100 value 0.072589
## final  value 0.072589
## stopped after 100 iterations
## # weights:  39
## initial  value 88.569429
## iter  10 value 52.057311
## iter  20 value 49.489339
## iter  30 value 49.478717
## final  value 49.478695
## converged
## # weights:  109
## initial  value 85.658770
## iter  10 value 12.616459
## iter  20 value 9.979147
## iter  30 value 6.967466
## iter  40 value 5.472989
## iter  50 value 5.439773
## iter  60 value 5.436268
## iter  70 value 5.435758
## iter  80 value 5.435403
## iter  90 value 5.435114
```

```
## iter 100 value 5.435092
## final  value 5.435092
## stopped after 100 iterations
## # weights:  179
## initial  value 94.014756
## iter  10 value 9.614060
## iter  20 value 0.234099
## iter  30 value 0.022176
## iter  40 value 0.001376
## final  value 0.000092
## converged
## # weights:  39
## initial  value 87.228509
## iter  10 value 57.631346
## iter  20 value 51.427902
## iter  30 value 43.972267
## iter  40 value 40.559650
## iter  50 value 39.313853
## iter  60 value 39.002215
## iter  70 value 38.973746
## final  value 38.973734
## converged
## # weights:  109
## initial  value 84.306901
## iter  10 value 34.525259
## iter  20 value 20.977475
## iter  30 value 14.037339
## iter  40 value 13.771425
## iter  50 value 13.716870
## iter  60 value 13.671838
## iter  70 value 13.584142
## iter  80 value 13.559821
## iter  90 value 13.559421
## final  value 13.559420
## converged
## # weights:  179
## initial  value 92.205157
## iter  10 value 25.996815
## iter  20 value 10.571112
## iter  30 value 8.990252
## iter  40 value 8.840946
## iter  50 value 8.836100
## final  value 8.836079
## converged
## # weights:  39
## initial  value 96.536657
## iter  10 value 47.667920
## iter  20 value 40.664939
## iter  30 value 35.682169
## iter  40 value 32.022733
## iter  50 value 30.912803
## iter  60 value 28.477832
## iter  70 value 27.498188
## iter  80 value 24.424616
```

```
## iter  90 value 24.287537
## iter 100 value 23.689402
## final  value 23.689402
## stopped after 100 iterations
## # weights:  109
## initial  value 97.964712
## iter  10 value 16.029815
## iter  20 value 13.199702
## iter  30 value 8.474735
## iter  40 value 7.036124
## iter  50 value 6.142626
## iter  60 value 5.602834
## iter  70 value 5.560212
## iter  80 value 5.551014
## iter  90 value 4.896932
## iter 100 value 4.160753
## final  value 4.160753
## stopped after 100 iterations
## # weights:  179
## initial  value 110.375823
## iter  10 value 8.369583
## iter  20 value 5.567377
## iter  30 value 3.875420
## iter  40 value 2.057444
## iter  50 value 2.037662
## iter  60 value 2.021935
## iter  70 value 0.178508
## iter  80 value 0.114990
## iter  90 value 0.110359
## iter 100 value 0.105149
## final  value 0.105149
## stopped after 100 iterations
## # weights:  39
## initial  value 80.957537
## iter  10 value 50.055387
## iter  20 value 41.115415
## iter  30 value 40.857893
## final  value 40.857541
## converged
## # weights:  109
## initial  value 82.797846
## iter  10 value 14.267774
## iter  20 value 8.640742
## iter  30 value 8.491461
## iter  40 value 7.934376
## iter  50 value 6.920440
## iter  60 value 6.087126
## iter  70 value 5.896673
## iter  80 value 5.659031
## iter  90 value 4.319553
## iter 100 value 4.208385
## final  value 4.208385
## stopped after 100 iterations
## # weights:  179
```

```
## initial  value 101.835834
## iter  10 value 26.695753
## iter  20 value 0.251809
## iter  30 value 0.006019
## iter  40 value 0.001160
## iter  50 value 0.000163
## iter  50 value 0.000087
## iter  50 value 0.000087
## final  value 0.000087
## converged
## # weights:  39
## initial  value 89.748768
## iter  10 value 64.560955
## iter  20 value 56.987643
## iter  30 value 52.296687
## iter  40 value 48.628113
## iter  50 value 47.283428
## iter  60 value 46.072337
## iter  70 value 45.582333
## final  value 45.578561
## converged
## # weights:  109
## initial  value 101.878225
## iter  10 value 32.576616
## iter  20 value 17.956448
## iter  30 value 14.510480
## iter  40 value 13.695570
## iter  50 value 13.353245
## iter  60 value 13.340087
## iter  70 value 13.339678
## final  value 13.339662
## converged
## # weights:  179
## initial  value 104.304063
## iter  10 value 22.654255
## iter  20 value 11.808058
## iter  30 value 10.135618
## iter  40 value 9.584948
## iter  50 value 9.553848
## final  value 9.553761
## converged
## # weights:  39
## initial  value 89.619804
## iter  10 value 54.870380
## iter  20 value 50.080364
## iter  30 value 49.220888
## iter  40 value 46.067817
## iter  50 value 44.704431
## iter  60 value 44.500894
## iter  70 value 44.248418
## iter  80 value 43.983202
## iter  90 value 43.912536
## iter 100 value 43.897615
## final  value 43.897615
```

```
## stopped after 100 iterations
## # weights:  109
## initial  value 82.148497
## iter  10 value 18.504338
## iter  20 value 16.534819
## iter  30 value 12.146233
## iter  40 value 10.851174
## iter  50 value 3.072431
## iter  60 value 0.404501
## iter  70 value 0.295789
## iter  80 value 0.275741
## iter  90 value 0.268108
## iter 100 value 0.256282
## final  value 0.256282
## stopped after 100 iterations
## # weights:  179
## initial  value 90.879574
## iter  10 value 12.276186
## iter  20 value 0.175685
## iter  30 value 0.135455
## iter  40 value 0.118041
## iter  50 value 0.110250
## iter  60 value 0.099248
## iter  70 value 0.090586
## iter  80 value 0.086845
## iter  90 value 0.084314
## iter 100 value 0.079695
## final  value 0.079695
## stopped after 100 iterations
## # weights:  39
## initial  value 90.885403
## iter  10 value 50.235584
## iter  20 value 41.293811
## iter  30 value 32.253235
## iter  40 value 28.547412
## iter  50 value 28.050527
## iter  60 value 28.023552
## iter  70 value 27.248049
## iter  80 value 26.701332
## iter  90 value 25.362784
## iter 100 value 24.804655
## final  value 24.804655
## stopped after 100 iterations
## # weights:  109
## initial  value 90.689643
## iter  10 value 44.000867
## iter  20 value 21.982741
## iter  30 value 19.441264
## iter  40 value 18.373513
## iter  50 value 16.517106
## iter  60 value 16.284408
## iter  70 value 15.712875
## iter  80 value 8.560844
## iter  90 value 6.663566
```

```
## iter 100 value 6.466321
## final  value 6.466321
## stopped after 100 iterations
## # weights:  179
## initial  value 99.004364
## iter  10 value 13.336342
## iter  20 value 0.175991
## iter  30 value 0.001295
## final  value 0.000090
## converged
## # weights:  39
## initial  value 87.859719
## iter  10 value 55.557296
## iter  20 value 50.743608
## iter  30 value 46.335764
## iter  40 value 45.690365
## iter  50 value 45.687632
## iter  50 value 45.687632
## iter  50 value 45.687632
## final  value 45.687632
## converged
## # weights:  109
## initial  value 95.752011
## iter  10 value 33.296873
## iter  20 value 15.201010
## iter  30 value 13.355825
## iter  40 value 12.000015
## iter  50 value 11.969858
## final  value 11.969847
## converged
## # weights:  179
## initial  value 88.645177
## iter  10 value 35.025365
## iter  20 value 12.234525
## iter  30 value 10.146700
## iter  40 value 9.608180
## iter  50 value 9.576469
## iter  60 value 9.527474
## iter  70 value 9.500696
## final  value 9.500285
## converged
## # weights:  39
## initial  value 84.162095
## iter  10 value 45.208478
## iter  20 value 36.056182
## iter  30 value 35.668986
## iter  40 value 35.645635
## iter  50 value 35.635089
## iter  60 value 33.746947
## iter  70 value 33.132181
## iter  80 value 33.070633
## iter  90 value 30.685026
## iter 100 value 30.559358
## final  value 30.559358
```

```
## stopped after 100 iterations
## # weights:  109
## initial  value 98.288410
## iter  10 value 64.716515
## iter  20 value 27.328697
## iter  30 value 23.962148
## iter  40 value 16.745104
## iter  50 value 13.808099
## iter  60 value 12.894992
## iter  70 value 12.861144
## iter  80 value 12.841487
## iter  90 value 12.799720
## iter 100 value 10.470363
## final  value 10.470363
## stopped after 100 iterations
## # weights:  179
## initial  value 92.586932
## iter  10 value 5.577873
## iter  20 value 2.646779
## iter  30 value 1.578574
## iter  40 value 0.448454
## iter  50 value 0.287208
## iter  60 value 0.260003
## iter  70 value 0.213915
## iter  80 value 0.156713
## iter  90 value 0.137436
## iter 100 value 0.122577
## final  value 0.122577
## stopped after 100 iterations
## # weights:  39
## initial  value 82.285651
## iter  10 value 49.576909
## iter  20 value 43.496566
## iter  30 value 43.367276
## iter  40 value 41.968308
## iter  50 value 40.155264
## iter  60 value 40.150604
## final  value 40.150354
## converged
## # weights:  109
## initial  value 81.113319
## iter  10 value 15.710306
## iter  20 value 8.650494
## iter  30 value 6.481966
## iter  40 value 6.407040
## iter  50 value 6.401020
## iter  60 value 6.397249
## iter  70 value 6.394094
## iter  80 value 6.393849
## iter  90 value 6.392790
## iter 100 value 6.227954
## final  value 6.227954
## stopped after 100 iterations
## # weights:  179
```

```
## initial  value 74.165043
## iter  10 value 10.374266
## iter  20 value 2.205221
## iter  30 value 1.433166
## iter  40 value 1.388080
## iter  50 value 1.386627
## iter  60 value 1.386295
## final  value 1.386295
## converged
## # weights:  39
## initial  value 78.806613
## iter  10 value 50.157954
## iter  20 value 43.376447
## iter  30 value 42.305114
## iter  40 value 40.775329
## iter  50 value 39.388855
## iter  60 value 38.689967
## iter  70 value 38.656501
## final  value 38.656137
## converged
## # weights:  109
## initial  value 89.419148
## iter  10 value 41.428152
## iter  20 value 25.601646
## iter  30 value 17.834672
## iter  40 value 12.642925
## iter  50 value 11.595612
## iter  60 value 10.358178
## iter  70 value 10.321986
## iter  80 value 10.321725
## final  value 10.321724
## converged
## # weights:  179
## initial  value 83.130812
## iter  10 value 24.345634
## iter  20 value 10.714409
## iter  30 value 8.870532
## iter  40 value 8.533697
## iter  50 value 8.509163
## iter  60 value 8.497566
## iter  70 value 8.497112
## final  value 8.497104
## converged
## # weights:  39
## initial  value 82.915363
## iter  10 value 44.195114
## iter  20 value 39.187604
## iter  30 value 38.445664
## iter  40 value 38.413880
## iter  50 value 38.408266
## iter  60 value 38.391194
## iter  70 value 33.912380
## iter  80 value 33.198933
## iter  90 value 33.098916
```

```
## iter 100 value 33.006130
## final  value 33.006130
## stopped after 100 iterations
## # weights:  109
## initial  value 75.536522
## iter  10 value 24.378592
## iter  20 value 13.316891
## iter  30 value 11.949264
## iter  40 value 11.488736
## iter  50 value 11.146335
## iter  60 value 10.409765
## iter  70 value 10.012196
## iter  80 value 9.595245
## iter  90 value 6.528174
## iter 100 value 6.020460
## final  value 6.020460
## stopped after 100 iterations
## # weights:  179
## initial  value 91.459843
## iter  10 value 17.012083
## iter  20 value 0.383727
## iter  30 value 0.184435
## iter  40 value 0.145075
## iter  50 value 0.118865
## iter  60 value 0.095490
## iter  70 value 0.087759
## iter  80 value 0.083136
## iter  90 value 0.078991
## iter 100 value 0.075963
## final  value 0.075963
## stopped after 100 iterations
## # weights:  39
## initial  value 86.925422
## iter  10 value 75.089706
## iter  20 value 51.597660
## iter  30 value 50.322401
## iter  40 value 50.135663
## iter  50 value 49.890367
## iter  60 value 49.469059
## iter  70 value 48.380570
## iter  80 value 48.070010
## iter  90 value 45.818251
## iter 100 value 45.380477
## final  value 45.380477
## stopped after 100 iterations
## # weights:  109
## initial  value 80.216185
## iter  10 value 10.797088
## iter  20 value 0.492589
## iter  30 value 0.023043
## iter  40 value 0.003348
## iter  50 value 0.000462
## iter  60 value 0.000189
## final  value 0.000085
```

```
## converged
## # weights:  179
## initial  value 92.942133
## iter  10 value 18.558935
## iter  20 value 9.135916
## iter  30 value 7.594404
## iter  40 value 5.998984
## iter  50 value 4.516121
## iter  60 value 3.997783
## iter  70 value 3.901226
## iter  80 value 3.869598
## iter  90 value 3.838507
## iter 100 value 3.768804
## final  value 3.768804
## stopped after 100 iterations
## # weights:  39
## initial  value 95.099086
## iter  10 value 56.038815
## iter  20 value 46.996571
## iter  30 value 46.541976
## iter  40 value 45.899882
## iter  50 value 44.852816
## iter  60 value 44.247409
## iter  70 value 44.080407
## final  value 44.079338
## converged
## # weights:  109
## initial  value 114.807598
## iter  10 value 47.933184
## iter  20 value 30.095918
## iter  30 value 19.618417
## iter  40 value 14.888073
## iter  50 value 13.973251
## iter  60 value 13.450400
## iter  70 value 11.919241
## iter  80 value 11.834870
## iter  90 value 11.832882
## final  value 11.832580
## converged
## # weights:  179
## initial  value 103.989063
## iter  10 value 48.679498
## iter  20 value 16.529536
## iter  30 value 12.114281
## iter  40 value 11.247450
## iter  50 value 11.104977
## iter  60 value 11.098787
## iter  70 value 11.098566
## final  value 11.098552
## converged
## # weights:  39
## initial  value 84.167025
## iter  10 value 55.517782
## iter  20 value 52.204104
```

```
## iter  30 value 51.519064
## iter  40 value 50.648501
## iter  50 value 48.581665
## iter  60 value 48.538721
## iter  70 value 48.029915
## iter  80 value 47.688211
## iter  90 value 47.665114
## iter 100 value 47.584245
## final  value 47.584245
## stopped after 100 iterations
## # weights:  109
## initial  value 111.186645
## iter  10 value 23.941476
## iter  20 value 7.791402
## iter  30 value 5.995794
## iter  40 value 0.497591
## iter  50 value 0.340925
## iter  60 value 0.331554
## iter  70 value 0.320785
## iter  80 value 0.308540
## iter  90 value 0.301206
## iter 100 value 0.296787
## final  value 0.296787
## stopped after 100 iterations
## # weights:  179
## initial  value 79.230253
## iter  10 value 16.340692
## iter  20 value 1.058126
## iter  30 value 0.170543
## iter  40 value 0.151643
## iter  50 value 0.127515
## iter  60 value 0.112913
## iter  70 value 0.104021
## iter  80 value 0.099967
## iter  90 value 0.096261
## iter 100 value 0.091898
## final  value 0.091898
## stopped after 100 iterations
## # weights:  39
## initial  value 84.115611
## iter  10 value 51.888072
## iter  20 value 42.919513
## iter  30 value 40.510190
## iter  40 value 40.462647
## iter  50 value 40.461453
## final  value 40.461439
## converged
## # weights:  109
## initial  value 88.593368
## iter  10 value 43.543549
## iter  20 value 6.637161
## iter  30 value 0.038279
## iter  40 value 0.008543
## iter  50 value 0.001907
```

```
## iter  60 value 0.000241
## final  value 0.000093
## converged
## # weights:  179
## initial  value 84.414587
## iter  10 value 18.519580
## iter  20 value 3.546465
## iter  30 value 0.151060
## iter  40 value 0.002930
## iter  50 value 0.000135
## iter  50 value 0.000082
## iter  50 value 0.000082
## final  value 0.000082
## converged
## # weights:  39
## initial  value 90.958227
## iter  10 value 56.066105
## iter  20 value 48.316351
## iter  30 value 48.031360
## iter  40 value 46.327371
## iter  50 value 44.724163
## iter  60 value 44.620837
## final  value 44.620744
## converged
## # weights:  109
## initial  value 86.736202
## iter  10 value 34.612246
## iter  20 value 16.580279
## iter  30 value 13.804108
## iter  40 value 13.607868
## iter  50 value 13.260563
## iter  60 value 13.154417
## iter  70 value 13.025307
## iter  80 value 12.966463
## final  value 12.966462
## converged
## # weights:  179
## initial  value 101.403698
## iter  10 value 35.958371
## iter  20 value 15.177125
## iter  30 value 12.051414
## iter  40 value 10.679620
## iter  50 value 10.343655
## iter  60 value 10.304440
## iter  70 value 10.299128
## iter  80 value 10.298832
## iter  90 value 10.298806
## iter 100 value 10.298803
## final  value 10.298803
## stopped after 100 iterations
## # weights:  39
## initial  value 85.541371
## iter  10 value 40.462490
## iter  20 value 39.144683
```

```
## iter  30 value 38.120839
## iter  40 value 36.371694
## iter  50 value 31.632393
## iter  60 value 31.271657
## iter  70 value 31.227020
## iter  80 value 31.172057
## iter  90 value 30.478786
## iter 100 value 29.343389
## final  value 29.343389
## stopped after 100 iterations
## # weights:  109
## initial  value 89.328189
## iter  10 value 16.856487
## iter  20 value 9.407713
## iter  30 value 7.715865
## iter  40 value 7.699714
## iter  50 value 7.070750
## iter  60 value 3.107886
## iter  70 value 0.279817
## iter  80 value 0.143693
## iter  90 value 0.134043
## iter 100 value 0.129457
## final  value 0.129457
## stopped after 100 iterations
## # weights:  179
## initial  value 94.432791
## iter  10 value 19.139524
## iter  20 value 2.816546
## iter  30 value 1.594628
## iter  40 value 0.224761
## iter  50 value 0.206273
## iter  60 value 0.185096
## iter  70 value 0.155346
## iter  80 value 0.125782
## iter  90 value 0.116220
## iter 100 value 0.098472
## final  value 0.098472
## stopped after 100 iterations
## # weights:  39
## initial  value 95.581378
## iter  10 value 59.749052
## iter  20 value 53.598882
## iter  30 value 52.162214
## iter  40 value 50.862310
## iter  50 value 46.575285
## iter  60 value 46.371992
## iter  70 value 46.184039
## iter  80 value 45.930161
## iter  90 value 45.876062
## iter 100 value 45.867832
## final  value 45.867832
## stopped after 100 iterations
## # weights:  109
## initial  value 89.923919
```

```
## iter  10 value 29.004092
## iter  20 value 21.413658
## iter  30 value 19.603756
## iter  40 value 18.642277
## iter  50 value 18.152229
## iter  60 value 18.092563
## iter  70 value 18.065668
## iter  80 value 12.138800
## iter  90 value 4.764959
## iter 100 value 0.345254
## final  value 0.345254
## stopped after 100 iterations
## # weights:  179
## initial  value 90.315614
## iter  10 value 40.845016
## iter  20 value 17.904211
## iter  30 value 15.699816
## iter  40 value 10.364004
## iter  50 value 0.917098
## iter  60 value 0.019451
## iter  70 value 0.002590
## iter  80 value 0.000530
## iter  90 value 0.000151
## iter 100 value 0.000130
## final  value 0.000130
## stopped after 100 iterations
## # weights:  39
## initial  value 85.169125
## iter  10 value 64.972884
## iter  20 value 52.467356
## iter  30 value 46.753811
## iter  40 value 45.058500
## iter  50 value 43.553622
## iter  60 value 41.378325
## iter  70 value 40.437582
## iter  80 value 40.419734
## final  value 40.419730
## converged
## # weights:  109
## initial  value 89.255698
## iter  10 value 30.551451
## iter  20 value 15.049853
## iter  30 value 13.823229
## iter  40 value 12.961858
## iter  50 value 11.828680
## iter  60 value 11.727350
## iter  70 value 11.724338
## final  value 11.724324
## converged
## # weights:  179
## initial  value 92.643328
## iter  10 value 32.356206
## iter  20 value 12.043873
## iter  30 value 9.610067
```

```
## iter  40 value 9.171488
## iter  50 value 9.127067
## iter  60 value 9.126000
## final  value 9.125989
## converged
## # weights:  39
## initial  value 86.436602
## iter  10 value 51.324144
## iter  20 value 41.189983
## iter  30 value 36.271056
## iter  40 value 23.473940
## iter  50 value 19.037496
## iter  60 value 14.684252
## iter  70 value 10.092664
## iter  80 value 7.391404
## iter  90 value 7.353136
## iter 100 value 7.284000
## final  value 7.284000
## stopped after 100 iterations
## # weights:  109
## initial  value 92.446436
## iter  10 value 7.748643
## iter  20 value 3.646915
## iter  30 value 3.250936
## iter  40 value 3.020993
## iter  50 value 1.715862
## iter  60 value 1.639589
## iter  70 value 1.633451
## iter  80 value 1.602800
## iter  90 value 1.596145
## iter 100 value 1.583612
## final  value 1.583612
## stopped after 100 iterations
## # weights:  179
## initial  value 84.105863
## iter  10 value 28.459374
## iter  20 value 3.942282
## iter  30 value 2.747349
## iter  40 value 2.726469
## iter  50 value 2.700101
## iter  60 value 2.680525
## iter  70 value 1.644747
## iter  80 value 1.597145
## iter  90 value 0.373498
## iter 100 value 0.213030
## final  value 0.213030
## stopped after 100 iterations
## # weights:  39
## initial  value 87.885213
## iter  10 value 44.213304
## iter  20 value 42.301055
## iter  30 value 41.199692
## iter  40 value 39.422634
## iter  50 value 39.165472
```

```
## iter  60 value 39.099620
## iter  70 value 39.098662
## iter  80 value 39.098118
## iter  90 value 39.092692
## iter 100 value 38.860468
## final  value 38.860468
## stopped after 100 iterations
## # weights:  109
## initial  value 80.616963
## iter  10 value 24.804407
## iter  20 value 19.850656
## iter  30 value 19.548855
## iter  40 value 19.477124
## iter  50 value 15.696901
## iter  60 value 7.474428
## iter  70 value 7.314817
## iter  80 value 7.278091
## iter  90 value 7.272003
## iter 100 value 3.395780
## final  value 3.395780
## stopped after 100 iterations
## # weights:  179
## initial  value 87.602008
## iter  10 value 20.302238
## iter  20 value 7.532904
## iter  30 value 3.263114
## iter  40 value 2.996990
## iter  50 value 1.476469
## iter  60 value 1.381468
## iter  70 value 0.030592
## iter  80 value 0.005738
## iter  90 value 0.002192
## iter 100 value 0.000936
## final  value 0.000936
## stopped after 100 iterations
## # weights:  39
## initial  value 91.305407
## iter  10 value 58.618654
## iter  20 value 53.080022
## iter  30 value 52.363335
## iter  40 value 51.065755
## iter  50 value 50.313106
## iter  60 value 49.461833
## iter  70 value 47.284185
## iter  80 value 47.221814
## final  value 47.221812
## converged
## # weights:  109
## initial  value 92.760705
## iter  10 value 27.576014
## iter  20 value 17.265204
## iter  30 value 13.778948
## iter  40 value 13.131824
## iter  50 value 13.130236
```

```
## final  value 13.130235
## converged
## # weights:  179
## initial  value 96.355526
## iter  10 value 33.826390
## iter  20 value 16.460663
## iter  30 value 10.778998
## iter  40 value 10.302176
## iter  50 value 10.172901
## iter  60 value 9.645958
## iter  70 value 9.617659
## iter  80 value 9.616849
## final  value 9.616825
## converged
## # weights:  39
## initial  value 87.074427
## iter  10 value 71.008343
## iter  20 value 56.164297
## iter  30 value 49.275055
## iter  40 value 47.825219
## iter  50 value 47.780336
## iter  60 value 47.751162
## iter  70 value 47.695417
## iter  80 value 47.658795
## iter  90 value 47.650970
## iter 100 value 47.566463
## final  value 47.566463
## stopped after 100 iterations
## # weights:  109
## initial  value 77.269200
## iter  10 value 35.617660
## iter  20 value 10.169319
## iter  30 value 5.360920
## iter  40 value 3.211887
## iter  50 value 2.393273
## iter  60 value 0.700683
## iter  70 value 0.425853
## iter  80 value 0.359251
## iter  90 value 0.335872
## iter 100 value 0.320847
## final  value 0.320847
## stopped after 100 iterations
## # weights:  179
## initial  value 79.680889
## iter  10 value 3.807592
## iter  20 value 0.126699
## iter  30 value 0.090285
## iter  40 value 0.083949
## iter  50 value 0.077477
## iter  60 value 0.073347
## iter  70 value 0.064331
## iter  80 value 0.058673
## iter  90 value 0.056376
## iter 100 value 0.054383
```

```
## final  value 0.054383
## stopped after 100 iterations
## # weights:  39
## initial  value 88.012074
## iter  10 value 71.405366
## iter  20 value 56.100726
## iter  30 value 56.076457
## iter  40 value 55.954540
## iter  50 value 55.646566
## iter  60 value 55.507305
## iter  70 value 55.458371
## iter  80 value 48.068367
## iter  90 value 44.233638
## iter 100 value 43.595158
## final  value 43.595158
## stopped after 100 iterations
## # weights:  109
## initial  value 81.471815
## iter  10 value 36.050582
## iter  20 value 15.036087
## iter  30 value 10.437203
## iter  40 value 0.553493
## iter  50 value 0.013375
## iter  60 value 0.003862
## iter  70 value 0.000989
## iter  80 value 0.000699
## iter  90 value 0.000587
## iter 100 value 0.000207
## final  value 0.000207
## stopped after 100 iterations
## # weights:  179
## initial  value 109.870317
## iter  10 value 7.851044
## iter  20 value 2.072646
## iter  30 value 1.914825
## iter  40 value 1.909850
## iter  50 value 1.909558
## final  value 1.909545
## converged
## # weights:  39
## initial  value 82.532556
## iter  10 value 50.471275
## iter  20 value 48.589357
## iter  30 value 46.680328
## iter  40 value 43.489034
## iter  50 value 43.372329
## final  value 43.372243
## converged
## # weights:  109
## initial  value 83.301827
## iter  10 value 50.239755
## iter  20 value 40.670091
## iter  30 value 31.821810
## iter  40 value 24.198455
```

```
## iter  50 value 15.692491
## iter  60 value 14.007769
## iter  70 value 13.350583
## iter  80 value 13.095102
## iter  90 value 13.067776
## final  value 13.067539
## converged
## # weights:  179
## initial  value 122.642259
## iter  10 value 34.125404
## iter  20 value 15.284064
## iter  30 value 11.129062
## iter  40 value 10.331692
## iter  50 value 9.949609
## iter  60 value 9.896971
## iter  70 value 9.896053
## iter  80 value 9.895976
## final  value 9.895975
## converged
## # weights:  39
## initial  value 84.988710
## iter  10 value 53.414109
## iter  20 value 48.781218
## iter  30 value 46.450066
## iter  40 value 45.855967
## iter  50 value 45.504685
## iter  60 value 44.001230
## iter  70 value 43.582510
## iter  80 value 43.501098
## iter  90 value 43.483141
## iter 100 value 42.489191
## final  value 42.489191
## stopped after 100 iterations
## # weights:  109
## initial  value 78.544943
## iter  10 value 34.269147
## iter  20 value 9.851332
## iter  30 value 7.574756
## iter  40 value 6.818164
## iter  50 value 6.345905
## iter  60 value 6.322714
## iter  70 value 6.295090
## iter  80 value 6.154939
## iter  90 value 5.614795
## iter 100 value 5.447095
## final  value 5.447095
## stopped after 100 iterations
## # weights:  179
## initial  value 95.661557
## iter  10 value 39.354820
## iter  20 value 12.037084
## iter  30 value 7.005599
## iter  40 value 0.186446
## iter  50 value 0.146341
```

```
## iter  60 value 0.135677
## iter  70 value 0.130545
## iter  80 value 0.114449
## iter  90 value 0.108235
## iter 100 value 0.101265
## final  value 0.101265
## stopped after 100 iterations
## # weights:  39
## initial  value 84.890458
## iter  10 value 56.609915
## iter  20 value 44.507153
## iter  30 value 35.914186
## iter  40 value 30.905717
## iter  50 value 26.887579
## iter  60 value 26.560884
## iter  70 value 25.304821
## iter  80 value 24.791798
## iter  90 value 24.715340
## iter 100 value 24.710278
## final  value 24.710278
## stopped after 100 iterations
## # weights:  109
## initial  value 99.098165
## iter  10 value 28.786201
## iter  20 value 7.929812
## iter  30 value 0.031978
## iter  40 value 0.006280
## iter  50 value 0.002113
## final  value 0.000012
## converged
## # weights:  179
## initial  value 115.439256
## iter  10 value 7.128630
## iter  20 value 2.070233
## iter  30 value 1.945668
## iter  40 value 1.921497
## iter  50 value 1.678276
## iter  60 value 0.391100
## iter  70 value 0.076208
## iter  80 value 0.029488
## iter  90 value 0.010619
## iter 100 value 0.003847
## final  value 0.003847
## stopped after 100 iterations
## # weights:  39
## initial  value 103.705680
## iter  10 value 53.211195
## iter  20 value 47.834961
## iter  30 value 44.319229
## iter  40 value 41.892499
## iter  50 value 38.594866
## iter  60 value 37.469823
## iter  70 value 37.362836
## iter  70 value 37.362835
```

```
## iter  70 value 37.362835
## final  value 37.362835
## converged
## # weights:  109
## initial  value 80.405311
## iter  10 value 31.917459
## iter  20 value 16.169677
## iter  30 value 11.327703
## iter  40 value 10.814074
## iter  50 value 10.778966
## iter  60 value 10.778060
## final  value 10.778056
## converged
## # weights:  179
## initial  value 84.189209
## iter  10 value 26.108640
## iter  20 value 12.013497
## iter  30 value 9.373290
## iter  40 value 8.958735
## iter  50 value 8.943334
## iter  60 value 8.943022
## final  value 8.943015
## converged
## # weights:  39
## initial  value 84.540267
## iter  10 value 44.420054
## iter  20 value 41.305691
## iter  30 value 31.367397
## iter  40 value 31.061725
## iter  50 value 31.059840
## iter  60 value 31.056806
## iter  70 value 31.055420
## iter  80 value 31.053729
## iter  90 value 31.049046
## iter 100 value 29.998950
## final  value 29.998950
## stopped after 100 iterations
## # weights:  109
## initial  value 81.228345
## iter  10 value 24.272873
## iter  20 value 7.497484
## iter  30 value 6.753635
## iter  40 value 6.483649
## iter  50 value 6.352889
## iter  60 value 6.264559
## iter  70 value 6.195808
## iter  80 value 3.586113
## iter  90 value 3.487459
## iter 100 value 3.435916
## final  value 3.435916
## stopped after 100 iterations
## # weights:  179
## initial  value 113.126314
## iter  10 value 19.505697
```

```
## iter  20 value 8.627369
## iter  30 value 8.443156
## iter  40 value 6.717805
## iter  50 value 4.099864
## iter  60 value 0.224279
## iter  70 value 0.166034
## iter  80 value 0.153499
## iter  90 value 0.145463
## iter 100 value 0.122348
## final  value 0.122348
## stopped after 100 iterations
## # weights:  39
## initial  value 86.097523
## iter  10 value 49.936030
## iter  20 value 43.890027
## iter  30 value 42.729551
## iter  40 value 42.591851
## iter  50 value 42.572274
## iter  60 value 42.569087
## iter  70 value 42.568819
## final  value 42.568312
## converged
## # weights:  109
## initial  value 84.320196
## iter  10 value 23.041738
## iter  20 value 7.016379
## iter  30 value 4.522576
## iter  40 value 4.498505
## iter  50 value 4.257135
## iter  60 value 4.187924
## iter  70 value 4.187898
## final  value 4.187898
## converged
## # weights:  179
## initial  value 119.704908
## iter  10 value 8.974781
## iter  20 value 3.231054
## iter  30 value 2.202606
## iter  40 value 0.317631
## iter  50 value 0.119630
## iter  60 value 0.017991
## iter  70 value 0.001912
## iter  80 value 0.000749
## iter  90 value 0.000415
## iter 100 value 0.000260
## final  value 0.000260
## stopped after 100 iterations
## # weights:  39
## initial  value 96.359105
## iter  10 value 64.894576
## iter  20 value 51.891959
## iter  30 value 48.754777
## iter  40 value 47.959488
## final  value 47.954624
```

```
## converged
## # weights:  109
## initial  value 97.005897
## iter  10 value 33.293174
## iter  20 value 18.525335
## iter  30 value 14.925314
## iter  40 value 14.565280
## iter  50 value 14.506521
## iter  60 value 14.483830
## iter  70 value 14.464465
## iter  80 value 14.463810
## iter  90 value 14.463780
## iter  90 value 14.463780
## iter  90 value 14.463780
## final  value 14.463780
## converged
## # weights:  179
## initial  value 94.403785
## iter  10 value 32.147049
## iter  20 value 17.150787
## iter  30 value 11.956276
## iter  40 value 10.328922
## iter  50 value 10.071316
## iter  60 value 10.049796
## iter  70 value 10.049173
## iter  80 value 10.049164
## iter  80 value 10.049164
## iter  80 value 10.049164
## final  value 10.049164
## converged
## # weights:  39
## initial  value 90.472972
## iter  10 value 48.666843
## iter  20 value 43.194239
## iter  30 value 38.995691
## iter  40 value 35.596253
## iter  50 value 35.483457
## iter  60 value 35.475603
## iter  70 value 35.466387
## iter  80 value 35.464677
## iter  90 value 35.416972
## iter 100 value 35.117280
## final  value 35.117280
## stopped after 100 iterations
## # weights:  109
## initial  value 89.592870
## iter  10 value 31.275267
## iter  20 value 18.922981
## iter  30 value 17.684342
## iter  40 value 16.672119
## iter  50 value 16.448323
## iter  60 value 15.837667
## iter  70 value 15.764839
## iter  80 value 14.154531
```

```
## iter  90 value 12.340381
## iter 100 value 12.326574
## final  value 12.326574
## stopped after 100 iterations
## # weights:  179
## initial  value 84.851448
## iter  10 value 23.438295
## iter  20 value 5.866080
## iter  30 value 4.022276
## iter  40 value 0.939609
## iter  50 value 0.441182
## iter  60 value 0.306766
## iter  70 value 0.301015
## iter  80 value 0.278531
## iter  90 value 0.258674
## iter 100 value 0.233688
## final  value 0.233688
## stopped after 100 iterations
## # weights:  39
## initial  value 82.020546
## iter  10 value 64.805221
## iter  20 value 41.690696
## iter  30 value 40.074506
## iter  40 value 40.072438
## final  value 40.072432
## converged
## # weights:  109
## initial  value 79.821808
## iter  10 value 27.937265
## iter  20 value 1.938374
## iter  30 value 0.198284
## iter  40 value 0.013956
## iter  50 value 0.004000
## iter  60 value 0.002540
## iter  70 value 0.000539
## iter  80 value 0.000221
## final  value 0.000096
## converged
## # weights:  179
## initial  value 85.287590
## iter  10 value 2.195586
## iter  20 value 0.019398
## iter  30 value 0.001846
## final  value 0.000095
## converged
## # weights:  39
## initial  value 84.317257
## iter  10 value 57.682888
## iter  20 value 50.444700
## iter  30 value 45.846096
## iter  40 value 45.692229
## final  value 45.691802
## converged
## # weights:  109
```

```
## initial  value 83.435358
## iter  10 value 31.643228
## iter  20 value 16.735840
## iter  30 value 13.280159
## iter  40 value 11.678191
## iter  50 value 11.580044
## iter  60 value 11.576538
## iter  70 value 11.576507
## iter  70 value 11.576507
## iter  70 value 11.576507
## final  value 11.576507
## converged
## # weights:  179
## initial  value 84.465331
## iter  10 value 36.219337
## iter  20 value 19.878112
## iter  30 value 11.322392
## iter  40 value 9.252890
## iter  50 value 8.599707
## iter  60 value 8.567128
## iter  70 value 8.565120
## iter  80 value 8.564941
## final  value 8.564932
## converged
## # weights:  39
## initial  value 89.738634
## iter  10 value 58.493085
## iter  20 value 57.203495
## iter  30 value 56.970584
## iter  40 value 56.953117
## iter  50 value 51.550271
## iter  60 value 50.715648
## iter  70 value 50.710615
## iter  80 value 50.575481
## iter  90 value 47.142865
## iter 100 value 47.131192
## final  value 47.131192
## stopped after 100 iterations
## # weights:  109
## initial  value 96.567744
## iter  10 value 37.915738
## iter  20 value 0.404338
## iter  30 value 0.280086
## iter  40 value 0.202904
## iter  50 value 0.157915
## iter  60 value 0.135142
## iter  70 value 0.128417
## iter  80 value 0.121374
## iter  90 value 0.112813
## iter 100 value 0.105724
## final  value 0.105724
## stopped after 100 iterations
## # weights:  179
## initial  value 119.659448
```

```
## iter  10 value 37.063911
## iter  20 value 17.493135
## iter  30 value 7.844024
## iter  40 value 7.159135
## iter  50 value 7.141693
## iter  60 value 7.130486
## iter  70 value 5.520374
## iter  80 value 5.502448
## iter  90 value 5.161716
## iter 100 value 0.189676
## final  value 0.189676
## stopped after 100 iterations
## # weights:  179
## initial  value 91.203441
## iter  10 value 27.811912
## iter  20 value 16.551713
## iter  30 value 12.649276
## iter  40 value 11.288908
## iter  50 value 10.775554
## iter  60 value 10.626294
## iter  70 value 10.618773
## iter  80 value 10.509283
## iter  90 value 10.451275
## iter 100 value 10.448875
## final  value 10.448875
## stopped after 100 iterations
```

```
nnpred_model2 <- predict(neuralnet_model2, newdata= data_norm[-samp,])
```

```
#viewing confusion matrix
confusionMatrix(nnpred_model2, factor(data_norm$PAM50.mRNA[-samp]), mode = "everything")
```

```
## Confusion Matrix and Statistics
##
##                  Reference
## Prediction        Basal.like HER2.enriched Luminal.A Luminal.B
##   Basal.like               5             1         0         0
##   HER2.enriched            0             1         0         0
##   Luminal.A                0             0         6         2
##   Luminal.B                0             1         0         5
##
## Overall Statistics
##
##                Accuracy : 0.8095
##                  95% CI : (0.5809, 0.9455)
##     No Information Rate : 0.3333
##     P-Value [Acc > NIR] : 1.026e-05
##
##                   Kappa : 0.7358
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
```

```
##
##                      Class: Basal.like Class: HER2.enriched Class: Luminal.A
## Sensitivity                     1.0000              0.33333            1.0000
## Specificity                     0.9375              1.00000            0.8667
## Pos Pred Value                  0.8333              1.00000            0.7500
## Neg Pred Value                  1.0000              0.90000            1.0000
## Precision                       0.8333              1.00000            0.7500
## Recall                          1.0000              0.33333            1.0000
## F1                              0.9091              0.50000            0.8571
## Prevalence                      0.2381              0.14286            0.2857
## Detection Rate                  0.2381              0.04762            0.2857
## Detection Prevalence            0.2857              0.04762            0.3810
## Balanced Accuracy               0.9688              0.66667            0.9333
##                      Class: Luminal.B
## Sensitivity                    0.7143
## Specificity                    0.9286
## Pos Pred Value                 0.8333
## Neg Pred Value                 0.8667
## Precision                      0.8333
## Recall                         0.7143
## F1                             0.7692
## Prevalence                     0.3333
## Detection Rate                 0.2381
## Detection Prevalence           0.2857
## Balanced Accuracy              0.8214
```

Model evaluation for NN

1. Accuracy : The overall model accuracy of Neural network model is 81%

2. Precision, Recall, F-1 : The Precision,Recall,F1 for Basal.like class is 0.8333, 1.0000 , 0.9091 The Precision,Recall,F1 for HER2.enriched class is 1.00000, 0.33333 , 0.50000 The Precision,Recall,F1 for Luminal.A class is 0.7500, 1.0000, 0.8571 The Precision,Recall,F1 for Luminal.B class is 0.8333, 0.7143,0.7692

3. Sensitivity and Specificity The Sensitivity and Specificity for Basal.like class is 1.0000 and 0.9375 The Sensitivity and Specificity for HER2.enriched class is 0.33333 and 1.00000 The Sensitivity and Specificity for Luminal.A is 1.0000 and 0.8667 The Sensitivity and Specificity for Luminal.B class is 0.7143 and 0.9286

4. The Kappa statistic: The kappa value for this model is 0.7358 which states that it is a good agreement.

Macro-averaged Metrics : The per-class metrics can be averaged over all the classes resulting in macro-averaged precision, recall and F-1.

```r
# macro-averaged precision
precision_nn <- c(0.8333,1.00000, 0.7500, 0.8333)
macro_precision_nn <- mean(precision_nn)
# macro-averaged recall
recall_nn <- c(1.0000, 0.33333, 1.0000, 0.7143)
macro_recall_nn<- mean(recall_nn)
# macro-averaged F-1
F1_nn<- c(0.9091,0.50000,0.8571,0.7692)
macroF1_nn <- mean(F1_nn)
```

```r
macro_average_nn <-data.frame(macro_precision_nn, macro_recall_nn, macroF1_nn)
macro_average_nn
```

```
##   macro_precision_nn macro_recall_nn macroF1_nn
## 1            0.85415       0.7619075    0.75885
```

AUC

```r
nn_auc <- multiclass.roc(test$PAM50.mRNA, as.ordered(nnpred_model2))
auc(nn_auc)
```

```
## Multi-class area under the curve: 0.8571
```

```r
Name_metrics <- c("Accuracy", "Precision", "Recall", "F-1", "AUC", "Kappa")
values_nn <- c(0.8095 , 0.85415, 0.7619075, 0.75885,0.8571,0.7358  )
metrics_nn <- data.frame(Name_metrics, values_nn)
print (metrics_nn)
```

```
##   Name_metrics values_nn
## 1     Accuracy 0.8095000
## 2    Precision 0.8541500
## 3       Recall 0.7619075
## 4          F-1 0.7588500
## 5          AUC 0.8571000
## 6        Kappa 0.7358000
```

Naive Baye's

The Naive Bayes Algorithm is a classifier based on applying Bayes theorem with independent assumptions between features. Meaning that all features in the data set are equally important and independent of one another. Bayesian probability Is rooted in the theory that the likelihood of an event should be based on the evidence across multiple trials. Naïve Bayes uses probabilities to classify groups based on prior probability. One advantage is that Naïve Bayes works with mixed data: nominal, continuous and ordinal variables. Naïve Bayes is fast and effective, handles missing and noisy data well, and requires few records for training and can also work well with large records. Disadvantages of Naïve Bayes is that it assumes that all the data predictors are independent when in data is far from this faulty assumption. Also, estimated probabilities are less reliable than predicted classes.

```r
nb_model3 <- naive_bayes(PAM50.mRNA ~ ., data = train, usekernel = T)
nbpred_model3 <- predict(nb_model3, newdata= data_norm[-samp,])
#viewing confusion matrix
confusionMatrix(nbpred_model3 , factor(data_norm$PAM50.mRNA[-samp]), mode = "everything")
```

```
## Confusion Matrix and Statistics
##
##                Reference
## Prediction      Basal.like HER2.enriched Luminal.A Luminal.B
##   Basal.like             3             1         0         0
##   HER2.enriched          1             2         0         0
##   Luminal.A              1             0         5         1
```

```
##   Luminal.B              0             0         1         6
##
## Overall Statistics
##
##                Accuracy : 0.7619
##                  95% CI : (0.5283, 0.9178)
##     No Information Rate : 0.3333
##     P-Value [Acc > NIR] : 7.251e-05
##
##                   Kappa : 0.6729
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Basal.like Class: HER2.enriched Class: Luminal.A
## Sensitivity                     0.6000              0.66667           0.8333
## Specificity                     0.9375              0.94444           0.8667
## Pos Pred Value                  0.7500              0.66667           0.7143
## Neg Pred Value                  0.8824              0.94444           0.9286
## Precision                       0.7500              0.66667           0.7143
## Recall                          0.6000              0.66667           0.8333
## F1                              0.6667              0.66667           0.7692
## Prevalence                      0.2381              0.14286           0.2857
## Detection Rate                  0.1429              0.09524           0.2381
## Detection Prevalence            0.1905              0.14286           0.3333
## Balanced Accuracy               0.7688              0.80556           0.8500
##                      Class: Luminal.B
## Sensitivity                    0.8571
## Specificity                    0.9286
## Pos Pred Value                 0.8571
## Neg Pred Value                 0.9286
## Precision                      0.8571
## Recall                         0.8571
## F1                             0.8571
## Prevalence                     0.3333
## Detection Rate                 0.2857
## Detection Prevalence           0.3333
## Balanced Accuracy              0.8929
```

Model evaluation for NB:

1. Accuracy : The overall model accuracy of Naive Baye's model is 76. 2%
2. Precision,Recall,F1 : The Precision,Recall,F1 for Basal.like class is 0.7500, 0.60000, 0.6667 The Precision,Recall,F1 for HER2.enriched class is 0.6667, 0.6667, 0.6667 The Precision,Recall,F1 for Luminal.A class is 0.7143, 0.8333, 0.71692 The Precision,Recall,F1 for Luminal.B class is 0.8571, 0.8571, 0.8571
3. Sensitivity and Specificity The Sensitivity and Specificity for Basal.like class is 0.60000 and 0.9375 The Sensitivity and Specificity for HER2.enriched class is 0.66667 and 0.94444 The Sensitivity and Specificity for Luminal.A is 0.8333 and 0.8667 The Sensitivity and Specificity for Luminal.B class is 0.8571 and 0.9286
4. The Kappa statistic: The kappa value for this model is 0.6729 which states that it is a good agreement.

Macro-averaged Metrics : The per-class metrics can be averaged over all the classes resulting in macro-averaged precision, recall and F-1.

```
# macro-averaged precision
precision_nb <- c(0.7500,0.66667,0.7143,0.8571)
macro_precision_nb <- mean(precision_nb)
# macro-averaged recall
recall_nb <- c(0.6000,0.66667,0.8333,0.8571)
macro_recall_nb<- mean(recall_nb)
# macro-averaged F-1
F1_nb<- c(0.6667,0.66667,0.7692,0.8571)
macroF1_nb <- mean(F1_nb)
macro_average_nb <-data.frame(macro_precision_nb, macro_recall_nb, macroF1_nb)
macro_average_nb
```

```
##   macro_precision_nb macro_recall_nb macroF1_nb
## 1          0.7470175       0.7392675  0.7399175
```

AUC

```
nb_auc <- multiclass.roc(test$PAM50.mRNA, as.ordered(nbpred_model3))
auc(nb_auc)
```

```
## Multi-class area under the curve: 0.8857
```

```
Name_metrics <- c("Accuracy", "Precision", "Recall", "F-1", "AUC", "Kappa")
values_nb <- c(0.7619, 0.7470175, 0.7392675,0.7399175, 0.8857, 0.6729 )
metrics_nb <- data.frame(Name_metrics, values_nb)
print (metrics_nb)
```

```
##   Name_metrics values_nb
## 1     Accuracy 0.7619000
## 2    Precision 0.7470175
## 3       Recall 0.7392675
## 4          F-1 0.7399175
## 5          AUC 0.8857000
## 6        Kappa 0.6729000
```

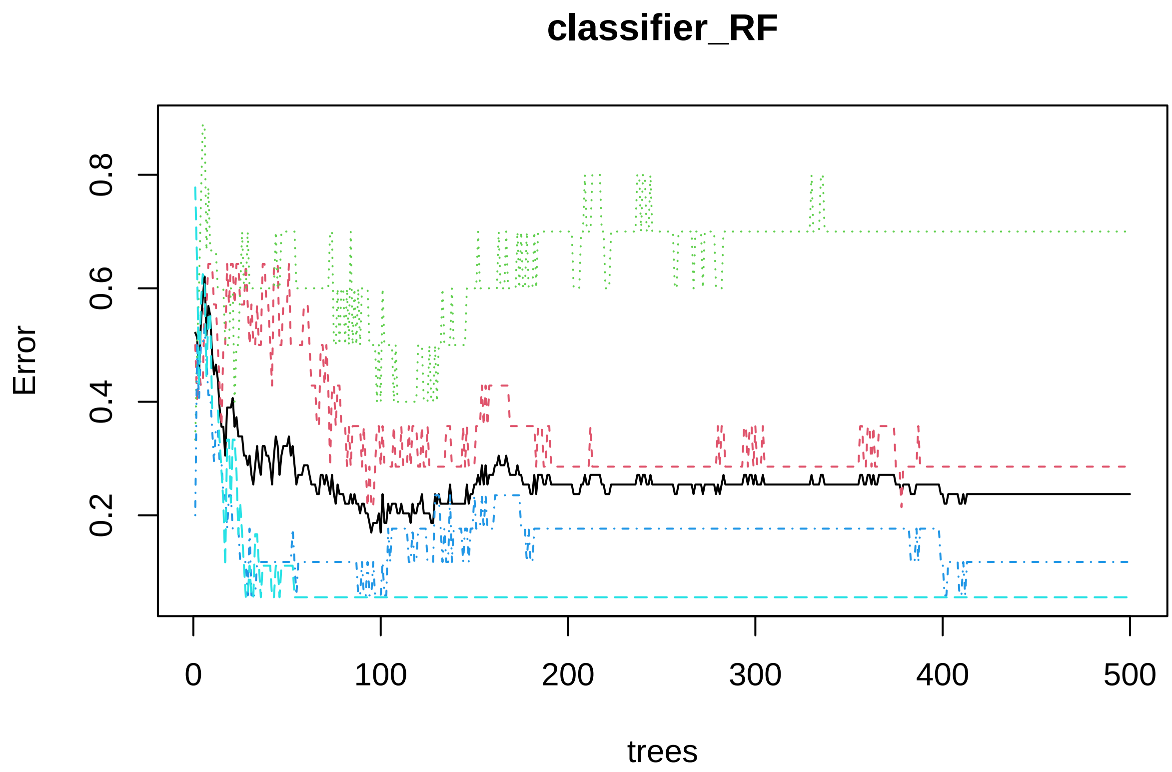
Random Forest

Random Forest is an ensemble of decision trees. It builds and combines multiple decision trees to get more accurate predictions. It's a non-linear classification algorithm. Each decision tree model is used when employed on its own. It works well with the multiclass classification.

```
# Fitting Random Forest to the train dataset
set.seed(120)  # Setting seed
classifier_RF = randomForest(x = train[,1:30],
                             y = train$PAM50.mRNA,
                             ntree = 500)
RF_pred <- predict(classifier_RF, newdata = test)
confusionMatrix(RF_pred, factor(data_norm$PAM50.mRNA[-samp]), mode = "everything")
```

```
## Confusion Matrix and Statistics
##
##                Reference
## Prediction      Basal.like HER2.enriched Luminal.A Luminal.B
##   Basal.like             4             1         1         1
##   HER2.enriched          0             1         0         0
##   Luminal.A              1             0         4         2
##   Luminal.B              0             1         1         4
##
## Overall Statistics
##
##                Accuracy : 0.619
##                  95% CI : (0.3844, 0.8189)
##     No Information Rate : 0.3333
##     P-Value [Acc > NIR] : 0.006807
##
##                   Kappa : 0.4734
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Basal.like Class: HER2.enriched Class: Luminal.A
## Sensitivity                     0.8000              0.33333           0.6667
## Specificity                     0.8125              1.00000           0.8000
## Pos Pred Value                  0.5714              1.00000           0.5714
## Neg Pred Value                  0.9286              0.90000           0.8571
## Precision                       0.5714              1.00000           0.5714
## Recall                          0.8000              0.33333           0.6667
## F1                              0.6667              0.50000           0.6154
## Prevalence                      0.2381              0.14286           0.2857
## Detection Rate                  0.1905              0.04762           0.1905
## Detection Prevalence            0.3333              0.04762           0.3333
## Balanced Accuracy               0.8063              0.66667           0.7333
##                      Class: Luminal.B
## Sensitivity                    0.5714
## Specificity                    0.8571
## Pos Pred Value                 0.6667
## Neg Pred Value                 0.8000
## Precision                      0.6667
## Recall                         0.5714
## F1                             0.6154
## Prevalence                     0.3333
## Detection Rate                 0.1905
## Detection Prevalence           0.2857
## Balanced Accuracy              0.7143
```

```
# Plotting model
plot(classifier_RF)
```

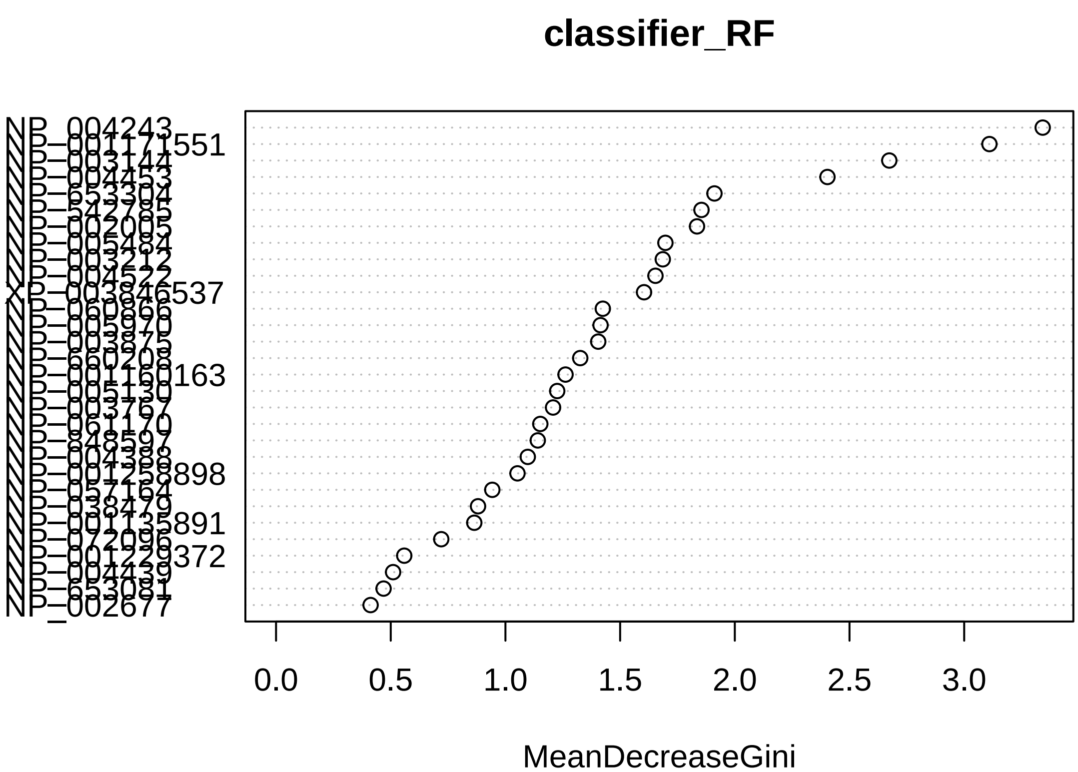



```r
# Importance plot
importance(classifier_RF)
```

```
##              MeanDecreaseGini
## NP_038479           0.8805231
## NP_001258898        1.0524888
## NP_542785           1.8547260
## NP_002005           1.8352126
## XP_003846537        1.6043369
## NP_660208           1.3260767
## NP_004439           0.5102471
## NP_004388           1.0973934
## NP_001229372        0.5588631
## NP_005130           1.2257370
## NP_004243           3.3422886
## NP_003144           2.6735076
## NP_001171551        3.1100743
## NP_072096           0.7202323
## NP_005484           1.6973190
## NP_061170           1.1520539
## NP_653304           1.9111497
## NP_653081           0.4687590
## NP_057164           0.9427079
## NP_004453           2.4038736
## NP_003212           1.6859924
## NP_060866           1.4245630
```

```
## NP_001160163        1.2619327
## NP_003875           1.4044818
## NP_002677           0.4121577
## NP_001135891        0.8641273
## NP_004522           1.6539665
## NP_003767           1.2076640
## NP_848597           1.1409587
## NP_005970           1.4146192
```

```
# Variable importance plot
varImpPlot(classifier_RF)
```



Model evaluation for RF: 1. Accuracy : The overall model accuracy of model is 61.9% 2. Precision,Recall,F1 : The Precision,Recall,F1 for Basal.like class is 0.5714 , 0.8000, 0.6667 The Precision,Recall,F1 for HER2.enriched class is 1.00000, 0.33333, 0.50000 The Precision,Recall,F1 for Luminal.A class is 0.5714, 0.6667, 0.6154 The Precision,Recall,F1 for Luminal.B class is 0.6667, 0.5714, 0.6154
3. Sensitivity and Specificity The Sensitivity and Specificity for Basal.like class is 0.80000 and 0.8125 The Sensitivity and Specificity for HER2.enriched class is 0.333333 and 1.00000 The Sensitivity and Specificity for Luminal.A is 0.6667 and 0.8000 The Sensitivity and Specificity for Luminal.B class is 0.5714 and 0.8571 4. The Kappa statistic: The kappa value for this model is 0.473 which states that it is a good agreement.

Macro-averaged Metrics : The per-class metrics can be averaged over all the classes resulting in macro-averaged precision, recall and F-1.

```
# macro-averaged precision
precision_rf<- c(0.5714,1.00000, 0.5714, 0.6667)
macro_precision_rf <- mean(precision_rf)
```

```r
# macro-averaged recall
recall_rf <- c(0.8000, 0.33333,0.6667,0.5714)
macro_recall_rf<- mean(recall_rf)
# macro-averaged F-1
F1_rf<- c(0.6667, 0.50000, 0.6154,0.6154)
macroF1_rf <- mean(F1_rf)
macro_average_rf <-data.frame(macro_precision_rf, macro_recall_rf, macroF1_rf)
macro_average_rf
```

```
##   macro_precision_rf macro_recall_rf macroF1_rf
## 1           0.702375       0.5928575   0.599375
```

AUC

```r
rf_auc <- multiclass.roc(test$PAM50.mRNA, as.ordered(RF_pred))
auc(rf_auc)
```

```
## Multi-class area under the curve: 0.7388
```

```r
Name_metrics <- c("Accuracy", "Precision", "Recall", "F-1", "AUC", "Kappa")
values_rf <- c(0.619, 0.702375, 0.5928575, 0.599375, 0.7388, 0.4734)
metrics_rf <- data.frame(Name_metrics, values_rf)
print (metrics_rf)
```

```
##   Name_metrics values_rf
## 1     Accuracy 0.6190000
## 2    Precision 0.7023750
## 3       Recall 0.5928575
## 4          F-1 0.5993750
## 5          AUC 0.7388000
## 6        Kappa 0.4734000
```

Comparing models

By comparing accuracy, precision, recall, f-1, AUC and kappa , Both SVM and the Neural Network model works best for the given datset have approximate same accuracy, precision, recall, f-1, AUC and kappa

```r
#SVM
print(metrics_svm)
```

```
##   Name_metrics values_svm
## 1     Accuracy  0.8095000
## 2    Precision  0.8428500
## 3       Recall  0.8095175
## 4          F-1  0.8057750
## 5          AUC  0.7897000
## 6        Kappa  0.7399000
```

```r
#NN
print(metrics_nn)
```

```
##   Name_metrics values_nn
## 1     Accuracy 0.8095000
## 2    Precision 0.8541500
## 3       Recall 0.7619075
## 4          F-1 0.7588500
## 5          AUC 0.8571000
## 6        Kappa 0.7358000
```

```r
#NB
print(metrics_nb)
```

```
##   Name_metrics values_nb
## 1     Accuracy 0.7619000
## 2    Precision 0.7470175
## 3       Recall 0.7392675
## 4          F-1 0.7399175
## 5          AUC 0.8857000
## 6        Kappa 0.6729000
```

```r
#RF
print(metrics_rf)
```

```
##   Name_metrics values_rf
## 1     Accuracy 0.6190000
## 2    Precision 0.7023750
## 3       Recall 0.5928575
## 4          F-1 0.5993750
## 5          AUC 0.7388000
## 6        Kappa 0.4734000
```

Though the SVM and neural network model achieved an accuracy of 81%, the precision, recall, AUC, kappa, and f-1 scores of neural network model are higher than SVM

Evaluation with k-fold cross-validation

- k-Fold Cross Validation is done for the whole dataset
- I have used k = 10 which means 10 folds take place along with 10 repetitions
- For testing the data, I have used 3 models to test the k-fold CV
- Accuracy of each model is printed and based on the observation average accuracy is around 75-80%

K-fold Cross Validation

#Creating a train function for cross validation #We use k = 10 folds with repeated validation = 10

```
fitControl <- trainControl(## 10-fold CV
                           method = "repeatedcv",
                           number = 10,repeats = 10,savePredictions = TRUE, summaryFunction = multiClas
## SVM
svm_fit <- train(PAM50.mRNA ~ ., data=data_norm, trControl= fitControl, method="svmLinear")
## NN
nn_fit <- train(PAM50.mRNA ~., data= data_norm,
                method = "nnet",
                trControl = fitControl)
```

```
## # weights:  39
## initial  value 104.299245
## iter  10 value 79.995263
## iter  20 value 68.794379
## iter  30 value 60.381853
## iter  40 value 59.388098
## iter  50 value 59.379352
## final  value 59.379337
## converged
## # weights:  109
## initial  value 116.362540
## iter  10 value 38.703189
## iter  20 value 27.949090
## iter  30 value 17.701280
## iter  40 value 14.439067
## iter  50 value 12.383946
## iter  60 value 6.798820
## iter  70 value 4.387518
## iter  80 value 4.103604
## iter  90 value 4.059599
## iter 100 value 4.000446
## final  value 4.000446
## stopped after 100 iterations
## # weights:  179
## initial  value 113.501953
## iter  10 value 25.731497
## iter  20 value 1.147697
## iter  30 value 0.007144
## iter  40 value 0.000410
## final  value 0.000094
## converged
## # weights:  39
## initial  value 106.824209
## iter  10 value 83.502515
## iter  20 value 68.645068
## iter  30 value 65.457292
## iter  40 value 61.513075
## iter  50 value 58.252477
## iter  60 value 57.896911
## final  value 57.894931
## converged
## # weights:  109
## initial  value 116.266962
```

```
## iter  10 value 51.596366
## iter  20 value 36.012333
## iter  30 value 21.950493
## iter  40 value 17.872911
## iter  50 value 17.036263
## iter  60 value 16.922137
## iter  70 value 16.914098
## final  value 16.913988
## converged
## # weights:  179
## initial  value 122.764369
## iter  10 value 38.320919
## iter  20 value 20.761799
## iter  30 value 14.930962
## iter  40 value 13.658736
## iter  50 value 12.792821
## iter  60 value 12.222951
## iter  70 value 12.160783
## iter  80 value 12.155308
## iter  90 value 12.155177
## final  value 12.155175
## converged
## # weights:  39
## initial  value 102.999903
## iter  10 value 71.735883
## iter  20 value 70.410970
## iter  30 value 70.294498
## iter  40 value 67.538440
## iter  50 value 66.281131
## iter  60 value 66.192470
## iter  70 value 66.108587
## iter  80 value 63.079601
## iter  90 value 61.633491
## iter 100 value 60.638393
## final  value 60.638393
## stopped after 100 iterations
## # weights:  109
## initial  value 99.973885
## iter  10 value 46.734583
## iter  20 value 31.972769
## iter  30 value 30.881697
## iter  40 value 28.947185
## iter  50 value 27.917324
## iter  60 value 22.957983
## iter  70 value 22.055213
## iter  80 value 18.966393
## iter  90 value 18.163339
## iter 100 value 18.117185
## final  value 18.117185
## stopped after 100 iterations
## # weights:  179
## initial  value 124.898739
## iter  10 value 26.580909
## iter  20 value 12.932771
```

```
## iter  30 value 8.485489
## iter  40 value 5.668525
## iter  50 value 2.874174
## iter  60 value 2.248487
## iter  70 value 2.188451
## iter  80 value 2.157638
## iter  90 value 2.128182
## iter 100 value 1.592795
## final  value 1.592795
## stopped after 100 iterations
## # weights:  39
## initial  value 107.534552
## iter  10 value 77.408126
## iter  20 value 62.583232
## iter  30 value 62.127657
## iter  40 value 61.841436
## iter  50 value 61.220111
## iter  60 value 59.870007
## iter  70 value 57.536401
## iter  80 value 57.193123
## iter  90 value 57.079719
## iter 100 value 56.830559
## final  value 56.830559
## stopped after 100 iterations
## # weights:  109
## initial  value 95.978593
## iter  10 value 27.730307
## iter  20 value 11.535128
## iter  30 value 9.429867
## iter  40 value 6.068945
## iter  50 value 2.904714
## iter  60 value 0.581600
## iter  70 value 0.258821
## iter  80 value 0.119119
## iter  90 value 0.050529
## iter 100 value 0.015378
## final  value 0.015378
## stopped after 100 iterations
## # weights:  179
## initial  value 110.151479
## iter  10 value 29.390762
## iter  20 value 12.489817
## iter  30 value 11.199423
## iter  40 value 11.006596
## iter  50 value 9.140870
## iter  60 value 8.865245
## iter  70 value 8.322997
## iter  80 value 7.494911
## iter  90 value 6.679223
## iter 100 value 6.612051
## final  value 6.612051
## stopped after 100 iterations
## # weights:  39
## initial  value 99.289685
```

```
## iter  10 value 74.506952
## iter  20 value 60.928284
## iter  30 value 56.968706
## iter  40 value 54.908474
## iter  50 value 54.781351
## final  value 54.781138
## converged
## # weights:  109
## initial  value 137.357072
## iter  10 value 46.207196
## iter  20 value 25.596747
## iter  30 value 17.876964
## iter  40 value 15.953225
## iter  50 value 15.860954
## iter  60 value 15.754487
## iter  70 value 15.742685
## final  value 15.742600
## converged
## # weights:  179
## initial  value 113.028811
## iter  10 value 51.580245
## iter  20 value 18.290789
## iter  30 value 13.097499
## iter  40 value 12.212833
## iter  50 value 12.004191
## iter  60 value 11.909150
## iter  70 value 11.650546
## iter  80 value 11.634106
## iter  90 value 11.633821
## final  value 11.633818
## converged
## # weights:  39
## initial  value 115.982494
## iter  10 value 67.485232
## iter  20 value 52.358131
## iter  30 value 49.659574
## iter  40 value 47.370464
## iter  50 value 46.753621
## iter  60 value 46.544948
## iter  70 value 46.539404
## iter  80 value 46.497780
## iter  90 value 46.492026
## iter 100 value 45.739198
## final  value 45.739198
## stopped after 100 iterations
## # weights:  109
## initial  value 130.792341
## iter  10 value 55.816138
## iter  20 value 31.748520
## iter  30 value 29.668303
## iter  40 value 26.709486
## iter  50 value 24.513222
## iter  60 value 22.782674
## iter  70 value 18.797008
```

```
## iter  80 value 17.362251
## iter  90 value 16.918780
## iter 100 value 16.305872
## final  value 16.305872
## stopped after 100 iterations
## # weights:  179
## initial  value 104.611807
## iter  10 value 22.178543
## iter  20 value 12.448488
## iter  30 value 10.927914
## iter  40 value 9.463426
## iter  50 value 7.778377
## iter  60 value 7.736406
## iter  70 value 7.716093
## iter  80 value 7.708814
## iter  90 value 7.688677
## iter 100 value 6.568364
## final  value 6.568364
## stopped after 100 iterations
## # weights:  39
## initial  value 106.172496
## iter  10 value 86.872725
## iter  20 value 57.511076
## iter  30 value 56.540269
## iter  40 value 56.439194
## iter  50 value 56.396876
## iter  60 value 56.391441
## iter  70 value 56.391033
## iter  80 value 56.385723
## final  value 56.385444
## converged
## # weights:  109
## initial  value 104.772786
## iter  10 value 55.672629
## iter  20 value 25.962566
## iter  30 value 21.773805
## iter  40 value 18.892384
## iter  50 value 18.247111
## iter  60 value 17.457173
## iter  70 value 16.139747
## iter  80 value 15.793450
## iter  90 value 15.553146
## iter 100 value 15.233484
## final  value 15.233484
## stopped after 100 iterations
## # weights:  179
## initial  value 111.814271
## iter  10 value 44.354336
## iter  20 value 10.307670
## iter  30 value 6.086850
## iter  40 value 5.348094
## iter  50 value 3.498877
## iter  60 value 2.820113
## iter  70 value 2.793611
```

```
## iter  80 value 2.780488
## iter  90 value 2.764216
## iter 100 value 1.571160
## final  value 1.571160
## stopped after 100 iterations
## # weights:  39
## initial  value 104.974226
## iter  10 value 80.474975
## iter  20 value 71.828073
## iter  30 value 63.278804
## iter  40 value 61.888456
## iter  50 value 59.784916
## iter  60 value 59.612207
## iter  70 value 59.417355
## iter  80 value 58.905908
## iter  90 value 58.679049
## iter 100 value 58.372545
## final  value 58.372545
## stopped after 100 iterations
## # weights:  109
## initial  value 106.528293
## iter  10 value 53.734265
## iter  20 value 30.959814
## iter  30 value 23.095271
## iter  40 value 18.686541
## iter  50 value 17.210192
## iter  60 value 16.941136
## iter  70 value 16.866421
## iter  80 value 16.860315
## iter  90 value 16.860243
## iter 100 value 16.860240
## final  value 16.860240
## stopped after 100 iterations
## # weights:  179
## initial  value 106.609535
## iter  10 value 63.899599
## iter  20 value 25.022424
## iter  30 value 15.515251
## iter  40 value 13.810678
## iter  50 value 12.793296
## iter  60 value 12.484983
## iter  70 value 12.334758
## iter  80 value 12.236790
## iter  90 value 12.231608
## iter 100 value 12.231195
## final  value 12.231195
## stopped after 100 iterations
## # weights:  39
## initial  value 101.251697
## iter  10 value 63.047555
## iter  20 value 57.734503
## iter  30 value 56.939382
## iter  40 value 55.428482
## iter  50 value 54.867257
```

```
## iter  60 value 54.258537
## iter  70 value 54.032692
## iter  80 value 53.996665
## iter  90 value 53.631573
## iter 100 value 53.219971
## final  value 53.219971
## stopped after 100 iterations
## # weights:  109
## initial  value 108.635563
## iter  10 value 48.039839
## iter  20 value 37.102114
## iter  30 value 29.573146
## iter  40 value 26.880421
## iter  50 value 23.348759
## iter  60 value 18.988432
## iter  70 value 16.018643
## iter  80 value 13.120232
## iter  90 value 9.478768
## iter 100 value 7.288661
## final  value 7.288661
## stopped after 100 iterations
## # weights:  179
## initial  value 100.607660
## iter  10 value 27.004845
## iter  20 value 7.453921
## iter  30 value 5.302572
## iter  40 value 4.961924
## iter  50 value 4.927010
## iter  60 value 4.543250
## iter  70 value 4.290189
## iter  80 value 4.282470
## iter  90 value 4.276498
## iter 100 value 4.262330
## final  value 4.262330
## stopped after 100 iterations
## # weights:  39
## initial  value 100.717327
## iter  10 value 64.985780
## iter  20 value 58.567277
## iter  30 value 55.655203
## iter  40 value 53.682472
## iter  50 value 51.761930
## iter  60 value 50.823440
## iter  70 value 49.179080
## iter  80 value 48.890285
## iter  90 value 48.568348
## iter 100 value 48.209226
## final  value 48.209226
## stopped after 100 iterations
## # weights:  109
## initial  value 113.829643
## iter  10 value 50.596999
## iter  20 value 23.609407
## iter  30 value 18.619909
```

```
## iter  40 value 17.125002
## iter  50 value 15.399086
## iter  60 value 14.397348
## iter  70 value 5.728594
## iter  80 value 4.104008
## iter  90 value 3.936000
## iter 100 value 3.876241
## final  value 3.876241
## stopped after 100 iterations
## # weights:  179
## initial  value 104.998431
## iter  10 value 22.333531
## iter  20 value 13.811587
## iter  30 value 9.801557
## iter  40 value 8.153056
## iter  50 value 7.130349
## iter  60 value 4.183457
## iter  70 value 2.460700
## iter  80 value 1.938867
## iter  90 value 1.920188
## iter 100 value 1.915055
## final  value 1.915055
## stopped after 100 iterations
## # weights:  39
## initial  value 105.049947
## iter  10 value 81.858467
## iter  20 value 73.393758
## iter  30 value 65.001082
## iter  40 value 60.848524
## iter  50 value 59.022504
## iter  60 value 58.300377
## iter  70 value 57.178534
## iter  80 value 56.598609
## iter  90 value 56.595445
## iter  90 value 56.595444
## iter  90 value 56.595444
## final  value 56.595444
## converged
## # weights:  109
## initial  value 107.200565
## iter  10 value 67.677230
## iter  20 value 36.521978
## iter  30 value 22.392395
## iter  40 value 17.668750
## iter  50 value 17.246634
## iter  60 value 17.121434
## iter  70 value 17.061321
## iter  80 value 17.009409
## iter  90 value 16.442380
## iter 100 value 16.308005
## final  value 16.308005
## stopped after 100 iterations
## # weights:  179
## initial  value 152.069661
```

```
## iter  10 value 61.784433
## iter  20 value 27.333358
## iter  30 value 17.521918
## iter  40 value 14.049912
## iter  50 value 12.613819
## iter  60 value 12.224530
## iter  70 value 12.202828
## iter  80 value 12.202575
## final  value 12.202574
## converged
## # weights:  39
## initial  value 100.626011
## iter  10 value 65.509069
## iter  20 value 58.342048
## iter  30 value 54.963527
## iter  40 value 54.552171
## iter  50 value 54.531254
## iter  60 value 54.501058
## iter  70 value 54.491701
## iter  80 value 54.471611
## iter  90 value 54.470959
## iter 100 value 54.464181
## final  value 54.464181
## stopped after 100 iterations
## # weights:  109
## initial  value 116.438720
## iter  10 value 26.557513
## iter  20 value 15.497749
## iter  30 value 10.841419
## iter  40 value 8.225107
## iter  50 value 7.381404
## iter  60 value 7.358429
## iter  70 value 7.346883
## iter  80 value 7.343283
## iter  90 value 7.337369
## iter 100 value 7.324477
## final  value 7.324477
## stopped after 100 iterations
## # weights:  179
## initial  value 110.390245
## iter  10 value 21.362538
## iter  20 value 4.026865
## iter  30 value 1.539409
## iter  40 value 0.173331
## iter  50 value 0.153800
## iter  60 value 0.136164
## iter  70 value 0.127874
## iter  80 value 0.120223
## iter  90 value 0.112022
## iter 100 value 0.106387
## final  value 0.106387
## stopped after 100 iterations
## # weights:  39
## initial  value 98.552367
```

```
## iter  10 value 67.855438
## iter  20 value 63.206718
## iter  30 value 62.068004
## iter  40 value 60.066793
## iter  50 value 58.205316
## iter  60 value 56.389511
## iter  70 value 54.260845
## iter  80 value 54.025681
## iter  90 value 53.933156
## iter 100 value 53.914262
## final  value 53.914262
## stopped after 100 iterations
## # weights:  109
## initial  value 107.177071
## iter  10 value 51.032188
## iter  20 value 29.849584
## iter  30 value 17.488961
## iter  40 value 16.282317
## iter  50 value 14.886328
## iter  60 value 14.796254
## iter  70 value 14.794958
## iter  80 value 14.783471
## iter  90 value 14.764270
## iter 100 value 14.748210
## final  value 14.748210
## stopped after 100 iterations
## # weights:  179
## initial  value 110.349521
## iter  10 value 24.671307
## iter  20 value 9.924925
## iter  30 value 5.793526
## iter  40 value 3.025712
## iter  50 value 2.306541
## iter  60 value 1.683548
## iter  70 value 1.373242
## iter  80 value 0.016938
## iter  90 value 0.003044
## iter 100 value 0.001418
## final  value 0.001418
## stopped after 100 iterations
## # weights:  39
## initial  value 117.025048
## iter  10 value 69.939157
## iter  20 value 62.618639
## iter  30 value 60.193304
## iter  40 value 56.433804
## iter  50 value 55.966883
## iter  60 value 55.787166
## iter  70 value 55.643447
## final  value 55.641012
## converged
## # weights:  109
## initial  value 107.239992
## iter  10 value 60.210263
```

```
## iter  20 value 33.247721
## iter  30 value 20.005296
## iter  40 value 16.829320
## iter  50 value 16.611187
## iter  60 value 16.585789
## iter  70 value 16.576311
## iter  80 value 16.575989
## iter  90 value 16.575887
## iter 100 value 16.570244
## final  value 16.570244
## stopped after 100 iterations
## # weights:  179
## initial  value 98.070342
## iter  10 value 40.086104
## iter  20 value 20.348670
## iter  30 value 14.270639
## iter  40 value 12.530497
## iter  50 value 12.316868
## iter  60 value 12.177518
## iter  70 value 12.115303
## iter  80 value 12.104557
## final  value 12.104504
## converged
## # weights:  39
## initial  value 100.912213
## iter  10 value 70.384471
## iter  20 value 52.876164
## iter  30 value 46.449586
## iter  40 value 43.333689
## iter  50 value 41.598764
## iter  60 value 40.001865
## iter  70 value 38.421120
## iter  80 value 37.921205
## iter  90 value 36.137344
## iter 100 value 34.847697
## final  value 34.847697
## stopped after 100 iterations
## # weights:  109
## initial  value 112.716553
## iter  10 value 52.125195
## iter  20 value 39.553309
## iter  30 value 37.208279
## iter  40 value 36.981957
## iter  50 value 36.923396
## iter  60 value 32.555826
## iter  70 value 32.029213
## iter  80 value 30.925918
## iter  90 value 30.267182
## iter 100 value 29.472615
## final  value 29.472615
## stopped after 100 iterations
## # weights:  179
## initial  value 118.677646
## iter  10 value 28.638221
```

```
## iter  20 value 15.491842
## iter  30 value 13.136416
## iter  40 value 12.318244
## iter  50 value 12.228116
## iter  60 value 12.050837
## iter  70 value 11.857411
## iter  80 value 11.816401
## iter  90 value 11.801959
## iter 100 value 11.759083
## final  value 11.759083
## stopped after 100 iterations
## # weights:  39
## initial  value 99.880365
## iter  10 value 57.961515
## iter  20 value 56.762476
## iter  30 value 56.721989
## final  value 56.721929
## converged
## # weights:  109
## initial  value 96.754578
## iter  10 value 34.799439
## iter  20 value 21.553847
## iter  30 value 18.274166
## iter  40 value 16.807930
## iter  50 value 16.266340
## iter  60 value 15.922762
## iter  70 value 15.843743
## iter  80 value 15.794671
## iter  90 value 15.120971
## iter 100 value 14.882752
## final  value 14.882752
## stopped after 100 iterations
## # weights:  179
## initial  value 103.676180
## iter  10 value 33.171005
## iter  20 value 13.314321
## iter  30 value 7.562081
## iter  40 value 5.631887
## iter  50 value 5.125401
## iter  60 value 5.057361
## iter  70 value 5.033289
## iter  80 value 5.024343
## iter  90 value 4.188562
## iter 100 value 4.164907
## final  value 4.164907
## stopped after 100 iterations
## # weights:  39
## initial  value 109.231542
## iter  10 value 81.919137
## iter  20 value 71.954902
## iter  30 value 61.252902
## iter  40 value 59.000512
## iter  50 value 58.645675
## iter  60 value 58.209525
```

```
## iter  70 value 57.945934
## iter  80 value 57.894568
## iter  90 value 57.824541
## iter 100 value 57.793448
## final  value 57.793448
## stopped after 100 iterations
## # weights:  109
## initial  value 107.791837
## iter  10 value 53.681348
## iter  20 value 36.243093
## iter  30 value 28.404314
## iter  40 value 22.999579
## iter  50 value 19.119749
## iter  60 value 17.219522
## iter  70 value 16.420321
## iter  80 value 16.287253
## iter  90 value 16.258708
## iter 100 value 16.248457
## final  value 16.248457
## stopped after 100 iterations
## # weights:  179
## initial  value 115.324174
## iter  10 value 40.915611
## iter  20 value 24.398844
## iter  30 value 16.096842
## iter  40 value 13.897308
## iter  50 value 13.622497
## iter  60 value 12.734113
## iter  70 value 12.536133
## iter  80 value 12.485224
## iter  90 value 12.460506
## iter 100 value 12.459113
## final  value 12.459113
## stopped after 100 iterations
## # weights:  39
## initial  value 101.757311
## iter  10 value 68.407113
## iter  20 value 63.642736
## iter  30 value 62.402660
## iter  40 value 55.957965
## iter  50 value 53.515893
## iter  60 value 51.354498
## iter  70 value 50.607364
## iter  80 value 49.028315
## iter  90 value 48.682490
## iter 100 value 47.601503
## final  value 47.601503
## stopped after 100 iterations
## # weights:  109
## initial  value 103.194169
## iter  10 value 52.745907
## iter  20 value 41.613003
## iter  30 value 39.727312
## iter  40 value 37.670857
```

```
## iter  50 value 32.824255
## iter  60 value 29.672659
## iter  70 value 28.608905
## iter  80 value 27.764998
## iter  90 value 27.713414
## iter 100 value 27.028474
## final  value 27.028474
## stopped after 100 iterations
## # weights:  179
## initial  value 110.863530
## iter  10 value 27.436186
## iter  20 value 14.791227
## iter  30 value 10.701541
## iter  40 value 9.301095
## iter  50 value 8.630477
## iter  60 value 7.591234
## iter  70 value 4.815353
## iter  80 value 4.761468
## iter  90 value 4.754548
## iter 100 value 4.730066
## final  value 4.730066
## stopped after 100 iterations
## # weights:  39
## initial  value 110.959131
## iter  10 value 63.465868
## iter  20 value 58.488543
## iter  30 value 57.203294
## iter  40 value 57.110512
## iter  50 value 57.007346
## iter  60 value 56.496470
## iter  70 value 56.462252
## iter  80 value 56.443633
## iter  90 value 56.390091
## iter 100 value 52.483491
## final  value 52.483491
## stopped after 100 iterations
## # weights:  109
## initial  value 108.824751
## iter  10 value 47.460205
## iter  20 value 26.905718
## iter  30 value 20.341997
## iter  40 value 16.560115
## iter  50 value 15.997723
## iter  60 value 15.915869
## iter  70 value 15.900988
## iter  80 value 15.893432
## iter  90 value 15.884524
## iter 100 value 15.883344
## final  value 15.883344
## stopped after 100 iterations
## # weights:  179
## initial  value 111.206377
## iter  10 value 25.127204
## iter  20 value 7.266960
```

```
## iter  30 value 4.714106
## iter  40 value 1.481820
## iter  50 value 1.406999
## iter  60 value 1.393125
## iter  70 value 1.389522
## iter  80 value 1.387648
## iter  90 value 1.386778
## iter 100 value 1.386588
## final  value 1.386588
## stopped after 100 iterations
## # weights:  39
## initial  value 100.917487
## iter  10 value 71.981814
## iter  20 value 60.175294
## iter  30 value 58.317043
## iter  40 value 57.186037
## iter  50 value 56.272042
## iter  60 value 55.872294
## iter  70 value 55.864496
## iter  80 value 55.862892
## iter  80 value 55.862892
## final  value 55.862892
## converged
## # weights:  109
## initial  value 104.944030
## iter  10 value 50.983381
## iter  20 value 31.509779
## iter  30 value 24.463671
## iter  40 value 18.705393
## iter  50 value 17.301566
## iter  60 value 16.273576
## iter  70 value 16.074725
## iter  80 value 15.446333
## iter  90 value 15.324312
## iter 100 value 15.322977
## final  value 15.322977
## stopped after 100 iterations
## # weights:  179
## initial  value 119.735846
## iter  10 value 58.348497
## iter  20 value 26.209849
## iter  30 value 15.392135
## iter  40 value 13.540317
## iter  50 value 13.085016
## iter  60 value 12.674765
## iter  70 value 12.249233
## iter  80 value 12.138040
## iter  90 value 12.062072
## iter 100 value 12.012855
## final  value 12.012855
## stopped after 100 iterations
## # weights:  39
## initial  value 106.136459
## iter  10 value 65.889177
```

```
## iter  20 value 57.929137
## iter  30 value 56.948422
## iter  40 value 56.669705
## iter  50 value 56.637367
## iter  60 value 56.634346
## iter  70 value 55.888021
## iter  80 value 54.384829
## iter  90 value 51.968506
## iter 100 value 51.953527
## final  value 51.953527
## stopped after 100 iterations
## # weights:  109
## initial  value 102.682068
## iter  10 value 27.112006
## iter  20 value 9.241030
## iter  30 value 5.248934
## iter  40 value 3.790089
## iter  50 value 3.768558
## iter  60 value 3.743937
## iter  70 value 3.664266
## iter  80 value 3.643337
## iter  90 value 3.630319
## iter 100 value 3.623522
## final  value 3.623522
## stopped after 100 iterations
## # weights:  179
## initial  value 132.329856
## iter  10 value 40.464593
## iter  20 value 7.703621
## iter  30 value 0.637454
## iter  40 value 0.282670
## iter  50 value 0.249801
## iter  60 value 0.235429
## iter  70 value 0.213995
## iter  80 value 0.199750
## iter  90 value 0.186244
## iter 100 value 0.170999
## final  value 0.170999
## stopped after 100 iterations
## # weights:  39
## initial  value 107.932002
## iter  10 value 82.114107
## iter  20 value 71.940654
## iter  30 value 64.243677
## iter  40 value 62.468894
## iter  50 value 61.935604
## iter  60 value 60.912114
## iter  70 value 59.415782
## iter  80 value 58.338321
## iter  90 value 58.285187
## iter 100 value 57.979243
## final  value 57.979243
## stopped after 100 iterations
## # weights:  109
```

```
## initial  value 98.842008
## iter  10 value 28.955405
## iter  20 value 19.944667
## iter  30 value 17.611146
## iter  40 value 10.582223
## iter  50 value 7.940914
## iter  60 value 6.535773
## iter  70 value 6.225027
## iter  80 value 4.855722
## iter  90 value 4.820651
## iter 100 value 4.794305
## final  value 4.794305
## stopped after 100 iterations
## # weights:  179
## initial  value 99.691223
## iter  10 value 16.235017
## iter  20 value 6.053412
## iter  30 value 0.050231
## iter  40 value 0.001047
## final  value 0.000067
## converged
## # weights:  39
## initial  value 100.342119
## iter  10 value 66.064036
## iter  20 value 63.202448
## iter  30 value 61.353635
## iter  40 value 58.557329
## iter  50 value 58.329317
## iter  60 value 58.185655
## iter  70 value 57.935024
## iter  80 value 57.929060
## final  value 57.929028
## converged
## # weights:  109
## initial  value 114.883864
## iter  10 value 60.194812
## iter  20 value 31.552175
## iter  30 value 21.947784
## iter  40 value 17.649295
## iter  50 value 17.059606
## iter  60 value 17.042136
## iter  70 value 17.041686
## iter  70 value 17.041685
## iter  70 value 17.041685
## final  value 17.041685
## converged
## # weights:  179
## initial  value 135.344635
## iter  10 value 62.292829
## iter  20 value 35.416389
## iter  30 value 25.528215
## iter  40 value 17.108175
## iter  50 value 15.490671
## iter  60 value 13.508728
```

```
## iter  70 value 12.997724
## iter  80 value 12.481864
## iter  90 value 12.450390
## iter 100 value 12.449450
## final  value 12.449450
## stopped after 100 iterations
## # weights:  39
## initial  value 96.281811
## iter  10 value 63.609748
## iter  20 value 57.973872
## iter  30 value 55.453585
## iter  40 value 55.411477
## iter  50 value 55.345670
## iter  60 value 55.256349
## iter  70 value 55.206646
## iter  80 value 53.726004
## iter  90 value 53.687078
## iter 100 value 53.647198
## final  value 53.647198
## stopped after 100 iterations
## # weights:  109
## initial  value 103.866339
## iter  10 value 38.025011
## iter  20 value 27.001563
## iter  30 value 21.842538
## iter  40 value 19.261342
## iter  50 value 19.003653
## iter  60 value 18.894929
## iter  70 value 18.811323
## iter  80 value 18.660865
## iter  90 value 18.462815
## iter 100 value 18.333249
## final  value 18.333249
## stopped after 100 iterations
## # weights:  179
## initial  value 115.247467
## iter  10 value 19.718212
## iter  20 value 2.403281
## iter  30 value 0.186954
## iter  40 value 0.161772
## iter  50 value 0.149354
## iter  60 value 0.134385
## iter  70 value 0.126576
## iter  80 value 0.115716
## iter  90 value 0.103181
## iter 100 value 0.096828
## final  value 0.096828
## stopped after 100 iterations
## # weights:  39
## initial  value 108.894872
## iter  10 value 73.916422
## iter  20 value 65.266602
## iter  30 value 62.575629
## iter  40 value 61.718241
```

```
## iter  50 value 61.590989
## iter  60 value 61.578241
## iter  70 value 61.574426
## iter  80 value 61.572429
## iter  90 value 61.571914
## iter 100 value 61.571797
## final  value 61.571797
## stopped after 100 iterations
## # weights:  109
## initial  value 102.560674
## iter  10 value 30.690458
## iter  20 value 14.741499
## iter  30 value 13.482866
## iter  40 value 12.212442
## iter  50 value 12.124850
## iter  60 value 10.842659
## iter  70 value 10.657895
## iter  80 value 10.495840
## iter  90 value 10.482271
## iter 100 value 10.479345
## final  value 10.479345
## stopped after 100 iterations
## # weights:  179
## initial  value 105.150326
## iter  10 value 20.393961
## iter  20 value 5.560496
## iter  30 value 3.471349
## iter  40 value 3.297772
## iter  50 value 3.295724
## iter  60 value 2.340295
## iter  70 value 1.909851
## final  value 1.909619
## converged
## # weights:  39
## initial  value 110.168234
## iter  10 value 73.003745
## iter  20 value 64.755496
## iter  30 value 64.610060
## iter  40 value 64.605490
## final  value 64.605478
## converged
## # weights:  109
## initial  value 113.847105
## iter  10 value 44.279322
## iter  20 value 27.604761
## iter  30 value 21.034629
## iter  40 value 18.344250
## iter  50 value 16.931710
## iter  60 value 16.760816
## iter  70 value 16.754013
## iter  80 value 16.753892
## final  value 16.753892
## converged
## # weights:  179
```

```
## initial  value 113.759595
## iter  10 value 43.098184
## iter  20 value 20.631854
## iter  30 value 15.325356
## iter  40 value 13.401510
## iter  50 value 12.720648
## iter  60 value 12.631544
## iter  70 value 12.608085
## iter  80 value 12.558423
## iter  90 value 12.493229
## iter 100 value 12.490125
## final  value 12.490125
## stopped after 100 iterations
## # weights:  39
## initial  value 113.229508
## iter  10 value 72.061956
## iter  20 value 57.918778
## iter  30 value 55.499836
## iter  40 value 52.932819
## iter  50 value 52.587012
## iter  60 value 52.578704
## iter  70 value 52.534078
## iter  80 value 51.803951
## iter  90 value 51.656701
## iter 100 value 51.644961
## final  value 51.644961
## stopped after 100 iterations
## # weights:  109
## initial  value 107.200968
## iter  10 value 46.784343
## iter  20 value 22.831097
## iter  30 value 8.638815
## iter  40 value 3.962849
## iter  50 value 2.730250
## iter  60 value 2.307990
## iter  70 value 2.256712
## iter  80 value 2.239470
## iter  90 value 2.232780
## iter 100 value 2.220600
## final  value 2.220600
## stopped after 100 iterations
## # weights:  179
## initial  value 147.812819
## iter  10 value 50.119464
## iter  20 value 15.137491
## iter  30 value 4.521312
## iter  40 value 0.406948
## iter  50 value 0.160106
## iter  60 value 0.143188
## iter  70 value 0.136240
## iter  80 value 0.127416
## iter  90 value 0.119076
## iter 100 value 0.106773
## final  value 0.106773
```

```
## stopped after 100 iterations
## # weights:  39
## initial  value 96.754508
## iter  10 value 63.341723
## iter  20 value 52.047592
## iter  30 value 47.012724
## iter  40 value 44.223938
## iter  50 value 42.665768
## iter  60 value 42.446280
## iter  70 value 42.385498
## iter  80 value 42.312469
## iter  90 value 42.296377
## iter 100 value 42.293163
## final  value 42.293163
## stopped after 100 iterations
## # weights:  109
## initial  value 107.598829
## iter  10 value 40.357649
## iter  20 value 4.992283
## iter  30 value 1.932641
## iter  40 value 1.388108
## iter  50 value 1.386534
## iter  60 value 1.386490
## iter  70 value 1.386341
## final  value 1.386341
## converged
## # weights:  179
## initial  value 130.835202
## iter  10 value 47.799740
## iter  20 value 28.302585
## iter  30 value 25.568887
## iter  40 value 24.101009
## iter  50 value 23.653896
## iter  60 value 23.487635
## iter  70 value 19.512113
## iter  80 value 14.864137
## iter  90 value 13.195525
## iter 100 value 8.790588
## final  value 8.790588
## stopped after 100 iterations
## # weights:  39
## initial  value 117.625333
## iter  10 value 84.737886
## iter  20 value 76.168626
## iter  30 value 70.701832
## iter  40 value 67.513768
## iter  50 value 66.968536
## iter  60 value 66.961837
## iter  70 value 66.961178
## final  value 66.961156
## converged
## # weights:  109
## initial  value 114.068774
## iter  10 value 44.952273
```

```
## iter  20 value 25.753066
## iter  30 value 19.603756
## iter  40 value 16.553390
## iter  50 value 16.409820
## iter  60 value 16.403952
## final  value 16.403938
## converged
## # weights:  179
## initial  value 104.955856
## iter  10 value 55.690905
## iter  20 value 24.103895
## iter  30 value 16.377522
## iter  40 value 13.678623
## iter  50 value 12.943146
## iter  60 value 12.451581
## iter  70 value 12.159373
## iter  80 value 12.017555
## iter  90 value 11.987827
## iter 100 value 11.985743
## final  value 11.985743
## stopped after 100 iterations
## # weights:  39
## initial  value 117.782625
## iter  10 value 64.787896
## iter  20 value 56.506052
## iter  30 value 51.372711
## iter  40 value 49.728805
## iter  50 value 46.880625
## iter  60 value 46.290194
## iter  70 value 45.209927
## iter  80 value 45.199754
## iter  90 value 40.538038
## iter 100 value 38.783141
## final  value 38.783141
## stopped after 100 iterations
## # weights:  109
## initial  value 105.848269
## iter  10 value 18.267208
## iter  20 value 3.891816
## iter  30 value 3.804844
## iter  40 value 3.630826
## iter  50 value 3.567383
## iter  60 value 3.531178
## iter  70 value 2.338964
## iter  80 value 1.511577
## iter  90 value 1.482782
## iter 100 value 0.213127
## final  value 0.213127
## stopped after 100 iterations
## # weights:  179
## initial  value 119.754249
## iter  10 value 19.431984
## iter  20 value 8.523413
## iter  30 value 4.887144
```

```
## iter  40 value 3.219587
## iter  50 value 2.276421
## iter  60 value 2.099917
## iter  70 value 2.055116
## iter  80 value 2.039856
## iter  90 value 2.032664
## iter 100 value 2.022019
## final  value 2.022019
## stopped after 100 iterations
## # weights:  39
## initial  value 104.764480
## iter  10 value 63.246282
## iter  20 value 61.323781
## iter  30 value 60.611185
## iter  40 value 60.519722
## iter  50 value 57.711113
## iter  60 value 54.692006
## iter  70 value 52.427619
## iter  80 value 51.925607
## iter  90 value 51.238292
## iter 100 value 50.944807
## final  value 50.944807
## stopped after 100 iterations
## # weights:  109
## initial  value 103.804462
## iter  10 value 47.808466
## iter  20 value 27.109549
## iter  30 value 25.265803
## iter  40 value 23.525787
## iter  50 value 23.256232
## iter  60 value 21.116967
## iter  70 value 20.790721
## iter  80 value 20.503890
## iter  90 value 20.387481
## iter 100 value 17.741720
## final  value 17.741720
## stopped after 100 iterations
## # weights:  179
## initial  value 114.975822
## iter  10 value 23.694777
## iter  20 value 10.433985
## iter  30 value 1.263466
## iter  40 value 0.058917
## iter  50 value 0.008678
## iter  60 value 0.003870
## iter  70 value 0.001816
## iter  80 value 0.001265
## iter  90 value 0.000424
## iter 100 value 0.000275
## final  value 0.000275
## stopped after 100 iterations
## # weights:  39
## initial  value 120.569025
## iter  10 value 71.814694
```

```
## iter  20 value 63.688957
## iter  30 value 61.620733
## iter  40 value 58.511222
## iter  50 value 57.961639
## iter  60 value 57.444182
## iter  70 value 57.377931
## iter  80 value 57.003372
## iter  90 value 56.434286
## iter 100 value 56.196210
## final  value 56.196210
## stopped after 100 iterations
## # weights:  109
## initial  value 103.408545
## iter  10 value 47.612621
## iter  20 value 28.336631
## iter  30 value 22.684814
## iter  40 value 18.948529
## iter  50 value 17.592884
## iter  60 value 16.588068
## iter  70 value 16.519867
## iter  80 value 16.518014
## final  value 16.518009
## converged
## # weights:  179
## initial  value 104.308140
## iter  10 value 50.166380
## iter  20 value 23.371493
## iter  30 value 14.335170
## iter  40 value 13.686882
## iter  50 value 13.601760
## iter  60 value 13.250208
## iter  70 value 12.900405
## iter  80 value 12.867244
## iter  90 value 12.820714
## iter 100 value 12.756087
## final  value 12.756087
## stopped after 100 iterations
## # weights:  39
## initial  value 120.621421
## iter  10 value 74.875171
## iter  20 value 56.586052
## iter  30 value 51.122404
## iter  40 value 47.262118
## iter  50 value 45.469478
## iter  60 value 45.313649
## iter  70 value 44.885904
## iter  80 value 44.826018
## iter  90 value 44.731634
## iter 100 value 44.687273
## final  value 44.687273
## stopped after 100 iterations
## # weights:  109
## initial  value 113.421039
## iter  10 value 31.834062
```

```
## iter  20 value 17.352883
## iter  30 value 12.351665
## iter  40 value 12.045616
## iter  50 value 11.909739
## iter  60 value 11.883491
## iter  70 value 11.765309
## iter  80 value 11.647654
## iter  90 value 11.577306
## iter 100 value 11.532177
## final  value 11.532177
## stopped after 100 iterations
## # weights:  179
## initial  value 91.351331
## iter  10 value 17.184451
## iter  20 value 0.628226
## iter  30 value 0.246212
## iter  40 value 0.230224
## iter  50 value 0.199532
## iter  60 value 0.175362
## iter  70 value 0.159984
## iter  80 value 0.150411
## iter  90 value 0.143870
## iter 100 value 0.138255
## final  value 0.138255
## stopped after 100 iterations
## # weights:  39
## initial  value 110.449141
## iter  10 value 67.797707
## iter  20 value 61.818435
## iter  30 value 61.011241
## iter  40 value 60.216677
## iter  50 value 55.187009
## iter  60 value 54.910575
## iter  70 value 54.099737
## iter  80 value 54.092101
## iter  90 value 54.082945
## iter 100 value 54.082830
## final  value 54.082830
## stopped after 100 iterations
## # weights:  109
## initial  value 102.533147
## iter  10 value 55.427692
## iter  20 value 34.586424
## iter  30 value 25.402731
## iter  40 value 19.149263
## iter  50 value 15.670454
## iter  60 value 13.630141
## iter  70 value 13.410338
## iter  80 value 11.456949
## iter  90 value 11.296778
## iter 100 value 11.257873
## final  value 11.257873
## stopped after 100 iterations
## # weights:  179
```

```
## initial  value 130.377959
## iter  10 value 32.501684
## iter  20 value 2.826998
## iter  30 value 0.052304
## iter  40 value 0.000183
## final  value 0.000081
## converged
## # weights:  39
## initial  value 104.728586
## iter  10 value 79.749280
## iter  20 value 67.331347
## iter  30 value 59.104183
## iter  40 value 56.931520
## iter  50 value 56.511162
## iter  60 value 56.263544
## iter  70 value 56.082908
## iter  80 value 56.010198
## final  value 56.009809
## converged
## # weights:  109
## initial  value 122.370198
## iter  10 value 58.603496
## iter  20 value 33.589782
## iter  30 value 21.254683
## iter  40 value 17.517896
## iter  50 value 15.869222
## iter  60 value 15.408248
## iter  70 value 15.372602
## iter  80 value 15.368923
## iter  90 value 15.368778
## final  value 15.368777
## converged
## # weights:  179
## initial  value 104.607661
## iter  10 value 38.735094
## iter  20 value 17.333637
## iter  30 value 13.194963
## iter  40 value 12.507821
## iter  50 value 12.387834
## iter  60 value 12.361019
## iter  70 value 12.359437
## iter  80 value 12.359250
## final  value 12.359247
## converged
## # weights:  39
## initial  value 101.726800
## iter  10 value 66.283439
## iter  20 value 57.303158
## iter  30 value 56.336324
## iter  40 value 55.237768
## iter  50 value 54.294321
## iter  60 value 53.968806
## iter  70 value 51.064236
## iter  80 value 50.433134
```

```
## iter  90 value 49.098840
## iter 100 value 48.450998
## final  value 48.450998
## stopped after 100 iterations
## # weights:  109
## initial  value 111.955568
## iter  10 value 78.479271
## iter  20 value 43.163637
## iter  30 value 27.507234
## iter  40 value 21.873629
## iter  50 value 20.352318
## iter  60 value 13.565364
## iter  70 value 13.513562
## iter  80 value 13.499072
## iter  90 value 13.288446
## iter 100 value 10.412232
## final  value 10.412232
## stopped after 100 iterations
## # weights:  179
## initial  value 107.997271
## iter  10 value 22.674823
## iter  20 value 6.362081
## iter  30 value 2.763221
## iter  40 value 2.717509
## iter  50 value 2.696336
## iter  60 value 2.465613
## iter  70 value 2.081662
## iter  80 value 1.471484
## iter  90 value 0.172761
## iter 100 value 0.155574
## final  value 0.155574
## stopped after 100 iterations
## # weights:  39
## initial  value 103.886470
## iter  10 value 67.344386
## iter  20 value 64.551048
## iter  30 value 63.754207
## iter  40 value 63.460116
## iter  50 value 63.426192
## iter  60 value 63.421501
## iter  70 value 63.421203
## iter  80 value 63.420945
## iter  90 value 63.420830
## final  value 63.420813
## converged
## # weights:  109
## initial  value 107.331717
## iter  10 value 34.019434
## iter  20 value 24.313956
## iter  30 value 19.528021
## iter  40 value 18.793431
## iter  50 value 15.314331
## iter  60 value 14.700858
## iter  70 value 8.868329
```

```
## iter  80 value 8.353681
## iter  90 value 8.055213
## iter 100 value 7.921747
## final  value 7.921747
## stopped after 100 iterations
## # weights:  179
## initial  value 119.341946
## iter  10 value 29.260662
## iter  20 value 10.545634
## iter  30 value 5.544076
## iter  40 value 3.055880
## iter  50 value 2.647555
## iter  60 value 0.096519
## iter  70 value 0.038205
## iter  80 value 0.013386
## iter  90 value 0.005842
## iter 100 value 0.001180
## final  value 0.001180
## stopped after 100 iterations
## # weights:  39
## initial  value 107.943692
## iter  10 value 73.184575
## iter  20 value 65.641014
## iter  30 value 63.547644
## iter  40 value 60.300469
## iter  50 value 60.049537
## iter  60 value 59.579260
## iter  70 value 59.106109
## iter  80 value 58.611613
## iter  90 value 57.879263
## iter 100 value 57.624212
## final  value 57.624212
## stopped after 100 iterations
## # weights:  109
## initial  value 103.475084
## iter  10 value 53.919216
## iter  20 value 29.723484
## iter  30 value 21.664634
## iter  40 value 19.160742
## iter  50 value 18.748583
## iter  60 value 18.602662
## iter  70 value 17.131767
## iter  80 value 16.901708
## iter  90 value 16.894407
## iter 100 value 16.892603
## final  value 16.892603
## stopped after 100 iterations
## # weights:  179
## initial  value 108.097968
## iter  10 value 48.924665
## iter  20 value 24.858059
## iter  30 value 15.815989
## iter  40 value 13.403120
## iter  50 value 12.614113
```

```
## iter  60 value 12.460090
## iter  70 value 12.450702
## iter  80 value 12.450540
## final  value 12.450536
## converged
## # weights:  39
## initial  value 115.454924
## iter  10 value 71.413989
## iter  20 value 62.974229
## iter  30 value 56.606915
## iter  40 value 53.905331
## iter  50 value 53.896478
## iter  60 value 53.892414
## iter  70 value 53.887586
## iter  80 value 52.767773
## iter  90 value 52.751005
## iter 100 value 52.748771
## final  value 52.748771
## stopped after 100 iterations
## # weights:  109
## initial  value 113.938518
## iter  10 value 35.060278
## iter  20 value 27.042466
## iter  30 value 13.422112
## iter  40 value 6.748456
## iter  50 value 5.786346
## iter  60 value 5.668109
## iter  70 value 5.637586
## iter  80 value 2.820368
## iter  90 value 2.225010
## iter 100 value 2.186598
## final  value 2.186598
## stopped after 100 iterations
## # weights:  179
## initial  value 118.218415
## iter  10 value 25.909847
## iter  20 value 12.803819
## iter  30 value 6.989589
## iter  40 value 6.510152
## iter  50 value 6.433262
## iter  60 value 6.398586
## iter  70 value 6.368578
## iter  80 value 5.308452
## iter  90 value 4.863248
## iter 100 value 2.780022
## final  value 2.780022
## stopped after 100 iterations
## # weights:  39
## initial  value 111.018778
## iter  10 value 62.708955
## iter  20 value 56.069550
## iter  30 value 54.005286
## iter  40 value 52.125735
## iter  50 value 51.234402
```

```
## iter  60 value 50.238236
## iter  70 value 49.806295
## iter  80 value 49.316557
## iter  90 value 48.005040
## iter 100 value 47.298507
## final  value 47.298507
## stopped after 100 iterations
## # weights:  109
## initial  value 117.907953
## iter  10 value 38.436704
## iter  20 value 24.825572
## iter  30 value 22.416181
## iter  40 value 20.491744
## iter  50 value 20.275936
## iter  60 value 20.235507
## iter  70 value 20.184980
## iter  80 value 20.139252
## iter  90 value 20.041602
## iter 100 value 19.864983
## final  value 19.864983
## stopped after 100 iterations
## # weights:  179
## initial  value 105.328276
## iter  10 value 20.402097
## iter  20 value 8.646863
## iter  30 value 7.759287
## iter  40 value 6.427525
## iter  50 value 6.329033
## iter  60 value 6.314727
## iter  70 value 5.948188
## iter  80 value 5.225066
## iter  90 value 1.464483
## iter 100 value 1.399467
## final  value 1.399467
## stopped after 100 iterations
## # weights:  39
## initial  value 107.950372
## iter  10 value 77.465959
## iter  20 value 72.231504
## iter  30 value 66.943362
## iter  40 value 59.435617
## iter  50 value 58.790556
## iter  60 value 58.583038
## iter  70 value 58.532780
## iter  80 value 58.528483
## final  value 58.528371
## converged
## # weights:  109
## initial  value 104.885899
## iter  10 value 44.535130
## iter  20 value 28.851385
## iter  30 value 20.433509
## iter  40 value 17.720537
## iter  50 value 17.073965
```

```
## iter  60 value 16.949024
## iter  70 value 16.627893
## iter  80 value 15.979658
## iter  90 value 15.968381
## final  value 15.968214
## converged
## # weights:  179
## initial  value 135.006360
## iter  10 value 40.221471
## iter  20 value 24.276930
## iter  30 value 15.254512
## iter  40 value 13.772375
## iter  50 value 12.933977
## iter  60 value 12.535304
## iter  70 value 12.415618
## iter  80 value 12.399639
## iter  90 value 12.398837
## final  value 12.398817
## converged
## # weights:  39
## initial  value 102.252185
## iter  10 value 57.893798
## iter  20 value 54.164271
## iter  30 value 52.992441
## iter  40 value 52.401022
## iter  50 value 51.459193
## iter  60 value 50.369940
## iter  70 value 49.350936
## iter  80 value 49.163109
## iter  90 value 48.416435
## iter 100 value 47.945262
## final  value 47.945262
## stopped after 100 iterations
## # weights:  109
## initial  value 115.785334
## iter  10 value 24.391870
## iter  20 value 12.769583
## iter  30 value 8.410923
## iter  40 value 8.189229
## iter  50 value 8.172680
## iter  60 value 8.155788
## iter  70 value 8.125105
## iter  80 value 8.078362
## iter  90 value 8.056941
## iter 100 value 8.050334
## final  value 8.050334
## stopped after 100 iterations
## # weights:  179
## initial  value 134.189972
## iter  10 value 52.438019
## iter  20 value 18.773631
## iter  30 value 12.851951
## iter  40 value 9.990585
## iter  50 value 9.809519
```

```
## iter  60 value 9.652385
## iter  70 value 9.629092
## iter  80 value 9.614704
## iter  90 value 9.597432
## iter 100 value 9.568336
## final  value 9.568336
## stopped after 100 iterations
## # weights:  39
## initial  value 104.866968
## iter  10 value 73.693383
## iter  20 value 68.395897
## iter  30 value 67.734504
## iter  40 value 67.081068
## iter  50 value 64.541467
## iter  60 value 62.515229
## iter  70 value 62.301896
## iter  80 value 61.067795
## iter  90 value 61.040956
## iter 100 value 61.013387
## final  value 61.013387
## stopped after 100 iterations
## # weights:  109
## initial  value 103.240359
## iter  10 value 39.397373
## iter  20 value 28.145510
## iter  30 value 22.790912
## iter  40 value 17.300873
## iter  50 value 13.603440
## iter  60 value 11.692283
## iter  70 value 8.900997
## iter  80 value 7.206432
## iter  90 value 5.569697
## iter 100 value 5.423758
## final  value 5.423758
## stopped after 100 iterations
## # weights:  179
## initial  value 107.657019
## iter  10 value 17.318848
## iter  20 value 4.847240
## iter  30 value 2.824152
## iter  40 value 1.899925
## iter  50 value 1.410387
## iter  60 value 0.014237
## iter  70 value 0.005619
## iter  80 value 0.002739
## iter  90 value 0.001787
## iter 100 value 0.001287
## final  value 0.001287
## stopped after 100 iterations
## # weights:  39
## initial  value 115.940116
## iter  10 value 80.433108
## iter  20 value 64.166528
## iter  30 value 60.732525
```

```
## iter  40 value 59.635453
## iter  50 value 59.078226
## iter  60 value 58.995451
## iter  70 value 58.780248
## iter  80 value 58.340269
## iter  90 value 58.153292
## iter 100 value 58.142893
## final  value 58.142893
## stopped after 100 iterations
## # weights:  109
## initial  value 109.906160
## iter  10 value 44.732187
## iter  20 value 32.476660
## iter  30 value 22.268931
## iter  40 value 18.126868
## iter  50 value 17.171169
## iter  60 value 17.071029
## iter  70 value 16.989255
## iter  80 value 16.714127
## iter  90 value 16.706393
## final  value 16.706373
## converged
## # weights:  179
## initial  value 121.964959
## iter  10 value 32.843419
## iter  20 value 18.458923
## iter  30 value 13.165546
## iter  40 value 12.555487
## iter  50 value 12.510685
## iter  60 value 12.493080
## iter  70 value 12.490919
## iter  80 value 12.490658
## iter  90 value 12.490643
## final  value 12.490642
## converged
## # weights:  39
## initial  value 100.338530
## iter  10 value 76.169395
## iter  20 value 70.448455
## iter  30 value 54.246536
## iter  40 value 48.802907
## iter  50 value 47.175589
## iter  60 value 47.107765
## iter  70 value 47.054691
## iter  80 value 47.026156
## iter  90 value 47.017621
## iter 100 value 47.010133
## final  value 47.010133
## stopped after 100 iterations
## # weights:  109
## initial  value 91.979990
## iter  10 value 30.707373
## iter  20 value 21.919875
## iter  30 value 17.714452
```

```
## iter  40 value 12.383581
## iter  50 value 9.600865
## iter  60 value 6.411896
## iter  70 value 6.114726
## iter  80 value 5.815612
## iter  90 value 5.528974
## iter 100 value 4.984915
## final  value 4.984915
## stopped after 100 iterations
## # weights:  179
## initial  value 90.186043
## iter  10 value 12.282116
## iter  20 value 1.873845
## iter  30 value 1.507811
## iter  40 value 0.473736
## iter  50 value 0.144523
## iter  60 value 0.123729
## iter  70 value 0.118167
## iter  80 value 0.112059
## iter  90 value 0.103234
## iter 100 value 0.095990
## final  value 0.095990
## stopped after 100 iterations
## # weights:  39
## initial  value 101.796799
## iter  10 value 72.835712
## iter  20 value 70.430026
## iter  30 value 70.013493
## iter  40 value 69.973718
## iter  50 value 69.968970
## iter  60 value 69.968507
## final  value 69.967892
## converged
## # weights:  109
## initial  value 114.626117
## iter  10 value 38.527097
## iter  20 value 24.571755
## iter  30 value 21.572643
## iter  40 value 20.168706
## iter  50 value 16.688982
## iter  60 value 12.992024
## iter  70 value 12.423947
## iter  80 value 11.798798
## iter  90 value 9.992020
## iter 100 value 7.020788
## final  value 7.020788
## stopped after 100 iterations
## # weights:  179
## initial  value 108.547980
## iter  10 value 27.010044
## iter  20 value 3.617901
## iter  30 value 1.928378
## iter  40 value 1.911100
## iter  50 value 1.909862
```

```
## iter  60 value 1.909543
## final  value 1.909543
## converged
## # weights:  39
## initial  value 100.239706
## iter  10 value 78.694682
## iter  20 value 67.427987
## iter  30 value 64.626249
## iter  40 value 61.717163
## iter  50 value 60.361951
## iter  60 value 60.288245
## final  value 60.288213
## converged
## # weights:  109
## initial  value 106.313650
## iter  10 value 43.068440
## iter  20 value 28.983081
## iter  30 value 22.984883
## iter  40 value 17.894523
## iter  50 value 17.235365
## iter  60 value 16.915588
## iter  70 value 16.358464
## iter  80 value 15.798334
## iter  90 value 15.794051
## final  value 15.794037
## converged
## # weights:  179
## initial  value 117.629130
## iter  10 value 41.854606
## iter  20 value 26.693568
## iter  30 value 18.463893
## iter  40 value 13.978631
## iter  50 value 12.741489
## iter  60 value 12.604487
## iter  70 value 12.585013
## iter  80 value 12.583861
## final  value 12.583839
## converged
## # weights:  39
## initial  value 103.631835
## iter  10 value 65.396030
## iter  20 value 54.768146
## iter  30 value 37.966065
## iter  40 value 35.718768
## iter  50 value 35.701729
## iter  60 value 35.688947
## iter  70 value 35.678597
## iter  80 value 35.666540
## iter  90 value 35.663116
## iter 100 value 35.660045
## final  value 35.660045
## stopped after 100 iterations
## # weights:  109
## initial  value 117.118302
```

```
## iter  10 value 35.340095
## iter  20 value 17.220076
## iter  30 value 14.223567
## iter  40 value 14.030370
## iter  50 value 13.894558
## iter  60 value 13.647203
## iter  70 value 13.204645
## iter  80 value 13.051009
## iter  90 value 12.962994
## iter 100 value 12.929135
## final  value 12.929135
## stopped after 100 iterations
## # weights:  179
## initial  value 101.943250
## iter  10 value 21.042763
## iter  20 value 5.771815
## iter  30 value 3.656828
## iter  40 value 3.471391
## iter  50 value 1.991634
## iter  60 value 1.603838
## iter  70 value 1.553675
## iter  80 value 1.546291
## iter  90 value 1.532752
## iter 100 value 1.520293
## final  value 1.520293
## stopped after 100 iterations
## # weights:  39
## initial  value 99.797558
## iter  10 value 65.945680
## iter  20 value 57.633580
## iter  30 value 54.165715
## iter  40 value 53.010454
## iter  50 value 51.946576
## iter  60 value 50.192814
## iter  70 value 48.590970
## iter  80 value 48.269517
## iter  90 value 48.131258
## iter 100 value 47.582145
## final  value 47.582145
## stopped after 100 iterations
## # weights:  109
## initial  value 97.850406
## iter  10 value 41.959992
## iter  20 value 10.897053
## iter  30 value 5.645714
## iter  40 value 5.109703
## iter  50 value 3.724841
## iter  60 value 3.404521
## iter  70 value 3.084039
## iter  80 value 2.927412
## iter  90 value 2.753889
## iter 100 value 2.547055
## final  value 2.547055
## stopped after 100 iterations
```

```
## # weights:  179
## initial  value 112.764363
## iter  10 value 23.686353
## iter  20 value 3.595541
## iter  30 value 2.243603
## iter  40 value 1.967209
## iter  50 value 1.914465
## iter  60 value 1.910244
## iter  70 value 1.512484
## iter  80 value 0.009200
## iter  90 value 0.003815
## iter 100 value 0.001384
## final  value 0.001384
## stopped after 100 iterations
## # weights:  39
## initial  value 115.324800
## iter  10 value 67.952091
## iter  20 value 63.175048
## iter  30 value 60.835177
## iter  40 value 58.722498
## iter  50 value 56.706761
## iter  60 value 56.624996
## iter  70 value 56.624357
## final  value 56.624349
## converged
## # weights:  109
## initial  value 108.072009
## iter  10 value 48.128830
## iter  20 value 30.797125
## iter  30 value 23.500813
## iter  40 value 17.361479
## iter  50 value 15.796159
## iter  60 value 15.355431
## iter  70 value 14.347634
## iter  80 value 14.254360
## final  value 14.254081
## converged
## # weights:  179
## initial  value 125.039959
## iter  10 value 30.179099
## iter  20 value 14.638748
## iter  30 value 12.198245
## iter  40 value 11.678432
## iter  50 value 11.606010
## iter  60 value 11.599622
## iter  70 value 11.599551
## final  value 11.599551
## converged
## # weights:  39
## initial  value 107.627648
## iter  10 value 65.001464
## iter  20 value 61.205110
## iter  30 value 57.776204
## iter  40 value 57.720982
```

```
## iter  50 value 57.706946
## iter  60 value 57.246883
## iter  70 value 56.640924
## iter  80 value 56.373159
## iter  90 value 55.755415
## iter 100 value 55.458089
## final  value 55.458089
## stopped after 100 iterations
## # weights:  109
## initial  value 108.253895
## iter  10 value 29.477915
## iter  20 value 22.458155
## iter  30 value 11.034093
## iter  40 value 10.664937
## iter  50 value 6.323761
## iter  60 value 5.354258
## iter  70 value 5.290192
## iter  80 value 5.274492
## iter  90 value 5.151863
## iter 100 value 4.912353
## final  value 4.912353
## stopped after 100 iterations
## # weights:  179
## initial  value 126.248823
## iter  10 value 17.031883
## iter  20 value 2.573441
## iter  30 value 2.423008
## iter  40 value 2.397704
## iter  50 value 2.382752
## iter  60 value 1.513084
## iter  70 value 0.350666
## iter  80 value 0.181823
## iter  90 value 0.172457
## iter 100 value 0.165114
## final  value 0.165114
## stopped after 100 iterations
## # weights:  39
## initial  value 99.092512
## iter  10 value 54.520354
## iter  20 value 52.461179
## iter  30 value 51.131887
## iter  40 value 51.123527
## iter  50 value 51.122706
## final  value 51.122704
## converged
## # weights:  109
## initial  value 104.389699
## iter  10 value 27.861184
## iter  20 value 16.934191
## iter  30 value 13.458953
## iter  40 value 11.705939
## iter  50 value 11.395261
## iter  60 value 10.838357
## iter  70 value 10.635628
```

```
## iter  80 value 10.235096
## iter  90 value 10.177024
## iter 100 value 10.115460
## final  value 10.115460
## stopped after 100 iterations
## # weights:  179
## initial  value 101.802878
## iter  10 value 25.946736
## iter  20 value 5.998618
## iter  30 value 2.284677
## iter  40 value 0.292031
## iter  50 value 0.024886
## iter  60 value 0.002933
## iter  70 value 0.000841
## iter  80 value 0.000362
## iter  90 value 0.000125
## iter  90 value 0.000078
## iter  90 value 0.000078
## final  value 0.000078
## converged
## # weights:  39
## initial  value 106.491510
## iter  10 value 81.936443
## iter  20 value 66.829675
## iter  30 value 58.211194
## iter  40 value 57.699985
## iter  50 value 57.166752
## iter  60 value 57.081910
## final  value 57.081874
## converged
## # weights:  109
## initial  value 112.703198
## iter  10 value 50.955553
## iter  20 value 34.678609
## iter  30 value 21.833766
## iter  40 value 16.577879
## iter  50 value 15.680038
## iter  60 value 15.480145
## iter  70 value 15.270827
## iter  80 value 15.266449
## final  value 15.266422
## converged
## # weights:  179
## initial  value 110.261485
## iter  10 value 40.124388
## iter  20 value 20.354962
## iter  30 value 13.681031
## iter  40 value 12.657736
## iter  50 value 12.231811
## iter  60 value 12.161312
## iter  70 value 12.081673
## iter  80 value 12.018442
## iter  90 value 12.017153
## final  value 12.017153
```

```
## converged
## # weights:  39
## initial  value 115.541619
## iter  10 value 69.763455
## iter  20 value 56.761979
## iter  30 value 56.176660
## iter  40 value 55.957441
## iter  50 value 55.498158
## iter  60 value 54.784496
## iter  70 value 54.614732
## iter  80 value 53.985752
## iter  90 value 53.746176
## iter 100 value 53.734136
## final  value 53.734136
## stopped after 100 iterations
## # weights:  109
## initial  value 101.441106
## iter  10 value 50.608195
## iter  20 value 29.747735
## iter  30 value 23.999537
## iter  40 value 22.719029
## iter  50 value 22.692488
## iter  60 value 22.288452
## iter  70 value 20.883098
## iter  80 value 20.707498
## iter  90 value 20.662697
## iter 100 value 20.628856
## final  value 20.628856
## stopped after 100 iterations
## # weights:  179
## initial  value 99.230238
## iter  10 value 26.101055
## iter  20 value 4.938801
## iter  30 value 1.932110
## iter  40 value 0.654284
## iter  50 value 0.330809
## iter  60 value 0.316018
## iter  70 value 0.297297
## iter  80 value 0.287929
## iter  90 value 0.271203
## iter 100 value 0.256847
## final  value 0.256847
## stopped after 100 iterations
## # weights:  39
## initial  value 104.669963
## iter  10 value 66.864078
## iter  20 value 57.140708
## iter  30 value 46.290808
## iter  40 value 42.824948
## iter  50 value 39.941510
## iter  60 value 39.464018
## iter  70 value 39.274388
## iter  80 value 39.192357
## iter  90 value 39.187777
```

```
## final  value 39.187680
## converged
## # weights:  109
## initial  value 102.806021
## iter  10 value 34.130442
## iter  20 value 18.861193
## iter  30 value 15.530283
## iter  40 value 14.860458
## iter  50 value 13.471908
## iter  60 value 12.538710
## iter  70 value 12.487662
## iter  80 value 12.462002
## iter  90 value 10.310143
## iter 100 value 10.248749
## final  value 10.248749
## stopped after 100 iterations
## # weights:  179
## initial  value 110.056506
## iter  10 value 29.548531
## iter  20 value 7.109959
## iter  30 value 0.138636
## iter  40 value 0.004803
## iter  50 value 0.000520
## final  value 0.000079
## converged
## # weights:  39
## initial  value 107.606755
## iter  10 value 64.890558
## iter  20 value 62.218865
## iter  30 value 60.288694
## iter  40 value 59.565045
## iter  50 value 59.470008
## iter  60 value 59.438217
## iter  70 value 59.288267
## iter  80 value 58.854671
## iter  90 value 58.320744
## iter 100 value 57.969901
## final  value 57.969901
## stopped after 100 iterations
## # weights:  109
## initial  value 103.328452
## iter  10 value 45.950875
## iter  20 value 27.123260
## iter  30 value 21.293860
## iter  40 value 18.066032
## iter  50 value 16.870077
## iter  60 value 16.818723
## iter  70 value 16.818030
## final  value 16.818018
## converged
## # weights:  179
## initial  value 113.379353
## iter  10 value 35.821643
## iter  20 value 19.753527
```

```
## iter  30 value 15.336133
## iter  40 value 13.298086
## iter  50 value 12.679920
## iter  60 value 12.258777
## iter  70 value 12.175820
## iter  80 value 11.870675
## iter  90 value 11.801158
## iter 100 value 11.799397
## final  value 11.799397
## stopped after 100 iterations
## # weights:  39
## initial  value 105.880894
## iter  10 value 72.160537
## iter  20 value 62.226050
## iter  30 value 60.131566
## iter  40 value 58.574585
## iter  50 value 58.315643
## iter  60 value 58.310338
## iter  70 value 57.111820
## iter  80 value 55.738623
## iter  90 value 55.049281
## iter 100 value 53.858656
## final  value 53.858656
## stopped after 100 iterations
## # weights:  109
## initial  value 105.445966
## iter  10 value 24.748807
## iter  20 value 8.480186
## iter  30 value 5.052165
## iter  40 value 3.145882
## iter  50 value 3.107279
## iter  60 value 3.076821
## iter  70 value 0.411933
## iter  80 value 0.224631
## iter  90 value 0.204758
## iter 100 value 0.191662
## final  value 0.191662
## stopped after 100 iterations
## # weights:  179
## initial  value 109.204451
## iter  10 value 39.441681
## iter  20 value 17.093497
## iter  30 value 12.699110
## iter  40 value 11.690340
## iter  50 value 11.587461
## iter  60 value 11.526514
## iter  70 value 11.380504
## iter  80 value 11.260548
## iter  90 value 10.941939
## iter 100 value 10.445425
## final  value 10.445425
## stopped after 100 iterations
## # weights:  39
## initial  value 98.363151
```

```
## iter  10 value 67.624509
## iter  20 value 60.633832
## iter  30 value 57.193424
## iter  40 value 56.093446
## iter  50 value 55.973291
## iter  60 value 55.956924
## iter  70 value 55.955302
## iter  80 value 55.954574
## iter  90 value 55.954275
## iter 100 value 55.954048
## final  value 55.954048
## stopped after 100 iterations
## # weights:  109
## initial  value 103.419247
## iter  10 value 46.156053
## iter  20 value 23.139476
## iter  30 value 13.198848
## iter  40 value 10.844461
## iter  50 value 2.386110
## iter  60 value 0.088193
## iter  70 value 0.008547
## iter  80 value 0.005125
## iter  90 value 0.002214
## iter 100 value 0.000690
## final  value 0.000690
## stopped after 100 iterations
## # weights:  179
## initial  value 106.351747
## iter  10 value 35.788512
## iter  20 value 21.996247
## iter  30 value 19.139947
## iter  40 value 18.227055
## iter  50 value 16.182392
## iter  60 value 14.422546
## iter  70 value 13.888150
## iter  80 value 13.462837
## iter  90 value 13.165692
## iter 100 value 12.388587
## final  value 12.388587
## stopped after 100 iterations
## # weights:  39
## initial  value 101.909049
## iter  10 value 83.815337
## iter  20 value 61.818776
## iter  30 value 58.439010
## iter  40 value 56.635246
## iter  50 value 55.989602
## iter  60 value 55.965725
## final  value 55.965721
## converged
## # weights:  109
## initial  value 113.992190
## iter  10 value 34.746678
## iter  20 value 19.581461
```

```
## iter  30 value 16.901982
## iter  40 value 16.466751
## iter  50 value 16.430641
## iter  60 value 16.430493
## iter  60 value 16.430493
## iter  60 value 16.430493
## final  value 16.430493
## converged
## # weights:  179
## initial  value 101.122494
## iter  10 value 40.285028
## iter  20 value 19.781269
## iter  30 value 13.669962
## iter  40 value 12.997945
## iter  50 value 12.772024
## iter  60 value 12.757873
## iter  70 value 12.753326
## iter  80 value 12.750597
## iter  90 value 12.737905
## iter 100 value 12.735693
## final  value 12.735693
## stopped after 100 iterations
## # weights:  39
## initial  value 98.298796
## iter  10 value 61.422001
## iter  20 value 58.642248
## iter  30 value 58.065218
## iter  40 value 58.046885
## iter  50 value 57.865301
## iter  60 value 57.552258
## iter  70 value 57.350448
## iter  80 value 57.061957
## iter  90 value 56.647756
## iter 100 value 56.521578
## final  value 56.521578
## stopped after 100 iterations
## # weights:  109
## initial  value 109.441374
## iter  10 value 49.270731
## iter  20 value 26.177021
## iter  30 value 21.712290
## iter  40 value 18.950270
## iter  50 value 18.532337
## iter  60 value 17.944845
## iter  70 value 17.750275
## iter  80 value 16.764449
## iter  90 value 14.358135
## iter 100 value 14.257848
## final  value 14.257848
## stopped after 100 iterations
## # weights:  179
## initial  value 107.599108
## iter  10 value 31.782188
## iter  20 value 11.582940
```

```
## iter  30 value 9.534893
## iter  40 value 8.602916
## iter  50 value 8.186872
## iter  60 value 6.368664
## iter  70 value 6.169211
## iter  80 value 2.927200
## iter  90 value 2.902793
## iter 100 value 2.883550
## final  value 2.883550
## stopped after 100 iterations
## # weights:  39
## initial  value 105.743871
## iter  10 value 54.754192
## iter  20 value 51.203334
## iter  30 value 50.923013
## iter  40 value 50.526205
## iter  50 value 49.996766
## iter  60 value 49.701266
## iter  70 value 49.551492
## iter  80 value 48.614428
## iter  90 value 48.541854
## iter 100 value 48.532960
## final  value 48.532960
## stopped after 100 iterations
## # weights:  109
## initial  value 98.378575
## iter  10 value 35.522758
## iter  20 value 19.777993
## iter  30 value 13.389981
## iter  40 value 12.625373
## iter  50 value 12.556115
## iter  60 value 10.750257
## iter  70 value 10.589102
## iter  80 value 10.142654
## iter  90 value 8.250222
## iter 100 value 8.181177
## final  value 8.181177
## stopped after 100 iterations
## # weights:  179
## initial  value 113.392088
## iter  10 value 32.077971
## iter  20 value 17.442423
## iter  30 value 13.508386
## iter  40 value 9.728475
## iter  50 value 6.937029
## iter  60 value 5.787623
## iter  70 value 4.548593
## iter  80 value 4.276075
## iter  90 value 2.285914
## iter 100 value 2.017153
## final  value 2.017153
## stopped after 100 iterations
## # weights:  39
## initial  value 110.298436
```

```
## iter  10 value 70.831364
## iter  20 value 61.775637
## iter  30 value 57.984538
## iter  40 value 57.599174
## final  value 57.592674
## converged
## # weights:  109
## initial  value 101.927428
## iter  10 value 46.247144
## iter  20 value 22.521389
## iter  30 value 17.588709
## iter  40 value 16.488760
## iter  50 value 16.460482
## iter  60 value 16.459684
## iter  70 value 16.183518
## iter  80 value 16.137454
## iter  90 value 16.137075
## final  value 16.137075
## converged
## # weights:  179
## initial  value 124.797322
## iter  10 value 45.810230
## iter  20 value 24.971244
## iter  30 value 17.316854
## iter  40 value 14.727914
## iter  50 value 12.960653
## iter  60 value 12.373773
## iter  70 value 12.074334
## iter  80 value 11.976357
## iter  90 value 11.968884
## iter 100 value 11.967812
## final  value 11.967812
## stopped after 100 iterations
## # weights:  39
## initial  value 101.612215
## iter  10 value 64.843294
## iter  20 value 57.960247
## iter  30 value 53.378408
## iter  40 value 50.908074
## iter  50 value 48.054990
## iter  60 value 48.041764
## iter  70 value 48.038991
## iter  80 value 48.035420
## iter  90 value 48.034289
## iter 100 value 48.032511
## final  value 48.032511
## stopped after 100 iterations
## # weights:  109
## initial  value 128.191366
## iter  10 value 55.618530
## iter  20 value 41.772728
## iter  30 value 31.440104
## iter  40 value 29.638257
## iter  50 value 26.358345
```

```
## iter  60 value 25.134564
## iter  70 value 24.992664
## iter  80 value 24.682289
## iter  90 value 23.984477
## iter 100 value 19.869928
## final  value 19.869928
## stopped after 100 iterations
## # weights:  179
## initial  value 100.306791
## iter  10 value 26.609017
## iter  20 value 13.561397
## iter  30 value 11.641858
## iter  40 value 9.221786
## iter  50 value 7.792437
## iter  60 value 6.398928
## iter  70 value 5.003824
## iter  80 value 4.919280
## iter  90 value 4.908407
## iter 100 value 2.506795
## final  value 2.506795
## stopped after 100 iterations
## # weights:  39
## initial  value 102.553626
## iter  10 value 70.148006
## iter  20 value 67.830716
## iter  30 value 67.439081
## iter  40 value 67.093759
## iter  50 value 66.560196
## iter  60 value 64.630462
## iter  70 value 64.624002
## iter  80 value 64.060548
## iter  90 value 64.000883
## iter 100 value 63.992547
## final  value 63.992547
## stopped after 100 iterations
## # weights:  109
## initial  value 97.286293
## iter  10 value 20.656260
## iter  20 value 11.181246
## iter  30 value 3.458362
## iter  40 value 3.367512
## iter  50 value 3.365139
## iter  60 value 3.365060
## final  value 3.365060
## converged
## # weights:  179
## initial  value 132.619398
## iter  10 value 22.534098
## iter  20 value 8.917627
## iter  30 value 3.969384
## iter  40 value 3.892390
## iter  50 value 3.888532
## iter  60 value 3.888307
## final  value 3.888307
```

```
## converged
## # weights:  39
## initial  value 109.991995
## iter  10 value 69.334335
## iter  20 value 60.102021
## iter  30 value 56.653929
## iter  40 value 56.310702
## iter  50 value 56.001484
## final  value 55.998821
## converged
## # weights:  109
## initial  value 107.568757
## iter  10 value 44.422833
## iter  20 value 27.715355
## iter  30 value 19.698976
## iter  40 value 16.187469
## iter  50 value 15.878375
## iter  60 value 15.710391
## iter  70 value 15.675832
## final  value 15.675699
## converged
## # weights:  179
## initial  value 165.953703
## iter  10 value 61.975633
## iter  20 value 20.955199
## iter  30 value 13.015305
## iter  40 value 12.076087
## iter  50 value 11.885068
## iter  60 value 11.828839
## iter  70 value 11.781080
## iter  80 value 11.776055
## iter  90 value 11.775850
## iter 100 value 11.775827
## final  value 11.775827
## stopped after 100 iterations
## # weights:  39
## initial  value 108.794921
## iter  10 value 71.007891
## iter  20 value 68.856002
## iter  30 value 68.210033
## iter  40 value 68.076816
## iter  50 value 67.987203
## iter  60 value 67.950347
## iter  70 value 67.938321
## iter  80 value 67.928485
## iter  90 value 67.923458
## iter 100 value 67.877822
## final  value 67.877822
## stopped after 100 iterations
## # weights:  109
## initial  value 107.900894
## iter  10 value 40.841989
## iter  20 value 21.071311
## iter  30 value 13.768799
```

```
## iter  40 value 12.782516
## iter  50 value 12.716667
## iter  60 value 12.247329
## iter  70 value 10.990797
## iter  80 value 10.750290
## iter  90 value 10.680139
## iter 100 value 10.635746
## final  value 10.635746
## stopped after 100 iterations
## # weights:  179
## initial  value 112.823429
## iter  10 value 36.415183
## iter  20 value 22.613074
## iter  30 value 19.019331
## iter  40 value 17.745161
## iter  50 value 17.402077
## iter  60 value 16.645010
## iter  70 value 15.978487
## iter  80 value 15.624066
## iter  90 value 15.607758
## iter 100 value 15.592408
## final  value 15.592408
## stopped after 100 iterations
## # weights:  39
## initial  value 108.629768
## iter  10 value 67.402471
## iter  20 value 58.695268
## iter  30 value 53.511530
## iter  40 value 49.684811
## iter  50 value 48.739661
## iter  60 value 48.677244
## iter  70 value 47.737636
## iter  80 value 47.194317
## iter  90 value 46.748951
## iter 100 value 46.642830
## final  value 46.642830
## stopped after 100 iterations
## # weights:  109
## initial  value 113.450153
## iter  10 value 46.638019
## iter  20 value 29.465079
## iter  30 value 27.548786
## iter  40 value 24.093047
## iter  50 value 22.343031
## iter  60 value 20.080774
## iter  70 value 15.199952
## iter  80 value 12.461883
## iter  90 value 12.289956
## iter 100 value 10.404381
## final  value 10.404381
## stopped after 100 iterations
## # weights:  179
## initial  value 113.906049
## iter  10 value 34.327061
```

```
## iter  20 value 5.716226
## iter  30 value 2.428107
## iter  40 value 1.931393
## iter  50 value 1.910801
## iter  60 value 1.909631
## iter  70 value 1.908669
## iter  80 value 1.907202
## iter  90 value 1.386891
## final  value 1.386310
## converged
## # weights:  39
## initial  value 122.529973
## iter  10 value 79.396166
## iter  20 value 64.985604
## iter  30 value 62.206387
## iter  40 value 60.081526
## iter  50 value 59.708559
## final  value 59.706366
## converged
## # weights:  109
## initial  value 110.888675
## iter  10 value 54.470268
## iter  20 value 28.999347
## iter  30 value 20.760679
## iter  40 value 18.376026
## iter  50 value 16.044729
## iter  60 value 15.885068
## iter  70 value 15.884350
## final  value 15.884347
## converged
## # weights:  179
## initial  value 128.878174
## iter  10 value 56.205250
## iter  20 value 24.379722
## iter  30 value 16.468165
## iter  40 value 13.774095
## iter  50 value 13.161681
## iter  60 value 13.022688
## iter  70 value 12.972723
## iter  80 value 12.865362
## iter  90 value 12.769547
## iter 100 value 12.621778
## final  value 12.621778
## stopped after 100 iterations
## # weights:  39
## initial  value 112.224905
## iter  10 value 61.512202
## iter  20 value 56.892719
## iter  30 value 55.881156
## iter  40 value 55.852551
## iter  50 value 54.757422
## iter  60 value 52.780134
## iter  70 value 52.379027
## iter  80 value 52.361468
```

```
## iter  90 value 52.351718
## iter 100 value 52.349046
## final  value 52.349046
## stopped after 100 iterations
## # weights:  109
## initial  value 114.821735
## iter  10 value 35.898037
## iter  20 value 15.665394
## iter  30 value 13.078620
## iter  40 value 12.855718
## iter  50 value 12.697503
## iter  60 value 12.292885
## iter  70 value 12.177201
## iter  80 value 12.150601
## iter  90 value 12.114948
## iter 100 value 12.090408
## final  value 12.090408
## stopped after 100 iterations
## # weights:  179
## initial  value 112.748959
## iter  10 value 28.986174
## iter  20 value 8.680665
## iter  30 value 3.286974
## iter  40 value 3.007362
## iter  50 value 2.944428
## iter  60 value 2.938071
## iter  70 value 2.927772
## iter  80 value 2.870394
## iter  90 value 2.055326
## iter 100 value 2.048359
## final  value 2.048359
## stopped after 100 iterations
## # weights:  39
## initial  value 95.850764
## iter  10 value 62.453250
## iter  20 value 57.903188
## iter  30 value 50.615236
## iter  40 value 47.879002
## iter  50 value 47.216466
## iter  60 value 47.167444
## iter  70 value 46.881449
## iter  80 value 45.768182
## iter  90 value 45.758869
## iter 100 value 44.747057
## final  value 44.747057
## stopped after 100 iterations
## # weights:  109
## initial  value 115.113788
## iter  10 value 35.844141
## iter  20 value 18.404776
## iter  30 value 16.750748
## iter  40 value 16.243209
## iter  50 value 16.191514
## iter  60 value 16.188828
```

```
## iter  70 value 16.188421
## iter  80 value 16.188386
## final  value 16.188378
## converged
## # weights:  179
## initial  value 98.513063
## iter  10 value 11.027990
## iter  20 value 0.375485
## iter  30 value 0.003338
## final  value 0.000063
## converged
## # weights:  39
## initial  value 98.246345
## iter  10 value 75.637567
## iter  20 value 62.043113
## iter  30 value 61.098588
## iter  40 value 60.071421
## iter  50 value 57.564738
## iter  60 value 57.131452
## iter  70 value 56.347132
## iter  80 value 55.781382
## iter  90 value 55.752338
## final  value 55.752265
## converged
## # weights:  109
## initial  value 97.917261
## iter  10 value 49.815846
## iter  20 value 29.049349
## iter  30 value 18.481692
## iter  40 value 16.472866
## iter  50 value 16.343455
## iter  60 value 16.341053
## iter  70 value 16.341018
## iter  70 value 16.341018
## iter  70 value 16.341018
## final  value 16.341018
## converged
## # weights:  179
## initial  value 116.019447
## iter  10 value 34.449699
## iter  20 value 16.765738
## iter  30 value 12.384215
## iter  40 value 11.945279
## iter  50 value 11.793083
## iter  60 value 11.659182
## iter  70 value 11.654419
## iter  80 value 11.653949
## iter  90 value 11.653946
## final  value 11.653945
## converged
## # weights:  39
## initial  value 97.285276
## iter  10 value 56.132521
## iter  20 value 53.182804
```

```
## iter  30 value 52.474062
## iter  40 value 51.545756
## iter  50 value 51.254311
## iter  60 value 50.255686
## iter  70 value 48.494321
## iter  80 value 44.747946
## iter  90 value 42.099681
## iter 100 value 41.183351
## final  value 41.183351
## stopped after 100 iterations
## # weights:  109
## initial  value 110.367790
## iter  10 value 32.758854
## iter  20 value 24.553723
## iter  30 value 22.242126
## iter  40 value 18.200096
## iter  50 value 16.305141
## iter  60 value 14.531900
## iter  70 value 14.121520
## iter  80 value 13.471591
## iter  90 value 13.445634
## iter 100 value 13.439581
## final  value 13.439581
## stopped after 100 iterations
## # weights:  179
## initial  value 103.522266
## iter  10 value 24.327191
## iter  20 value 11.539824
## iter  30 value 5.156288
## iter  40 value 3.623094
## iter  50 value 3.258195
## iter  60 value 2.958701
## iter  70 value 2.387416
## iter  80 value 2.243098
## iter  90 value 2.201411
## iter 100 value 2.153700
## final  value 2.153700
## stopped after 100 iterations
## # weights:  39
## initial  value 104.273895
## iter  10 value 80.178196
## iter  20 value 66.431267
## iter  30 value 63.061843
## iter  40 value 59.589535
## iter  50 value 56.644395
## iter  60 value 53.806732
## iter  70 value 53.400959
## iter  80 value 53.360288
## iter  90 value 53.343806
## iter 100 value 53.340406
## final  value 53.340406
## stopped after 100 iterations
## # weights:  109
## initial  value 104.200368
```

```
## iter  10 value 21.243159
## iter  20 value 14.672576
## iter  30 value 13.342334
## iter  40 value 12.862696
## iter  50 value 12.394133
## iter  60 value 12.358623
## iter  70 value 12.247926
## iter  80 value 12.200178
## iter  90 value 12.187596
## iter 100 value 11.548474
## final  value 11.548474
## stopped after 100 iterations
## # weights:  179
## initial  value 111.120113
## iter  10 value 37.173051
## iter  20 value 13.196762
## iter  30 value 5.858393
## iter  40 value 3.104145
## iter  50 value 0.864227
## iter  60 value 0.274956
## iter  70 value 0.087390
## iter  80 value 0.016942
## iter  90 value 0.002319
## iter 100 value 0.000615
## final  value 0.000615
## stopped after 100 iterations
## # weights:  39
## initial  value 104.685204
## iter  10 value 75.140028
## iter  20 value 65.893640
## iter  30 value 64.216871
## iter  40 value 61.255605
## iter  50 value 59.087264
## iter  60 value 58.293563
## iter  70 value 58.015434
## iter  80 value 57.571189
## iter  90 value 57.133244
## iter 100 value 57.114779
## final  value 57.114779
## stopped after 100 iterations
## # weights:  109
## initial  value 105.860992
## iter  10 value 52.608029
## iter  20 value 26.844929
## iter  30 value 18.915280
## iter  40 value 16.107803
## iter  50 value 15.697892
## iter  60 value 15.682900
## iter  70 value 15.682415
## final  value 15.682415
## converged
## # weights:  179
## initial  value 100.267651
## iter  10 value 26.444931
```

```
## iter  20 value 16.495048
## iter  30 value 14.037741
## iter  40 value 13.412082
## iter  50 value 12.767397
## iter  60 value 12.364658
## iter  70 value 12.289889
## iter  80 value 12.274146
## iter  90 value 11.989018
## iter 100 value 11.937742
## final  value 11.937742
## stopped after 100 iterations
## # weights:  39
## initial  value 109.747464
## iter  10 value 56.331905
## iter  20 value 49.041478
## iter  30 value 46.397400
## iter  40 value 45.541175
## iter  50 value 45.428697
## iter  60 value 44.929897
## iter  70 value 44.795721
## iter  80 value 44.595495
## iter  90 value 44.015911
## iter 100 value 43.945279
## final  value 43.945279
## stopped after 100 iterations
## # weights:  109
## initial  value 113.605104
## iter  10 value 43.466165
## iter  20 value 13.322778
## iter  30 value 12.275673
## iter  40 value 3.683058
## iter  50 value 3.018265
## iter  60 value 2.891851
## iter  70 value 2.710816
## iter  80 value 2.667923
## iter  90 value 2.652158
## iter 100 value 1.528409
## final  value 1.528409
## stopped after 100 iterations
## # weights:  179
## initial  value 106.179434
## iter  10 value 20.801837
## iter  20 value 2.620206
## iter  30 value 0.302520
## iter  40 value 0.250760
## iter  50 value 0.228579
## iter  60 value 0.215545
## iter  70 value 0.203794
## iter  80 value 0.192145
## iter  90 value 0.184748
## iter 100 value 0.171013
## final  value 0.171013
## stopped after 100 iterations
## # weights:  39
```

```
## initial  value 100.973925
## iter  10 value 57.784520
## iter  20 value 52.654989
## iter  30 value 50.229106
## iter  40 value 50.017123
## iter  50 value 49.974248
## iter  60 value 49.956866
## iter  70 value 49.940940
## iter  80 value 49.937328
## iter  90 value 49.936365
## iter 100 value 49.925771
## final  value 49.925771
## stopped after 100 iterations
## # weights:  109
## initial  value 105.825365
## iter  10 value 76.407707
## iter  20 value 22.095252
## iter  30 value 18.100752
## iter  40 value 17.654298
## iter  50 value 17.178281
## iter  60 value 16.967075
## iter  70 value 16.949367
## iter  80 value 16.562687
## iter  90 value 15.824019
## iter 100 value 15.411064
## final  value 15.411064
## stopped after 100 iterations
## # weights:  179
## initial  value 142.362018
## iter  10 value 30.525406
## iter  20 value 15.346714
## iter  30 value 9.294052
## iter  40 value 8.462412
## iter  50 value 8.252965
## iter  60 value 7.934935
## iter  70 value 6.902517
## iter  80 value 5.465348
## iter  90 value 5.415021
## iter 100 value 5.398348
## final  value 5.398348
## stopped after 100 iterations
## # weights:  39
## initial  value 100.160587
## iter  10 value 76.431954
## iter  20 value 64.302241
## iter  30 value 60.977127
## iter  40 value 59.615263
## iter  50 value 58.452224
## iter  60 value 58.296665
## final  value 58.296647
## converged
## # weights:  109
## initial  value 103.178689
## iter  10 value 55.083940
```

```
## iter  20 value 35.274241
## iter  30 value 21.559043
## iter  40 value 16.599123
## iter  50 value 16.115686
## iter  60 value 15.885448
## iter  70 value 15.668320
## iter  80 value 15.658130
## final  value 15.658085
## converged
## # weights:  179
## initial  value 119.207751
## iter  10 value 35.043853
## iter  20 value 19.259180
## iter  30 value 14.215892
## iter  40 value 13.225754
## iter  50 value 12.315779
## iter  60 value 12.073245
## iter  70 value 12.054459
## iter  80 value 12.053437
## final  value 12.053428
## converged
## # weights:  39
## initial  value 102.870859
## iter  10 value 65.530454
## iter  20 value 57.153446
## iter  30 value 51.913187
## iter  40 value 51.479502
## iter  50 value 51.473677
## iter  60 value 51.472720
## iter  70 value 51.471604
## iter  80 value 51.463795
## iter  90 value 50.363243
## iter 100 value 46.940685
## final  value 46.940685
## stopped after 100 iterations
## # weights:  109
## initial  value 106.702826
## iter  10 value 39.530385
## iter  20 value 31.274918
## iter  30 value 28.143945
## iter  40 value 28.086041
## iter  50 value 28.029798
## iter  60 value 28.011869
## iter  70 value 27.901559
## iter  80 value 27.489760
## iter  90 value 24.101177
## iter 100 value 23.644284
## final  value 23.644284
## stopped after 100 iterations
## # weights:  179
## initial  value 131.102634
## iter  10 value 33.895810
## iter  20 value 15.953847
## iter  30 value 1.198418
```

```
## iter  40 value 0.281151
## iter  50 value 0.245688
## iter  60 value 0.220019
## iter  70 value 0.197471
## iter  80 value 0.173831
## iter  90 value 0.160837
## iter 100 value 0.145285
## final  value 0.145285
## stopped after 100 iterations
## # weights:  39
## initial  value 103.592126
## iter  10 value 79.208572
## iter  20 value 73.755657
## iter  30 value 72.896207
## iter  40 value 71.964296
## iter  50 value 71.126707
## iter  60 value 70.989323
## iter  70 value 70.785329
## iter  80 value 70.698563
## iter  90 value 69.189643
## iter 100 value 68.510562
## final  value 68.510562
## stopped after 100 iterations
## # weights:  109
## initial  value 106.964333
## iter  10 value 44.649207
## iter  20 value 21.816080
## iter  30 value 15.075303
## iter  40 value 14.089928
## iter  50 value 13.680059
## iter  60 value 13.633925
## iter  70 value 13.627821
## iter  80 value 13.627396
## iter  90 value 13.627041
## iter 100 value 13.620659
## final  value 13.620659
## stopped after 100 iterations
## # weights:  179
## initial  value 141.144873
## iter  10 value 54.513365
## iter  20 value 31.163049
## iter  30 value 18.840029
## iter  40 value 6.466062
## iter  50 value 0.491646
## iter  60 value 0.133271
## iter  70 value 0.029541
## iter  80 value 0.007058
## iter  90 value 0.002955
## iter 100 value 0.000949
## final  value 0.000949
## stopped after 100 iterations
## # weights:  39
## initial  value 100.055874
## iter  10 value 73.232858
```

```
## iter  20 value 64.678985
## iter  30 value 61.608996
## iter  40 value 56.456073
## iter  50 value 55.024790
## iter  60 value 54.999220
## final  value 54.999116
## converged
## # weights:  109
## initial  value 101.514721
## iter  10 value 45.969373
## iter  20 value 26.365913
## iter  30 value 21.266877
## iter  40 value 16.977484
## iter  50 value 16.230839
## iter  60 value 16.217339
## iter  70 value 16.209484
## iter  80 value 16.187465
## iter  90 value 16.169314
## iter 100 value 16.168323
## final  value 16.168323
## stopped after 100 iterations
## # weights:  179
## initial  value 104.303083
## iter  10 value 35.011912
## iter  20 value 19.831508
## iter  30 value 14.055075
## iter  40 value 12.933150
## iter  50 value 12.813755
## iter  60 value 12.306663
## iter  70 value 11.898151
## iter  80 value 11.837618
## iter  90 value 11.837181
## final  value 11.837157
## converged
## # weights:  39
## initial  value 96.801867
## iter  10 value 63.620322
## iter  20 value 57.892841
## iter  30 value 56.838873
## iter  40 value 56.219903
## iter  50 value 53.626095
## iter  60 value 49.140965
## iter  70 value 44.667961
## iter  80 value 40.556063
## iter  90 value 36.705894
## iter 100 value 36.003240
## final  value 36.003240
## stopped after 100 iterations
## # weights:  109
## initial  value 109.479868
## iter  10 value 32.572522
## iter  20 value 19.541014
## iter  30 value 18.301975
## iter  40 value 18.104545
```

```
## iter  50 value 18.074769
## iter  60 value 18.059927
## iter  70 value 17.614126
## iter  80 value 17.574032
## iter  90 value 16.046639
## iter 100 value 12.460793
## final  value 12.460793
## stopped after 100 iterations
## # weights:  179
## initial  value 111.920541
## iter  10 value 37.578512
## iter  20 value 12.645302
## iter  30 value 11.388523
## iter  40 value 9.620623
## iter  50 value 9.098781
## iter  60 value 8.992492
## iter  70 value 8.891099
## iter  80 value 8.697371
## iter  90 value 8.505899
## iter 100 value 5.382842
## final  value 5.382842
## stopped after 100 iterations
## # weights:  39
## initial  value 111.713833
## iter  10 value 79.246710
## iter  20 value 57.860666
## iter  30 value 56.787143
## iter  40 value 56.250428
## iter  50 value 55.686564
## iter  60 value 54.384607
## iter  70 value 53.267637
## iter  80 value 53.012650
## iter  90 value 51.101749
## iter 100 value 51.022758
## final  value 51.022758
## stopped after 100 iterations
## # weights:  109
## initial  value 120.647719
## iter  10 value 63.132511
## iter  20 value 36.602502
## iter  30 value 26.648291
## iter  40 value 23.688396
## iter  50 value 21.632804
## iter  60 value 21.408187
## iter  70 value 21.132168
## iter  80 value 20.455011
## iter  90 value 19.733412
## iter 100 value 17.952214
## final  value 17.952214
## stopped after 100 iterations
## # weights:  179
## initial  value 104.277310
## iter  10 value 23.973221
## iter  20 value 4.155488
```

```
## iter  30 value 2.297378
## iter  40 value 2.250008
## iter  50 value 2.249362
## final  value 2.249356
## converged
## # weights:  39
## initial  value 102.263714
## iter  10 value 72.966869
## iter  20 value 63.939617
## iter  30 value 57.829239
## iter  40 value 56.970629
## iter  50 value 56.742280
## iter  60 value 56.326926
## iter  70 value 55.708456
## iter  80 value 55.686515
## final  value 55.686510
## converged
## # weights:  109
## initial  value 110.621111
## iter  10 value 42.607705
## iter  20 value 22.965918
## iter  30 value 17.436947
## iter  40 value 16.868241
## iter  50 value 16.831300
## iter  60 value 16.829190
## iter  70 value 16.829109
## final  value 16.829108
## converged
## # weights:  179
## initial  value 136.559433
## iter  10 value 47.009197
## iter  20 value 26.503933
## iter  30 value 17.023482
## iter  40 value 13.653284
## iter  50 value 12.781369
## iter  60 value 12.629725
## iter  70 value 12.604546
## iter  80 value 12.602509
## iter  90 value 12.579541
## iter 100 value 12.572201
## final  value 12.572201
## stopped after 100 iterations
## # weights:  39
## initial  value 106.054116
## iter  10 value 68.605511
## iter  20 value 62.390504
## iter  30 value 60.442573
## iter  40 value 59.435690
## iter  50 value 54.404426
## iter  60 value 50.285366
## iter  70 value 48.798674
## iter  80 value 48.393695
## iter  90 value 47.996002
## iter 100 value 47.527822
```

```
## final  value 47.527822
## stopped after 100 iterations
## # weights:  109
## initial  value 112.321504
## iter  10 value 47.353748
## iter  20 value 26.897734
## iter  30 value 15.043379
## iter  40 value 12.644512
## iter  50 value 11.955071
## iter  60 value 11.666453
## iter  70 value 11.253217
## iter  80 value 10.966730
## iter  90 value 9.490496
## iter 100 value 9.229535
## final  value 9.229535
## stopped after 100 iterations
## # weights:  179
## initial  value 102.179906
## iter  10 value 18.568774
## iter  20 value 3.508090
## iter  30 value 0.655172
## iter  40 value 0.185853
## iter  50 value 0.167920
## iter  60 value 0.159749
## iter  70 value 0.144850
## iter  80 value 0.132991
## iter  90 value 0.117110
## iter 100 value 0.106325
## final  value 0.106325
## stopped after 100 iterations
## # weights:  39
## initial  value 111.480998
## iter  10 value 78.242925
## iter  20 value 73.444508
## iter  30 value 69.506263
## iter  40 value 68.014797
## iter  50 value 67.849233
## iter  60 value 67.828279
## iter  70 value 67.825893
## iter  80 value 67.825610
## iter  90 value 67.825400
## final  value 67.825337
## converged
## # weights:  109
## initial  value 114.175458
## iter  10 value 50.689604
## iter  20 value 37.328890
## iter  30 value 31.590767
## iter  40 value 31.457850
## iter  50 value 31.296343
## iter  60 value 31.211943
## iter  70 value 31.160221
## iter  80 value 31.143343
## iter  90 value 31.119216
```

```
## iter 100 value 31.055241
## final  value 31.055241
## stopped after 100 iterations
## # weights:  179
## initial  value 136.031181
## iter  10 value 29.466597
## iter  20 value 15.446634
## iter  30 value 11.987605
## iter  40 value 9.698625
## iter  50 value 7.126793
## iter  60 value 6.082322
## iter  70 value 5.846941
## iter  80 value 5.625418
## iter  90 value 5.378058
## iter 100 value 4.618173
## final  value 4.618173
## stopped after 100 iterations
## # weights:  39
## initial  value 108.610709
## iter  10 value 92.176523
## iter  20 value 70.321851
## iter  30 value 62.516397
## iter  40 value 61.273200
## iter  50 value 61.262374
## final  value 61.262364
## converged
## # weights:  109
## initial  value 142.176533
## iter  10 value 75.274168
## iter  20 value 47.143641
## iter  30 value 34.925998
## iter  40 value 22.069397
## iter  50 value 17.370121
## iter  60 value 16.839118
## iter  70 value 16.697304
## iter  80 value 16.679119
## iter  90 value 16.678242
## iter 100 value 16.678227
## final  value 16.678227
## stopped after 100 iterations
## # weights:  179
## initial  value 114.377077
## iter  10 value 39.244631
## iter  20 value 18.233864
## iter  30 value 15.055457
## iter  40 value 13.744873
## iter  50 value 13.089238
## iter  60 value 12.959814
## iter  70 value 12.677389
## iter  80 value 12.619670
## iter  90 value 12.618037
## final  value 12.618011
## converged
## # weights:  39
```

```
## initial  value 107.724661
## iter  10 value 71.430965
## iter  20 value 66.711827
## iter  30 value 65.020372
## iter  40 value 64.229349
## iter  50 value 64.141627
## iter  60 value 61.321386
## iter  70 value 60.498812
## iter  80 value 60.094100
## iter  90 value 59.406336
## iter 100 value 58.950842
## final  value 58.950842
## stopped after 100 iterations
## # weights:  109
## initial  value 108.904984
## iter  10 value 45.818045
## iter  20 value 27.374777
## iter  30 value 15.843102
## iter  40 value 13.368509
## iter  50 value 11.419307
## iter  60 value 11.068135
## iter  70 value 11.043391
## iter  80 value 10.993268
## iter  90 value 10.783770
## iter 100 value 10.635422
## final  value 10.635422
## stopped after 100 iterations
## # weights:  179
## initial  value 105.547978
## iter  10 value 24.652374
## iter  20 value 1.721313
## iter  30 value 0.317535
## iter  40 value 0.284089
## iter  50 value 0.245125
## iter  60 value 0.226665
## iter  70 value 0.197506
## iter  80 value 0.179815
## iter  90 value 0.160319
## iter 100 value 0.142928
## final  value 0.142928
## stopped after 100 iterations
## # weights:  39
## initial  value 120.645515
## iter  10 value 61.637485
## iter  20 value 53.123121
## iter  30 value 48.896885
## iter  40 value 48.715487
## iter  50 value 48.714829
## iter  60 value 48.714706
## iter  60 value 48.714706
## iter  60 value 48.714706
## final  value 48.714706
## converged
## # weights:  109
```

```
## initial  value 106.861698
## iter  10 value 22.601379
## iter  20 value 10.206481
## iter  30 value 9.499900
## iter  40 value 9.433939
## iter  50 value 9.424377
## iter  60 value 9.366633
## iter  70 value 9.326111
## iter  80 value 9.272575
## iter  90 value 9.260439
## iter 100 value 9.222738
## final  value 9.222738
## stopped after 100 iterations
## # weights:  179
## initial  value 98.938722
## iter  10 value 17.703871
## iter  20 value 9.831781
## iter  30 value 6.229459
## iter  40 value 5.584642
## iter  50 value 5.555802
## iter  60 value 3.320219
## iter  70 value 3.293536
## iter  80 value 3.167083
## iter  90 value 3.148088
## iter 100 value 3.143881
## final  value 3.143881
## stopped after 100 iterations
## # weights:  39
## initial  value 109.335008
## iter  10 value 79.676130
## iter  20 value 66.874308
## iter  30 value 62.342386
## iter  40 value 61.042049
## iter  50 value 59.267360
## iter  60 value 58.817616
## iter  70 value 58.812712
## final  value 58.812628
## converged
## # weights:  109
## initial  value 145.111699
## iter  10 value 86.303677
## iter  20 value 48.857213
## iter  30 value 25.180623
## iter  40 value 17.647503
## iter  50 value 16.928812
## iter  60 value 16.404424
## iter  70 value 16.274916
## iter  80 value 16.247700
## iter  90 value 16.237666
## iter 100 value 16.233934
## final  value 16.233934
## stopped after 100 iterations
## # weights:  179
## initial  value 120.650479
```

```
## iter  10 value 35.934519
## iter  20 value 18.102816
## iter  30 value 14.347485
## iter  40 value 12.788833
## iter  50 value 12.095441
## iter  60 value 11.909278
## iter  70 value 11.804437
## iter  80 value 11.793172
## iter  90 value 11.792811
## iter 100 value 11.792798
## final  value 11.792798
## stopped after 100 iterations
## # weights:  39
## initial  value 105.058638
## iter  10 value 78.685765
## iter  20 value 61.916126
## iter  30 value 59.164554
## iter  40 value 59.156549
## iter  50 value 59.109079
## iter  60 value 58.005356
## iter  70 value 57.790018
## iter  80 value 57.758283
## iter  90 value 57.725369
## iter 100 value 55.805571
## final  value 55.805571
## stopped after 100 iterations
## # weights:  109
## initial  value 100.919183
## iter  10 value 46.992471
## iter  20 value 8.827525
## iter  30 value 8.555688
## iter  40 value 8.535719
## iter  50 value 8.516062
## iter  60 value 8.502384
## iter  70 value 8.491016
## iter  80 value 8.483104
## iter  90 value 8.477313
## iter 100 value 8.471854
## final  value 8.471854
## stopped after 100 iterations
## # weights:  179
## initial  value 103.582615
## iter  10 value 28.582405
## iter  20 value 9.640441
## iter  30 value 6.065557
## iter  40 value 5.002357
## iter  50 value 4.290510
## iter  60 value 4.179200
## iter  70 value 4.111337
## iter  80 value 4.065425
## iter  90 value 4.041556
## iter 100 value 4.032525
## final  value 4.032525
## stopped after 100 iterations
```

```
## # weights:  39
## initial  value 101.782962
## iter  10 value 63.538181
## iter  20 value 57.534621
## iter  30 value 52.627096
## iter  40 value 51.794453
## iter  50 value 51.261330
## iter  60 value 51.258879
## iter  70 value 50.643050
## iter  80 value 50.086128
## iter  90 value 50.083170
## iter 100 value 50.079993
## final  value 50.079993
## stopped after 100 iterations
## # weights:  109
## initial  value 129.743763
## iter  10 value 37.640433
## iter  20 value 25.819287
## iter  30 value 21.980830
## iter  40 value 20.449987
## iter  50 value 19.446399
## iter  60 value 18.713876
## iter  70 value 17.638092
## iter  80 value 14.347201
## iter  90 value 14.067092
## iter 100 value 13.612554
## final  value 13.612554
## stopped after 100 iterations
## # weights:  179
## initial  value 105.748942
## iter  10 value 52.283717
## iter  20 value 12.942157
## iter  30 value 9.968846
## iter  40 value 8.587180
## iter  50 value 7.526429
## iter  60 value 5.244329
## iter  70 value 2.426233
## iter  80 value 0.158527
## iter  90 value 0.045803
## iter 100 value 0.022936
## final  value 0.022936
## stopped after 100 iterations
## # weights:  39
## initial  value 107.914127
## iter  10 value 75.450615
## iter  20 value 62.906812
## iter  30 value 60.135136
## iter  40 value 57.707300
## iter  50 value 57.538580
## iter  60 value 57.025204
## iter  70 value 56.121134
## iter  80 value 55.252132
## iter  90 value 54.213145
## final  value 54.207165
```

```
## converged
## # weights:  109
## initial  value 112.021578
## iter  10 value 53.765593
## iter  20 value 29.344986
## iter  30 value 19.989816
## iter  40 value 16.226425
## iter  50 value 15.447023
## iter  60 value 15.249666
## iter  70 value 15.247884
## iter  80 value 15.247825
## final  value 15.247824
## converged
## # weights:  179
## initial  value 100.916432
## iter  10 value 29.115380
## iter  20 value 15.897803
## iter  30 value 13.455035
## iter  40 value 12.771820
## iter  50 value 12.035579
## iter  60 value 11.874778
## iter  70 value 11.860929
## iter  80 value 11.860628
## final  value 11.860625
## converged
## # weights:  39
## initial  value 109.489056
## iter  10 value 79.237084
## iter  20 value 56.231497
## iter  30 value 53.489126
## iter  40 value 51.955538
## iter  50 value 51.353480
## iter  60 value 50.027010
## iter  70 value 49.199211
## iter  80 value 48.746208
## iter  90 value 48.585407
## iter 100 value 47.740760
## final  value 47.740760
## stopped after 100 iterations
## # weights:  109
## initial  value 114.920171
## iter  10 value 35.067807
## iter  20 value 22.209082
## iter  30 value 21.535110
## iter  40 value 18.112931
## iter  50 value 17.587471
## iter  60 value 17.548903
## iter  70 value 17.539604
## iter  80 value 17.525455
## iter  90 value 17.512475
## iter 100 value 17.500748
## final  value 17.500748
## stopped after 100 iterations
## # weights:  179
```

```
## initial  value 114.293964
## iter  10 value 20.980641
## iter  20 value 7.444786
## iter  30 value 5.627557
## iter  40 value 5.029257
## iter  50 value 3.018262
## iter  60 value 2.643045
## iter  70 value 2.583162
## iter  80 value 2.448768
## iter  90 value 0.403540
## iter 100 value 0.319113
## final  value 0.319113
## stopped after 100 iterations
## # weights:  39
## initial  value 104.998400
## iter  10 value 65.387418
## iter  20 value 55.477505
## iter  30 value 52.459363
## iter  40 value 49.830522
## iter  50 value 47.659868
## iter  60 value 46.665754
## iter  70 value 46.369165
## iter  80 value 46.352326
## iter  90 value 46.329716
## iter 100 value 46.006090
## final  value 46.006090
## stopped after 100 iterations
## # weights:  109
## initial  value 102.743289
## iter  10 value 30.690013
## iter  20 value 20.372395
## iter  30 value 18.373636
## iter  40 value 15.410071
## iter  50 value 14.657805
## iter  60 value 8.496365
## iter  70 value 7.812179
## iter  80 value 7.075790
## iter  90 value 7.022297
## iter 100 value 6.768809
## final  value 6.768809
## stopped after 100 iterations
## # weights:  179
## initial  value 113.419119
## iter  10 value 15.849269
## iter  20 value 0.460053
## iter  30 value 0.002249
## final  value 0.000091
## converged
## # weights:  39
## initial  value 109.775895
## iter  10 value 82.341835
## iter  20 value 72.463490
## iter  30 value 68.560593
## iter  40 value 63.323000
```

```
## iter  50 value 59.900773
## iter  60 value 56.980065
## iter  70 value 56.732388
## final  value 56.732046
## converged
## # weights:  109
## initial  value 107.624634
## iter  10 value 60.097713
## iter  20 value 31.943296
## iter  30 value 20.570084
## iter  40 value 17.380692
## iter  50 value 17.148130
## iter  60 value 17.143968
## final  value 17.143850
## converged
## # weights:  179
## initial  value 113.279239
## iter  10 value 31.886952
## iter  20 value 17.598580
## iter  30 value 14.606289
## iter  40 value 12.420506
## iter  50 value 12.121150
## iter  60 value 11.972272
## iter  70 value 11.961330
## iter  80 value 11.960746
## iter  90 value 11.960684
## final  value 11.960682
## converged
## # weights:  39
## initial  value 104.642163
## iter  10 value 80.124375
## iter  20 value 68.035844
## iter  30 value 63.527875
## iter  40 value 61.474930
## iter  50 value 58.870838
## iter  60 value 58.119046
## iter  70 value 58.111727
## iter  80 value 58.081951
## iter  90 value 58.059267
## iter 100 value 58.056581
## final  value 58.056581
## stopped after 100 iterations
## # weights:  109
## initial  value 118.713302
## iter  10 value 35.495847
## iter  20 value 23.053432
## iter  30 value 17.678575
## iter  40 value 13.383633
## iter  50 value 6.403845
## iter  60 value 5.771216
## iter  70 value 5.146710
## iter  80 value 5.104529
## iter  90 value 5.074264
## iter 100 value 5.050892
```

```
## final  value 5.050892
## stopped after 100 iterations
## # weights:  179
## initial  value 136.136052
## iter  10 value 46.161538
## iter  20 value 32.615980
## iter  30 value 28.986056
## iter  40 value 27.673266
## iter  50 value 24.785605
## iter  60 value 22.698249
## iter  70 value 21.604710
## iter  80 value 21.483422
## iter  90 value 21.324813
## iter 100 value 21.203244
## final  value 21.203244
## stopped after 100 iterations
## # weights:  39
## initial  value 113.350016
## iter  10 value 70.729232
## iter  20 value 62.349199
## iter  30 value 59.609717
## iter  40 value 59.014316
## iter  50 value 57.435928
## iter  60 value 54.055970
## iter  70 value 53.599324
## iter  80 value 53.577901
## iter  90 value 53.560967
## iter 100 value 53.479627
## final  value 53.479627
## stopped after 100 iterations
## # weights:  109
## initial  value 104.944288
## iter  10 value 30.882796
## iter  20 value 11.783503
## iter  30 value 8.486227
## iter  40 value 7.040081
## iter  50 value 7.038859
## iter  60 value 6.990009
## iter  70 value 6.968175
## iter  80 value 6.968151
## iter  90 value 6.968089
## iter 100 value 6.968057
## final  value 6.968057
## stopped after 100 iterations
## # weights:  179
## initial  value 112.800098
## iter  10 value 26.388570
## iter  20 value 5.599708
## iter  30 value 1.552520
## iter  40 value 1.399780
## iter  50 value 1.386405
## iter  60 value 1.386349
## iter  70 value 1.386321
## iter  80 value 1.386313
```

```
## final  value 1.386312
## converged
## # weights:  39
## initial  value 112.669379
## iter  10 value 93.971481
## iter  20 value 77.797487
## iter  30 value 66.077188
## iter  40 value 62.868417
## iter  50 value 60.977595
## iter  60 value 59.630071
## iter  70 value 59.126414
## iter  80 value 58.866708
## iter  90 value 58.675459
## iter 100 value 58.462103
## final  value 58.462103
## stopped after 100 iterations
## # weights:  109
## initial  value 97.018452
## iter  10 value 55.793926
## iter  20 value 30.563067
## iter  30 value 19.111092
## iter  40 value 17.362120
## iter  50 value 17.196488
## iter  60 value 17.187790
## iter  70 value 17.187614
## final  value 17.187614
## converged
## # weights:  179
## initial  value 110.573094
## iter  10 value 41.750471
## iter  20 value 22.404796
## iter  30 value 14.663886
## iter  40 value 12.767774
## iter  50 value 12.070396
## iter  60 value 11.977927
## iter  70 value 11.968827
## iter  80 value 11.968221
## final  value 11.968218
## converged
## # weights:  39
## initial  value 102.668271
## iter  10 value 76.222737
## iter  20 value 71.120357
## iter  30 value 70.002522
## iter  40 value 66.179117
## iter  50 value 63.429916
## iter  60 value 62.316294
## iter  70 value 61.335220
## iter  80 value 59.783985
## iter  90 value 59.404063
## iter 100 value 59.345563
## final  value 59.345563
## stopped after 100 iterations
## # weights:  109
```

```
## initial  value 106.120849
## iter  10 value 32.403149
## iter  20 value 18.474979
## iter  30 value 13.088859
## iter  40 value 11.447226
## iter  50 value 8.970656
## iter  60 value 8.864178
## iter  70 value 8.804195
## iter  80 value 8.647459
## iter  90 value 5.813813
## iter 100 value 4.556247
## final  value 4.556247
## stopped after 100 iterations
## # weights:  179
## initial  value 106.316868
## iter  10 value 23.770381
## iter  20 value 11.783803
## iter  30 value 9.676904
## iter  40 value 8.118734
## iter  50 value 7.545715
## iter  60 value 7.511020
## iter  70 value 7.445875
## iter  80 value 7.423390
## iter  90 value 7.414385
## iter 100 value 7.367584
## final  value 7.367584
## stopped after 100 iterations
## # weights:  39
## initial  value 105.344985
## iter  10 value 60.114813
## iter  20 value 52.056150
## iter  30 value 48.603365
## iter  40 value 47.673760
## iter  50 value 47.586850
## iter  60 value 47.504725
## iter  70 value 47.190616
## iter  80 value 46.238303
## iter  90 value 46.055363
## iter 100 value 45.661020
## final  value 45.661020
## stopped after 100 iterations
## # weights:  109
## initial  value 100.276078
## iter  10 value 43.295442
## iter  20 value 25.915349
## iter  30 value 23.194969
## iter  40 value 21.158871
## iter  50 value 19.071355
## iter  60 value 17.812854
## iter  70 value 16.256714
## iter  80 value 8.509209
## iter  90 value 6.254669
## iter 100 value 5.901522
## final  value 5.901522
```

```
## stopped after 100 iterations
## # weights:  179
## initial  value 97.761042
## iter  10 value 17.154700
## iter  20 value 7.829067
## iter  30 value 3.227378
## iter  40 value 2.747947
## iter  50 value 0.046893
## iter  60 value 0.015838
## iter  70 value 0.006520
## iter  80 value 0.003891
## iter  90 value 0.002845
## iter 100 value 0.001090
## final  value 0.001090
## stopped after 100 iterations
## # weights:  39
## initial  value 101.671479
## iter  10 value 70.382295
## iter  20 value 62.066615
## iter  30 value 59.764257
## iter  40 value 59.088796
## iter  50 value 58.916054
## iter  60 value 58.834693
## iter  70 value 58.832265
## final  value 58.832239
## converged
## # weights:  109
## initial  value 107.998837
## iter  10 value 60.476972
## iter  20 value 45.654734
## iter  30 value 31.672688
## iter  40 value 20.794969
## iter  50 value 18.011520
## iter  60 value 16.053407
## iter  70 value 15.741586
## iter  80 value 15.728957
## iter  90 value 15.728822
## final  value 15.728820
## converged
## # weights:  179
## initial  value 123.720915
## iter  10 value 40.468597
## iter  20 value 25.862052
## iter  30 value 17.573230
## iter  40 value 14.579384
## iter  50 value 13.731864
## iter  60 value 13.452821
## iter  70 value 12.803875
## iter  80 value 12.559815
## iter  90 value 12.364204
## iter 100 value 12.345274
## final  value 12.345274
## stopped after 100 iterations
## # weights:  39
```

```
## initial  value 104.100554
## iter  10 value 66.890695
## iter  20 value 56.156042
## iter  30 value 51.173877
## iter  40 value 46.797223
## iter  50 value 44.345010
## iter  60 value 44.239260
## iter  70 value 43.372208
## iter  80 value 43.302513
## iter  90 value 42.916780
## iter 100 value 42.882260
## final  value 42.882260
## stopped after 100 iterations
## # weights:  109
## initial  value 110.092708
## iter  10 value 44.928603
## iter  20 value 32.047071
## iter  30 value 28.337515
## iter  40 value 27.179590
## iter  50 value 26.412745
## iter  60 value 24.530238
## iter  70 value 24.468218
## iter  80 value 22.752311
## iter  90 value 21.922952
## iter 100 value 21.888506
## final  value 21.888506
## stopped after 100 iterations
## # weights:  179
## initial  value 117.480129
## iter  10 value 26.056083
## iter  20 value 14.870582
## iter  30 value 10.580739
## iter  40 value 10.144599
## iter  50 value 9.985516
## iter  60 value 9.963580
## iter  70 value 9.921854
## iter  80 value 9.786458
## iter  90 value 7.964102
## iter 100 value 6.558887
## final  value 6.558887
## stopped after 100 iterations
## # weights:  39
## initial  value 98.626120
## iter  10 value 79.910268
## iter  20 value 68.317892
## iter  30 value 65.890290
## iter  40 value 62.895747
## iter  50 value 59.481216
## iter  60 value 57.686905
## iter  70 value 57.410938
## iter  80 value 57.292126
## iter  90 value 57.276123
## iter 100 value 57.271071
## final  value 57.271071
```

```
## stopped after 100 iterations
## # weights:  109
## initial  value 144.941972
## iter  10 value 77.123106
## iter  20 value 24.284521
## iter  30 value 19.662510
## iter  40 value 18.675186
## iter  50 value 16.316879
## iter  60 value 16.023601
## iter  70 value 15.582439
## iter  80 value 15.484077
## iter  90 value 14.857626
## iter 100 value 14.839381
## final  value 14.839381
## stopped after 100 iterations
## # weights:  179
## initial  value 104.057813
## iter  10 value 15.322900
## iter  20 value 2.267731
## iter  30 value 1.440125
## iter  40 value 1.386743
## final  value 1.386299
## converged
## # weights:  39
## initial  value 103.571185
## iter  10 value 70.173304
## iter  20 value 63.246199
## iter  30 value 60.504459
## iter  40 value 60.162146
## iter  50 value 59.895116
## iter  60 value 59.401383
## iter  70 value 58.845643
## final  value 58.844214
## converged
## # weights:  109
## initial  value 114.942385
## iter  10 value 47.235792
## iter  20 value 31.410793
## iter  30 value 23.149571
## iter  40 value 18.383528
## iter  50 value 16.339475
## iter  60 value 16.044604
## iter  70 value 15.984868
## iter  80 value 15.739692
## iter  90 value 15.726611
## iter 100 value 15.726518
## final  value 15.726518
## stopped after 100 iterations
## # weights:  179
## initial  value 114.203579
## iter  10 value 30.198653
## iter  20 value 17.327694
## iter  30 value 13.825932
## iter  40 value 12.743544
```

```
## iter  50 value 12.296795
## iter  60 value 12.202201
## iter  70 value 12.167712
## iter  80 value 12.164789
## iter  90 value 12.164686
## final  value 12.164678
## converged
## # weights:  39
## initial  value 105.847642
## iter  10 value 81.982261
## iter  20 value 64.064822
## iter  30 value 63.955642
## iter  40 value 63.954360
## iter  50 value 63.948536
## iter  60 value 63.917226
## iter  70 value 59.457799
## iter  80 value 58.373931
## iter  90 value 58.037982
## iter 100 value 57.187626
## final  value 57.187626
## stopped after 100 iterations
## # weights:  109
## initial  value 106.936039
## iter  10 value 37.802223
## iter  20 value 19.992552
## iter  30 value 11.378917
## iter  40 value 10.923480
## iter  50 value 6.559897
## iter  60 value 5.622165
## iter  70 value 5.569550
## iter  80 value 5.500612
## iter  90 value 0.282542
## iter 100 value 0.240582
## final  value 0.240582
## stopped after 100 iterations
## # weights:  179
## initial  value 126.812508
## iter  10 value 19.841783
## iter  20 value 0.682379
## iter  30 value 0.171284
## iter  40 value 0.151431
## iter  50 value 0.141022
## iter  60 value 0.126759
## iter  70 value 0.120292
## iter  80 value 0.113210
## iter  90 value 0.103905
## iter 100 value 0.100037
## final  value 0.100037
## stopped after 100 iterations
## # weights:  39
## initial  value 102.331851
## iter  10 value 77.118741
## iter  20 value 75.645531
## iter  30 value 74.549658
```

```
## iter  40 value 73.721185
## iter  50 value 73.186026
## iter  60 value 71.937548
## iter  70 value 68.992252
## iter  80 value 66.079788
## iter  90 value 65.765124
## iter 100 value 65.747099
## final  value 65.747099
## stopped after 100 iterations
## # weights:  109
## initial  value 108.028265
## iter  10 value 49.317289
## iter  20 value 35.085843
## iter  30 value 27.572547
## iter  40 value 24.487502
## iter  50 value 19.450854
## iter  60 value 13.490658
## iter  70 value 12.082220
## iter  80 value 11.724555
## iter  90 value 11.597832
## iter 100 value 11.154063
## final  value 11.154063
## stopped after 100 iterations
## # weights:  179
## initial  value 104.751551
## iter  10 value 29.066701
## iter  20 value 7.801708
## iter  30 value 6.297922
## iter  40 value 6.172064
## iter  50 value 5.233742
## iter  60 value 4.792694
## iter  70 value 4.782133
## iter  80 value 4.781743
## iter  90 value 4.781042
## iter 100 value 4.780860
## final  value 4.780860
## stopped after 100 iterations
## # weights:  39
## initial  value 103.743076
## iter  10 value 76.126151
## iter  20 value 63.917704
## iter  30 value 60.665179
## iter  40 value 59.454249
## iter  50 value 57.937775
## iter  60 value 57.913853
## final  value 57.913845
## converged
## # weights:  109
## initial  value 104.302171
## iter  10 value 48.039656
## iter  20 value 31.112935
## iter  30 value 23.007944
## iter  40 value 17.853326
## iter  50 value 17.175604
```

```
## iter  60 value 17.133322
## iter  70 value 17.132918
## final  value 17.132917
## converged
## # weights:  179
## initial  value 127.097661
## iter  10 value 48.790091
## iter  20 value 24.244372
## iter  30 value 14.552219
## iter  40 value 12.402271
## iter  50 value 12.250747
## iter  60 value 12.235741
## iter  70 value 12.233540
## iter  80 value 12.233358
## final  value 12.233354
## converged
## # weights:  39
## initial  value 101.214908
## iter  10 value 57.856495
## iter  20 value 49.857730
## iter  30 value 45.087983
## iter  40 value 42.571795
## iter  50 value 41.809917
## iter  60 value 41.786536
## iter  70 value 41.766615
## iter  80 value 41.749286
## iter  90 value 41.726401
## iter 100 value 41.717333
## final  value 41.717333
## stopped after 100 iterations
## # weights:  109
## initial  value 114.460738
## iter  10 value 26.376054
## iter  20 value 14.035897
## iter  30 value 5.341266
## iter  40 value 4.259323
## iter  50 value 4.086854
## iter  60 value 1.732371
## iter  70 value 0.225418
## iter  80 value 0.194038
## iter  90 value 0.178908
## iter 100 value 0.167144
## final  value 0.167144
## stopped after 100 iterations
## # weights:  179
## initial  value 100.455778
## iter  10 value 19.326568
## iter  20 value 2.203497
## iter  30 value 2.046491
## iter  40 value 2.032757
## iter  50 value 1.496368
## iter  60 value 0.157461
## iter  70 value 0.113411
## iter  80 value 0.107761
```

```
## iter  90 value 0.104948
## iter 100 value 0.098663
## final  value 0.098663
## stopped after 100 iterations
## # weights:  39
## initial  value 112.864063
## iter  10 value 62.462087
## iter  20 value 55.510725
## iter  30 value 52.142977
## iter  40 value 50.505459
## iter  50 value 48.869881
## iter  60 value 48.618819
## iter  70 value 47.891296
## iter  80 value 46.751051
## iter  90 value 45.436124
## iter 100 value 45.029033
## final  value 45.029033
## stopped after 100 iterations
## # weights:  109
## initial  value 118.942175
## iter  10 value 29.365561
## iter  20 value 13.913647
## iter  30 value 11.398030
## iter  40 value 9.533676
## iter  50 value 9.114137
## iter  60 value 9.023861
## iter  70 value 8.885837
## iter  80 value 8.826752
## iter  90 value 8.589774
## iter 100 value 8.241541
## final  value 8.241541
## stopped after 100 iterations
## # weights:  179
## initial  value 114.418584
## iter  10 value 27.335317
## iter  20 value 1.596331
## iter  30 value 0.059301
## iter  40 value 0.003534
## iter  50 value 0.000353
## iter  60 value 0.000242
## final  value 0.000083
## converged
## # weights:  39
## initial  value 100.799018
## iter  10 value 69.652839
## iter  20 value 62.652819
## iter  30 value 60.119425
## iter  40 value 59.945466
## iter  50 value 59.475821
## iter  60 value 58.757867
## iter  70 value 58.432540
## iter  80 value 58.424767
## final  value 58.424747
## converged
```

```
## # weights:  109
## initial  value 103.169973
## iter  10 value 55.363697
## iter  20 value 28.392282
## iter  30 value 20.062653
## iter  40 value 18.759972
## iter  50 value 18.545062
## iter  60 value 18.255249
## iter  70 value 17.149313
## iter  80 value 16.855156
## iter  90 value 16.027823
## iter 100 value 15.929265
## final  value 15.929265
## stopped after 100 iterations
## # weights:  179
## initial  value 111.943346
## iter  10 value 49.714763
## iter  20 value 28.826984
## iter  30 value 16.145633
## iter  40 value 13.411749
## iter  50 value 12.947011
## iter  60 value 12.718059
## iter  70 value 12.537811
## iter  80 value 12.517755
## iter  90 value 12.516124
## iter 100 value 12.515708
## final  value 12.515708
## stopped after 100 iterations
## # weights:  39
## initial  value 103.759376
## iter  10 value 66.053519
## iter  20 value 57.723898
## iter  30 value 57.338882
## iter  40 value 56.280778
## iter  50 value 56.245932
## iter  60 value 56.226694
## iter  70 value 55.134037
## iter  80 value 53.871905
## iter  90 value 52.680799
## iter 100 value 52.632227
## final  value 52.632227
## stopped after 100 iterations
## # weights:  109
## initial  value 118.250672
## iter  10 value 33.272180
## iter  20 value 19.501960
## iter  30 value 14.308341
## iter  40 value 12.284254
## iter  50 value 10.582490
## iter  60 value 10.508805
## iter  70 value 10.421186
## iter  80 value 8.018689
## iter  90 value 7.806529
## iter 100 value 7.793830
```

```
## final  value 7.793830
## stopped after 100 iterations
## # weights:  179
## initial  value 148.202269
## iter  10 value 56.558341
## iter  20 value 26.479386
## iter  30 value 19.184836
## iter  40 value 16.191693
## iter  50 value 13.423162
## iter  60 value 12.744376
## iter  70 value 11.780772
## iter  80 value 9.320126
## iter  90 value 7.417660
## iter 100 value 5.583016
## final  value 5.583016
## stopped after 100 iterations
## # weights:  39
## initial  value 102.418690
## iter  10 value 71.055217
## iter  20 value 67.158590
## iter  30 value 66.769307
## iter  40 value 64.429576
## iter  50 value 58.258540
## iter  60 value 57.853237
## iter  70 value 56.987415
## iter  80 value 55.347471
## iter  90 value 54.955668
## iter 100 value 54.942286
## final  value 54.942286
## stopped after 100 iterations
## # weights:  109
## initial  value 107.352464
## iter  10 value 47.984754
## iter  20 value 33.645589
## iter  30 value 16.722743
## iter  40 value 14.057835
## iter  50 value 13.439227
## iter  60 value 12.480507
## iter  70 value 8.779317
## iter  80 value 8.001448
## iter  90 value 6.484014
## iter 100 value 5.279890
## final  value 5.279890
## stopped after 100 iterations
## # weights:  179
## initial  value 108.400527
## iter  10 value 29.485720
## iter  20 value 13.479316
## iter  30 value 6.086225
## iter  40 value 2.366901
## iter  50 value 1.943584
## iter  60 value 1.925196
## iter  70 value 1.918077
## iter  80 value 1.911607
```

```
## iter  90 value 1.910946
## iter 100 value 1.910353
## final  value 1.910353
## stopped after 100 iterations
## # weights:  39
## initial  value 100.498558
## iter  10 value 72.863891
## iter  20 value 65.038302
## iter  30 value 62.552814
## iter  40 value 59.521106
## iter  50 value 58.275421
## iter  60 value 57.626380
## iter  70 value 57.549974
## final  value 57.549638
## converged
## # weights:  109
## initial  value 116.104385
## iter  10 value 37.909599
## iter  20 value 26.356494
## iter  30 value 21.022665
## iter  40 value 17.201416
## iter  50 value 16.109427
## iter  60 value 16.071303
## final  value 16.071091
## converged
## # weights:  179
## initial  value 104.956466
## iter  10 value 36.318322
## iter  20 value 20.596644
## iter  30 value 14.937412
## iter  40 value 13.056861
## iter  50 value 12.407184
## iter  60 value 12.159840
## iter  70 value 11.921136
## iter  80 value 11.794267
## iter  90 value 11.777995
## iter 100 value 11.777649
## final  value 11.777649
## stopped after 100 iterations
## # weights:  39
## initial  value 101.454706
## iter  10 value 83.182233
## iter  20 value 65.771691
## iter  30 value 65.682662
## iter  40 value 64.496917
## iter  50 value 63.703936
## iter  60 value 63.678678
## iter  70 value 63.670216
## iter  80 value 63.664699
## iter  90 value 63.660485
## iter 100 value 63.282982
## final  value 63.282982
## stopped after 100 iterations
## # weights:  109
```

```
## initial  value 107.794895
## iter  10 value 39.211013
## iter  20 value 17.750283
## iter  30 value 14.292229
## iter  40 value 13.848316
## iter  50 value 13.789629
## iter  60 value 13.739810
## iter  70 value 13.630570
## iter  80 value 13.455004
## iter  90 value 11.003166
## iter 100 value 7.783344
## final  value 7.783344
## stopped after 100 iterations
## # weights:  179
## initial  value 103.415146
## iter  10 value 24.953071
## iter  20 value 6.832968
## iter  30 value 4.254160
## iter  40 value 3.998683
## iter  50 value 3.900428
## iter  60 value 3.819728
## iter  70 value 3.668319
## iter  80 value 3.467882
## iter  90 value 3.215982
## iter 100 value 3.206754
## final  value 3.206754
## stopped after 100 iterations
## # weights:  39
## initial  value 103.877719
## iter  10 value 64.147785
## iter  20 value 51.995981
## iter  30 value 51.241590
## iter  40 value 51.212248
## iter  50 value 51.176162
## iter  60 value 50.635683
## iter  70 value 50.487206
## final  value 50.487088
## converged
## # weights:  109
## initial  value 104.283856
## iter  10 value 32.515271
## iter  20 value 12.151861
## iter  30 value 9.025931
## iter  40 value 8.576796
## iter  50 value 8.055914
## iter  60 value 7.802894
## iter  70 value 7.287348
## iter  80 value 7.229937
## iter  90 value 7.218107
## iter 100 value 7.209943
## final  value 7.209943
## stopped after 100 iterations
## # weights:  179
## initial  value 144.903137
```

```
## iter  10 value 44.076925
## iter  20 value 17.596644
## iter  30 value 15.087289
## iter  40 value 14.563269
## iter  50 value 10.352749
## iter  60 value 6.475133
## iter  70 value 6.282097
## iter  80 value 5.545461
## iter  90 value 5.545303
## iter 100 value 5.545264
## final  value 5.545264
## stopped after 100 iterations
## # weights:  39
## initial  value 101.783259
## iter  10 value 83.271780
## iter  20 value 63.992951
## iter  30 value 58.957729
## iter  40 value 58.767410
## iter  50 value 58.764643
## final  value 58.764475
## converged
## # weights:  109
## initial  value 100.139730
## iter  10 value 43.931145
## iter  20 value 23.671386
## iter  30 value 17.530501
## iter  40 value 16.050389
## iter  50 value 15.651794
## iter  60 value 15.617358
## final  value 15.617284
## converged
## # weights:  179
## initial  value 102.106877
## iter  10 value 34.941892
## iter  20 value 17.666120
## iter  30 value 13.932899
## iter  40 value 13.055006
## iter  50 value 12.705135
## iter  60 value 12.620219
## iter  70 value 12.591342
## iter  80 value 12.582013
## iter  90 value 12.581567
## final  value 12.581563
## converged
## # weights:  39
## initial  value 103.317784
## iter  10 value 76.721712
## iter  20 value 61.428351
## iter  30 value 58.273222
## iter  40 value 56.857703
## iter  50 value 54.590488
## iter  60 value 53.882255
## iter  70 value 53.662346
## iter  80 value 53.332685
```

```
## iter  90 value 52.775318
## iter 100 value 52.720022
## final  value 52.720022
## stopped after 100 iterations
## # weights:  109
## initial  value 129.941677
## iter  10 value 60.195476
## iter  20 value 27.532384
## iter  30 value 10.376122
## iter  40 value 5.788703
## iter  50 value 4.396850
## iter  60 value 3.885895
## iter  70 value 3.761280
## iter  80 value 3.742005
## iter  90 value 3.725927
## iter 100 value 3.687669
## final  value 3.687669
## stopped after 100 iterations
## # weights:  179
## initial  value 111.463558
## iter  10 value 18.731761
## iter  20 value 7.272737
## iter  30 value 4.765955
## iter  40 value 3.170226
## iter  50 value 2.994089
## iter  60 value 2.974798
## iter  70 value 2.967666
## iter  80 value 1.626395
## iter  90 value 1.569963
## iter 100 value 0.207197
## final  value 0.207197
## stopped after 100 iterations
## # weights:  39
## initial  value 100.126293
## iter  10 value 68.405075
## iter  20 value 55.765061
## iter  30 value 55.032503
## iter  40 value 51.629556
## iter  50 value 47.032136
## iter  60 value 42.566856
## iter  70 value 41.546683
## iter  80 value 41.468771
## iter  90 value 41.434893
## iter 100 value 41.252546
## final  value 41.252546
## stopped after 100 iterations
## # weights:  109
## initial  value 106.303020
## iter  10 value 48.377013
## iter  20 value 22.074398
## iter  30 value 17.603824
## iter  40 value 17.158395
## iter  50 value 17.116130
## iter  60 value 17.102090
```

```
## iter  70 value 17.092924
## iter  80 value 17.088672
## iter  90 value 16.891493
## iter 100 value 16.867100
## final  value 16.867100
## stopped after 100 iterations
## # weights:  179
## initial  value 105.622444
## iter  10 value 22.276828
## iter  20 value 11.035662
## iter  30 value 7.575096
## iter  40 value 7.254733
## iter  50 value 7.188528
## iter  60 value 6.837464
## iter  70 value 5.349598
## iter  80 value 4.492616
## iter  90 value 3.960821
## iter 100 value 1.497602
## final  value 1.497602
## stopped after 100 iterations
## # weights:  39
## initial  value 103.204839
## iter  10 value 70.888866
## iter  20 value 64.854832
## iter  30 value 60.505710
## iter  40 value 59.323505
## iter  50 value 59.110164
## iter  60 value 59.051548
## iter  70 value 59.035015
## iter  70 value 59.035015
## iter  70 value 59.035015
## final  value 59.035015
## converged
## # weights:  109
## initial  value 128.849614
## iter  10 value 61.938800
## iter  20 value 36.552475
## iter  30 value 22.405648
## iter  40 value 17.283416
## iter  50 value 16.586665
## iter  60 value 16.515742
## iter  70 value 16.477041
## iter  80 value 16.466998
## iter  90 value 16.466202
## final  value 16.466183
## converged
## # weights:  179
## initial  value 110.271610
## iter  10 value 50.180700
## iter  20 value 31.554709
## iter  30 value 17.315662
## iter  40 value 12.944208
## iter  50 value 12.251342
## iter  60 value 12.159385
```

```
## iter  70 value 12.150538
## iter  80 value 12.149933
## iter  90 value 12.149916
## final  value 12.149915
## converged
## # weights:  39
## initial  value 116.089303
## iter  10 value 67.748410
## iter  20 value 61.994831
## iter  30 value 59.615635
## iter  40 value 58.915516
## iter  50 value 58.520884
## iter  60 value 58.472508
## iter  70 value 58.370575
## iter  80 value 58.324050
## iter  90 value 58.128299
## iter 100 value 57.037993
## final  value 57.037993
## stopped after 100 iterations
## # weights:  109
## initial  value 115.247747
## iter  10 value 54.195659
## iter  20 value 26.147525
## iter  30 value 11.149365
## iter  40 value 7.042627
## iter  50 value 5.315308
## iter  60 value 5.088945
## iter  70 value 4.482849
## iter  80 value 3.926541
## iter  90 value 2.850173
## iter 100 value 0.233829
## final  value 0.233829
## stopped after 100 iterations
## # weights:  179
## initial  value 120.202035
## iter  10 value 24.849869
## iter  20 value 5.699435
## iter  30 value 2.140725
## iter  40 value 0.298732
## iter  50 value 0.233885
## iter  60 value 0.218877
## iter  70 value 0.201590
## iter  80 value 0.185795
## iter  90 value 0.166678
## iter 100 value 0.154118
## final  value 0.154118
## stopped after 100 iterations
## # weights:  39
## initial  value 111.245106
## iter  10 value 66.224925
## iter  20 value 58.223940
## iter  30 value 56.860679
## iter  40 value 56.397640
## iter  50 value 55.970450
```

```
## iter  60 value 55.966223
## iter  70 value 55.957568
## iter  80 value 55.952434
## iter  90 value 55.949369
## iter 100 value 54.456930
## final  value 54.456930
## stopped after 100 iterations
## # weights:  109
## initial  value 123.392432
## iter  10 value 45.416071
## iter  20 value 36.055904
## iter  30 value 31.993854
## iter  40 value 30.507479
## iter  50 value 29.519126
## iter  60 value 28.094557
## iter  70 value 25.689433
## iter  80 value 25.554975
## iter  90 value 24.800984
## iter 100 value 23.651460
## final  value 23.651460
## stopped after 100 iterations
## # weights:  179
## initial  value 105.709171
## iter  10 value 43.103155
## iter  20 value 14.170640
## iter  30 value 12.900424
## iter  40 value 12.833486
## iter  50 value 12.823268
## iter  60 value 12.821913
## final  value 12.821723
## converged
## # weights:  39
## initial  value 105.265412
## iter  10 value 81.937971
## iter  20 value 70.282207
## iter  30 value 62.482980
## iter  40 value 59.963098
## iter  50 value 59.667168
## final  value 59.663345
## converged
## # weights:  109
## initial  value 105.580125
## iter  10 value 63.714006
## iter  20 value 35.025028
## iter  30 value 21.801435
## iter  40 value 17.655637
## iter  50 value 16.452754
## iter  60 value 16.089910
## iter  70 value 15.963306
## iter  80 value 15.961979
## final  value 15.961975
## converged
## # weights:  179
## initial  value 114.650738
```

```
## iter  10 value 41.052686
## iter  20 value 21.329416
## iter  30 value 14.684476
## iter  40 value 13.090797
## iter  50 value 12.767833
## iter  60 value 12.689669
## iter  70 value 12.600563
## iter  80 value 12.503758
## iter  90 value 12.409280
## iter 100 value 12.210580
## final  value 12.210580
## stopped after 100 iterations
## # weights:  39
## initial  value 115.811519
## iter  10 value 79.337877
## iter  20 value 58.080930
## iter  30 value 57.255951
## iter  40 value 57.123048
## iter  50 value 56.103605
## iter  60 value 55.394270
## iter  70 value 53.976200
## iter  80 value 53.766214
## iter  90 value 53.248921
## iter 100 value 52.902043
## final  value 52.902043
## stopped after 100 iterations
## # weights:  109
## initial  value 117.923969
## iter  10 value 24.646291
## iter  20 value 14.026214
## iter  30 value 9.177271
## iter  40 value 5.924326
## iter  50 value 5.483767
## iter  60 value 5.135268
## iter  70 value 4.958622
## iter  80 value 4.928019
## iter  90 value 4.916795
## iter 100 value 4.661728
## final  value 4.661728
## stopped after 100 iterations
## # weights:  179
## initial  value 116.128278
## iter  10 value 42.986851
## iter  20 value 14.446667
## iter  30 value 11.459803
## iter  40 value 8.716805
## iter  50 value 8.694895
## iter  60 value 8.657438
## iter  70 value 8.621765
## iter  80 value 8.574368
## iter  90 value 8.551392
## iter 100 value 8.529179
## final  value 8.529179
## stopped after 100 iterations
```

```
## # weights:  39
## initial  value 107.340911
## iter  10 value 72.660866
## iter  20 value 66.396492
## iter  30 value 65.011520
## iter  40 value 64.354710
## iter  50 value 64.190403
## iter  60 value 64.042797
## iter  70 value 62.329625
## iter  80 value 62.147423
## iter  90 value 62.069756
## iter 100 value 61.801182
## final  value 61.801182
## stopped after 100 iterations
## # weights:  109
## initial  value 103.874866
## iter  10 value 23.723727
## iter  20 value 18.175229
## iter  30 value 16.711179
## iter  40 value 16.525947
## iter  50 value 15.656980
## iter  60 value 15.653166
## iter  70 value 15.652339
## iter  80 value 11.993317
## iter  90 value 11.857439
## iter 100 value 11.846196
## final  value 11.846196
## stopped after 100 iterations
## # weights:  179
## initial  value 113.038569
## iter  10 value 32.378972
## iter  20 value 8.421653
## iter  30 value 4.424333
## iter  40 value 3.355625
## iter  50 value 3.324333
## iter  60 value 3.139607
## iter  70 value 3.055359
## final  value 3.014211
## converged
## # weights:  39
## initial  value 99.041836
## iter  10 value 67.109224
## iter  20 value 60.501539
## iter  30 value 59.480042
## iter  40 value 59.323734
## iter  50 value 59.118990
## iter  60 value 59.041670
## iter  70 value 59.004644
## iter  80 value 59.000747
## iter  90 value 59.000643
## iter  90 value 59.000642
## iter  90 value 59.000642
## final  value 59.000642
## converged
```

```
## # weights:  109
## initial  value 101.656206
## iter  10 value 54.337202
## iter  20 value 35.092868
## iter  30 value 20.243122
## iter  40 value 17.059275
## iter  50 value 16.739259
## iter  60 value 16.728669
## iter  70 value 16.728506
## final  value 16.728505
## converged
## # weights:  179
## initial  value 123.961804
## iter  10 value 43.347079
## iter  20 value 23.015554
## iter  30 value 15.211703
## iter  40 value 13.614319
## iter  50 value 13.066238
## iter  60 value 12.610179
## iter  70 value 12.497111
## iter  80 value 12.479448
## iter  90 value 12.479088
## final  value 12.479084
## converged
## # weights:  39
## initial  value 108.017094
## iter  10 value 65.099989
## iter  20 value 59.685023
## iter  30 value 57.108309
## iter  40 value 56.280465
## iter  50 value 55.785627
## iter  60 value 55.453078
## iter  70 value 55.036672
## iter  80 value 53.334857
## iter  90 value 52.551244
## iter 100 value 52.147786
## final  value 52.147786
## stopped after 100 iterations
## # weights:  109
## initial  value 116.672782
## iter  10 value 41.651438
## iter  20 value 27.238467
## iter  30 value 23.052093
## iter  40 value 19.038733
## iter  50 value 15.491976
## iter  60 value 11.624136
## iter  70 value 10.343665
## iter  80 value 9.972205
## iter  90 value 9.149049
## iter 100 value 8.944735
## final  value 8.944735
## stopped after 100 iterations
## # weights:  179
## initial  value 94.282572
```

```
## iter  10 value 22.961099
## iter  20 value 7.777698
## iter  30 value 0.681871
## iter  40 value 0.224789
## iter  50 value 0.192345
## iter  60 value 0.176125
## iter  70 value 0.165881
## iter  80 value 0.152971
## iter  90 value 0.143239
## iter 100 value 0.134904
## final  value 0.134904
## stopped after 100 iterations
## # weights:  39
## initial  value 110.021643
## iter  10 value 68.212301
## iter  20 value 59.550413
## iter  30 value 59.481303
## iter  40 value 59.392364
## iter  50 value 59.143030
## iter  60 value 57.941421
## iter  70 value 57.452159
## iter  80 value 57.352470
## iter  90 value 57.315200
## iter 100 value 51.377015
## final  value 51.377015
## stopped after 100 iterations
## # weights:  109
## initial  value 102.449494
## iter  10 value 44.123670
## iter  20 value 39.494610
## iter  30 value 36.662274
## iter  40 value 36.340838
## iter  50 value 36.286334
## iter  60 value 28.772854
## iter  70 value 26.174654
## iter  80 value 23.531557
## iter  90 value 22.911295
## iter 100 value 22.525275
## final  value 22.525275
## stopped after 100 iterations
## # weights:  179
## initial  value 109.368167
## iter  10 value 32.193699
## iter  20 value 7.439406
## iter  30 value 6.206705
## iter  40 value 6.078528
## iter  50 value 5.561726
## iter  60 value 5.463691
## iter  70 value 5.024068
## iter  80 value 5.023187
## iter  90 value 5.022409
## iter 100 value 5.022270
## final  value 5.022270
## stopped after 100 iterations
```

```
## # weights:  39
## initial  value 109.439745
## iter  10 value 73.986853
## iter  20 value 63.028384
## iter  30 value 62.211043
## iter  40 value 60.641053
## iter  50 value 58.404440
## iter  60 value 58.245921
## final  value 58.245131
## converged
## # weights:  109
## initial  value 107.880325
## iter  10 value 53.370218
## iter  20 value 26.541850
## iter  30 value 18.213279
## iter  40 value 16.622744
## iter  50 value 15.745120
## iter  60 value 15.589815
## iter  70 value 15.571255
## iter  80 value 15.570163
## final  value 15.570148
## converged
## # weights:  179
## initial  value 111.497857
## iter  10 value 43.211401
## iter  20 value 19.413065
## iter  30 value 13.084488
## iter  40 value 12.228906
## iter  50 value 11.910745
## iter  60 value 11.877340
## iter  70 value 11.811154
## iter  80 value 11.695662
## iter  90 value 11.690528
## iter 100 value 11.690448
## final  value 11.690448
## stopped after 100 iterations
## # weights:  39
## initial  value 103.125773
## iter  10 value 71.451501
## iter  20 value 61.829624
## iter  30 value 56.122091
## iter  40 value 53.219752
## iter  50 value 52.470908
## iter  60 value 52.453926
## iter  70 value 52.418181
## iter  80 value 52.376890
## iter  90 value 52.374963
## iter 100 value 52.367397
## final  value 52.367397
## stopped after 100 iterations
## # weights:  109
## initial  value 99.332307
## iter  10 value 37.815508
## iter  20 value 21.659869
```

```
## iter  30 value 14.800785
## iter  40 value 10.486945
## iter  50 value 9.264006
## iter  60 value 8.688543
## iter  70 value 8.076080
## iter  80 value 7.965414
## iter  90 value 7.813975
## iter 100 value 7.733311
## final  value 7.733311
## stopped after 100 iterations
## # weights:  179
## initial  value 121.814606
## iter  10 value 38.978621
## iter  20 value 13.983112
## iter  30 value 6.622314
## iter  40 value 4.770951
## iter  50 value 3.858405
## iter  60 value 3.551938
## iter  70 value 3.525053
## iter  80 value 3.497984
## iter  90 value 3.443982
## iter 100 value 3.393790
## final  value 3.393790
## stopped after 100 iterations
## # weights:  39
## initial  value 102.174818
## iter  10 value 67.613526
## iter  20 value 59.602468
## iter  30 value 56.104884
## iter  40 value 52.593574
## iter  50 value 50.422135
## iter  60 value 48.705386
## iter  70 value 46.473855
## iter  80 value 45.935973
## iter  90 value 44.882313
## iter 100 value 42.778879
## final  value 42.778879
## stopped after 100 iterations
## # weights:  109
## initial  value 123.849203
## iter  10 value 44.407363
## iter  20 value 27.265906
## iter  30 value 25.611426
## iter  40 value 24.241634
## iter  50 value 23.730479
## iter  60 value 23.511143
## iter  70 value 23.332120
## iter  80 value 23.039623
## iter  90 value 23.029611
## iter 100 value 23.028798
## final  value 23.028798
## stopped after 100 iterations
## # weights:  179
## initial  value 102.813888
```

```
## iter  10 value 10.676891
## iter  20 value 3.874461
## iter  30 value 0.197353
## iter  40 value 0.022392
## iter  50 value 0.006858
## iter  60 value 0.003255
## iter  70 value 0.002284
## iter  80 value 0.000879
## iter  90 value 0.000760
## iter 100 value 0.000644
## final  value 0.000644
## stopped after 100 iterations
## # weights:  39
## initial  value 114.315697
## iter  10 value 76.631101
## iter  20 value 63.977421
## iter  30 value 60.801777
## iter  40 value 58.862362
## iter  50 value 58.805680
## final  value 58.805662
## converged
## # weights:  109
## initial  value 106.364714
## iter  10 value 51.340241
## iter  20 value 31.023406
## iter  30 value 23.868594
## iter  40 value 21.237593
## iter  50 value 17.254159
## iter  60 value 15.957460
## iter  70 value 15.783566
## iter  80 value 15.782541
## final  value 15.782540
## converged
## # weights:  179
## initial  value 118.194570
## iter  10 value 49.684520
## iter  20 value 26.817583
## iter  30 value 18.452851
## iter  40 value 16.126790
## iter  50 value 15.198806
## iter  60 value 13.817211
## iter  70 value 12.730359
## iter  80 value 12.569357
## iter  90 value 12.555857
## iter 100 value 12.555210
## final  value 12.555210
## stopped after 100 iterations
## # weights:  39
## initial  value 104.093704
## iter  10 value 87.064566
## iter  20 value 73.034495
## iter  30 value 64.654842
## iter  40 value 62.123315
## iter  50 value 60.579212
```

```
## iter  60 value 56.954798
## iter  70 value 56.276110
## iter  80 value 56.235138
## iter  90 value 56.114725
## iter 100 value 56.111023
## final  value 56.111023
## stopped after 100 iterations
## # weights:  109
## initial  value 105.599813
## iter  10 value 33.900488
## iter  20 value 20.542418
## iter  30 value 16.328696
## iter  40 value 12.349470
## iter  50 value 11.675740
## iter  60 value 11.176623
## iter  70 value 10.955960
## iter  80 value 10.919433
## iter  90 value 10.340963
## iter 100 value 10.194449
## final  value 10.194449
## stopped after 100 iterations
## # weights:  179
## initial  value 121.186413
## iter  10 value 30.571532
## iter  20 value 10.703225
## iter  30 value 6.003909
## iter  40 value 4.975763
## iter  50 value 4.935455
## iter  60 value 4.291098
## iter  70 value 2.088678
## iter  80 value 2.056861
## iter  90 value 0.178236
## iter 100 value 0.148225
## final  value 0.148225
## stopped after 100 iterations
## # weights:  39
## initial  value 110.877185
## iter  10 value 76.407135
## iter  20 value 72.348556
## iter  30 value 69.966259
## iter  40 value 69.547092
## iter  50 value 69.498840
## iter  60 value 69.495193
## iter  70 value 69.493092
## iter  80 value 69.492085
## iter  90 value 69.491704
## iter 100 value 69.491507
## final  value 69.491507
## stopped after 100 iterations
## # weights:  109
## initial  value 105.196367
## iter  10 value 37.023872
## iter  20 value 17.167431
## iter  30 value 9.115901
```

```
## iter  40 value 8.242085
## iter  50 value 7.944407
## iter  60 value 7.800878
## iter  70 value 7.691244
## iter  80 value 7.599190
## iter  90 value 7.447350
## iter 100 value 6.996422
## final  value 6.996422
## stopped after 100 iterations
## # weights:  179
## initial  value 106.516563
## iter  10 value 20.375429
## iter  20 value 5.266175
## iter  30 value 3.049331
## iter  40 value 0.101928
## iter  50 value 0.018554
## iter  60 value 0.006918
## iter  70 value 0.001465
## iter  80 value 0.000610
## iter  90 value 0.000306
## iter 100 value 0.000224
## final  value 0.000224
## stopped after 100 iterations
## # weights:  39
## initial  value 101.404151
## iter  10 value 77.673161
## iter  20 value 64.204767
## iter  30 value 60.219105
## iter  40 value 58.820615
## iter  50 value 56.904625
## iter  60 value 56.388151
## iter  70 value 56.328674
## final  value 56.328205
## converged
## # weights:  109
## initial  value 101.292210
## iter  10 value 50.777953
## iter  20 value 29.976999
## iter  30 value 22.164987
## iter  40 value 17.258583
## iter  50 value 17.016999
## iter  60 value 16.955515
## iter  70 value 16.954735
## iter  70 value 16.954735
## iter  70 value 16.954735
## final  value 16.954735
## converged
## # weights:  179
## initial  value 104.055174
## iter  10 value 47.348492
## iter  20 value 23.581423
## iter  30 value 15.088989
## iter  40 value 13.470877
## iter  50 value 12.780743
```

```
## iter  60 value 12.646527
## iter  70 value 12.619079
## iter  80 value 12.615867
## iter  90 value 12.615342
## final  value 12.615286
## converged
## # weights:  39
## initial  value 113.953935
## iter  10 value 74.348849
## iter  20 value 64.698372
## iter  30 value 60.667436
## iter  40 value 55.076762
## iter  50 value 54.340443
## iter  60 value 53.771952
## iter  70 value 52.066827
## iter  80 value 51.695259
## iter  90 value 49.969988
## iter 100 value 49.864780
## final  value 49.864780
## stopped after 100 iterations
## # weights:  109
## initial  value 105.875971
## iter  10 value 30.724684
## iter  20 value 20.858453
## iter  30 value 20.198774
## iter  40 value 20.147281
## iter  50 value 20.127714
## iter  60 value 19.977423
## iter  70 value 18.690555
## iter  80 value 18.638091
## iter  90 value 18.600364
## iter 100 value 15.358080
## final  value 15.358080
## stopped after 100 iterations
## # weights:  179
## initial  value 113.916567
## iter  10 value 22.879010
## iter  20 value 19.433213
## iter  30 value 16.111486
## iter  40 value 14.549640
## iter  50 value 14.292227
## iter  60 value 14.034004
## iter  70 value 13.700443
## iter  80 value 13.235370
## iter  90 value 13.043564
## iter 100 value 12.931508
## final  value 12.931508
## stopped after 100 iterations
## # weights:  39
## initial  value 101.336606
## iter  10 value 58.713996
## iter  20 value 53.202679
## iter  30 value 50.970440
## iter  40 value 46.339869
```

```
## iter  50 value 45.662357
## iter  60 value 45.654508
## iter  70 value 45.654307
## iter  80 value 45.654286
## iter  80 value 45.654286
## iter  80 value 45.654286
## final  value 45.654286
## converged
## # weights:  109
## initial  value 113.403331
## iter  10 value 34.088838
## iter  20 value 16.824174
## iter  30 value 9.719780
## iter  40 value 7.304369
## iter  50 value 4.207232
## iter  60 value 3.889981
## iter  70 value 3.739552
## iter  80 value 3.509259
## iter  90 value 3.378364
## iter 100 value 3.346991
## final  value 3.346991
## stopped after 100 iterations
## # weights:  179
## initial  value 102.553090
## iter  10 value 30.479127
## iter  20 value 20.209764
## iter  30 value 14.850936
## iter  40 value 12.200090
## iter  50 value 9.978704
## iter  60 value 9.364917
## iter  70 value 9.270626
## iter  80 value 9.179696
## iter  90 value 8.911495
## iter 100 value 8.835730
## final  value 8.835730
## stopped after 100 iterations
## # weights:  39
## initial  value 123.515370
## iter  10 value 83.153644
## iter  20 value 70.419075
## iter  30 value 64.038411
## iter  40 value 62.307588
## iter  50 value 59.468386
## iter  60 value 58.712169
## iter  70 value 58.678013
## final  value 58.677908
## converged
## # weights:  109
## initial  value 109.985406
## iter  10 value 51.749223
## iter  20 value 35.665648
## iter  30 value 25.664766
## iter  40 value 21.912126
## iter  50 value 19.258182
```

```
## iter  60 value 17.923731
## iter  70 value 17.399123
## iter  80 value 17.054677
## iter  90 value 17.008316
## iter 100 value 16.999392
## final  value 16.999392
## stopped after 100 iterations
## # weights:  179
## initial  value 109.986602
## iter  10 value 40.930350
## iter  20 value 23.371774
## iter  30 value 15.478120
## iter  40 value 12.919731
## iter  50 value 12.301632
## iter  60 value 12.187109
## iter  70 value 12.177108
## iter  80 value 12.174443
## iter  90 value 12.174280
## final  value 12.174272
## converged
## # weights:  39
## initial  value 106.896869
## iter  10 value 75.647908
## iter  20 value 62.928572
## iter  30 value 60.338873
## iter  40 value 56.850236
## iter  50 value 54.587161
## iter  60 value 52.077134
## iter  70 value 49.266493
## iter  80 value 46.856633
## iter  90 value 46.431459
## iter 100 value 46.049128
## final  value 46.049128
## stopped after 100 iterations
## # weights:  109
## initial  value 104.227153
## iter  10 value 49.408174
## iter  20 value 33.398251
## iter  30 value 26.351524
## iter  40 value 21.805630
## iter  50 value 20.833078
## iter  60 value 20.257052
## iter  70 value 20.185209
## iter  80 value 20.136020
## iter  90 value 20.069878
## iter 100 value 20.020672
## final  value 20.020672
## stopped after 100 iterations
## # weights:  179
## initial  value 132.382320
## iter  10 value 67.797836
## iter  20 value 45.232275
## iter  30 value 22.550660
## iter  40 value 11.525468
```

```
## iter  50 value 9.119962
## iter  60 value 9.022706
## iter  70 value 8.996181
## iter  80 value 8.961726
## iter  90 value 8.433787
## iter 100 value 8.333212
## final  value 8.333212
## stopped after 100 iterations
## # weights:  39
## initial  value 106.255009
## iter  10 value 66.829748
## iter  20 value 61.989661
## iter  30 value 60.600386
## iter  40 value 59.364435
## iter  50 value 58.857610
## iter  60 value 58.583840
## iter  70 value 56.685739
## iter  80 value 55.652402
## iter  90 value 54.301840
## iter 100 value 54.060996
## final  value 54.060996
## stopped after 100 iterations
## # weights:  109
## initial  value 95.237205
## iter  10 value 46.263256
## iter  20 value 14.889634
## iter  30 value 9.748428
## iter  40 value 7.481983
## iter  50 value 6.447576
## iter  60 value 6.260024
## iter  70 value 6.245994
## iter  80 value 6.245665
## iter  90 value 6.243223
## iter 100 value 6.243155
## final  value 6.243155
## stopped after 100 iterations
## # weights:  179
## initial  value 103.675430
## iter  10 value 29.037170
## iter  20 value 10.186919
## iter  30 value 5.119725
## iter  40 value 2.403088
## iter  50 value 0.084056
## iter  60 value 0.012795
## iter  70 value 0.001609
## iter  80 value 0.000367
## iter  90 value 0.000108
## iter  90 value 0.000095
## iter  90 value 0.000095
## final  value 0.000095
## converged
## # weights:  39
## initial  value 101.282811
## iter  10 value 68.911659
```

```
## iter  20 value 65.579028
## iter  30 value 63.183165
## iter  40 value 60.489143
## iter  50 value 58.956900
## iter  60 value 58.877260
## iter  70 value 58.853650
## iter  80 value 58.814921
## iter  90 value 58.812273
## final  value 58.812269
## converged
## # weights:  109
## initial  value 115.216886
## iter  10 value 50.025580
## iter  20 value 28.517549
## iter  30 value 20.338125
## iter  40 value 16.609221
## iter  50 value 16.169486
## iter  60 value 16.134992
## iter  70 value 16.134684
## final  value 16.134684
## converged
## # weights:  179
## initial  value 116.085321
## iter  10 value 30.954048
## iter  20 value 18.705041
## iter  30 value 15.362583
## iter  40 value 13.987375
## iter  50 value 12.235154
## iter  60 value 11.987891
## iter  70 value 11.935045
## iter  80 value 11.889550
## iter  90 value 11.814101
## iter 100 value 11.698297
## final  value 11.698297
## stopped after 100 iterations
## # weights:  39
## initial  value 110.172818
## iter  10 value 66.795218
## iter  20 value 56.627134
## iter  30 value 55.113840
## iter  40 value 53.916655
## iter  50 value 53.513457
## iter  60 value 53.429708
## iter  70 value 53.424925
## iter  80 value 53.409361
## iter  90 value 53.323997
## iter 100 value 52.024818
## final  value 52.024818
## stopped after 100 iterations
## # weights:  109
## initial  value 105.943214
## iter  10 value 61.305445
## iter  20 value 46.566526
## iter  30 value 45.255248
```

```
## iter  40 value 44.839251
## iter  50 value 44.365836
## iter  60 value 43.802310
## iter  70 value 42.896344
## iter  80 value 42.581652
## iter  90 value 41.774748
## iter 100 value 41.655646
## final  value 41.655646
## stopped after 100 iterations
## # weights:  179
## initial  value 114.208948
## iter  10 value 13.133927
## iter  20 value 0.377683
## iter  30 value 0.206190
## iter  40 value 0.182578
## iter  50 value 0.161110
## iter  60 value 0.137105
## iter  70 value 0.126345
## iter  80 value 0.118637
## iter  90 value 0.111652
## iter 100 value 0.104741
## final  value 0.104741
## stopped after 100 iterations
## # weights:  39
## initial  value 97.141722
## iter  10 value 63.657723
## iter  20 value 56.257900
## iter  30 value 50.666105
## iter  40 value 43.475527
## iter  50 value 39.802194
## iter  60 value 38.635474
## iter  70 value 38.446019
## iter  80 value 38.401404
## iter  90 value 38.375354
## iter 100 value 38.361117
## final  value 38.361117
## stopped after 100 iterations
## # weights:  109
## initial  value 109.996305
## iter  10 value 22.052461
## iter  20 value 17.123695
## iter  30 value 16.218858
## iter  40 value 15.686876
## iter  50 value 14.917484
## iter  60 value 13.971951
## iter  70 value 12.201914
## iter  80 value 10.281824
## iter  90 value 10.224822
## iter 100 value 9.675752
## final  value 9.675752
## stopped after 100 iterations
## # weights:  179
## initial  value 130.458739
## iter  10 value 47.501540
```

```
## iter  20 value 23.194329
## iter  30 value 17.354286
## iter  40 value 16.617792
## iter  50 value 14.678477
## iter  60 value 14.372833
## iter  70 value 14.274735
## iter  80 value 14.227572
## iter  90 value 14.076666
## iter 100 value 13.723333
## final  value 13.723333
## stopped after 100 iterations
## # weights:  39
## initial  value 108.177681
## iter  10 value 72.116776
## iter  20 value 64.391265
## iter  30 value 60.224527
## iter  40 value 57.103019
## iter  50 value 55.732328
## iter  60 value 55.658225
## final  value 55.657593
## converged
## # weights:  109
## initial  value 106.246967
## iter  10 value 40.889581
## iter  20 value 27.603289
## iter  30 value 17.852300
## iter  40 value 16.264181
## iter  50 value 16.007933
## iter  60 value 15.766623
## iter  70 value 15.270262
## iter  80 value 14.501568
## iter  90 value 14.486939
## final  value 14.486893
## converged
## # weights:  179
## initial  value 100.280449
## iter  10 value 44.011581
## iter  20 value 22.418312
## iter  30 value 15.536459
## iter  40 value 13.070783
## iter  50 value 12.258427
## iter  60 value 11.768666
## iter  70 value 11.601077
## iter  80 value 11.450492
## iter  90 value 11.432543
## iter 100 value 11.409719
## final  value 11.409719
## stopped after 100 iterations
## # weights:  39
## initial  value 100.902533
## iter  10 value 69.495457
## iter  20 value 56.489412
## iter  30 value 52.155389
## iter  40 value 49.536678
```

```
## iter  50 value 47.961094
## iter  60 value 46.255032
## iter  70 value 45.697401
## iter  80 value 45.109495
## iter  90 value 44.840348
## iter 100 value 43.633264
## final  value 43.633264
## stopped after 100 iterations
## # weights:  109
## initial  value 105.241944
## iter  10 value 18.004443
## iter  20 value 13.521945
## iter  30 value 11.639554
## iter  40 value 11.310311
## iter  50 value 11.252484
## iter  60 value 11.203879
## iter  70 value 11.133833
## iter  80 value 11.101025
## iter  90 value 11.046981
## iter 100 value 11.000635
## final  value 11.000635
## stopped after 100 iterations
## # weights:  179
## initial  value 97.749766
## iter  10 value 25.020107
## iter  20 value 10.201067
## iter  30 value 8.053348
## iter  40 value 7.416027
## iter  50 value 6.988303
## iter  60 value 2.676693
## iter  70 value 2.448800
## iter  80 value 0.245567
## iter  90 value 0.207879
## iter 100 value 0.195222
## final  value 0.195222
## stopped after 100 iterations
## # weights:  39
## initial  value 102.074074
## iter  10 value 76.071231
## iter  20 value 71.110618
## iter  30 value 69.010607
## iter  40 value 68.620046
## iter  50 value 68.575700
## iter  60 value 68.571629
## iter  70 value 68.570057
## iter  80 value 68.569102
## final  value 68.569063
## converged
## # weights:  109
## initial  value 107.852459
## iter  10 value 59.224926
## iter  20 value 39.232537
## iter  30 value 36.123728
## iter  40 value 33.782363
```

```
## iter  50 value 33.393481
## iter  60 value 32.726052
## iter  70 value 31.822126
## iter  80 value 31.287364
## iter  90 value 30.988612
## iter 100 value 30.313712
## final  value 30.313712
## stopped after 100 iterations
## # weights:  179
## initial  value 122.246607
## iter  10 value 26.359998
## iter  20 value 16.447792
## iter  30 value 15.652143
## iter  40 value 15.491780
## iter  50 value 14.761786
## iter  60 value 14.753042
## iter  70 value 14.729587
## iter  80 value 12.982306
## iter  90 value 12.848875
## iter 100 value 12.844613
## final  value 12.844613
## stopped after 100 iterations
## # weights:  39
## initial  value 117.616004
## iter  10 value 70.091623
## iter  20 value 61.919012
## iter  30 value 60.350121
## iter  40 value 59.883131
## iter  50 value 59.557645
## iter  60 value 58.750542
## final  value 58.738443
## converged
## # weights:  109
## initial  value 110.271079
## iter  10 value 57.231152
## iter  20 value 29.598527
## iter  30 value 19.980459
## iter  40 value 17.459025
## iter  50 value 17.018922
## iter  60 value 16.885743
## iter  70 value 16.687703
## iter  80 value 16.614984
## iter  90 value 16.613148
## iter  90 value 16.613148
## iter  90 value 16.613148
## final  value 16.613148
## converged
## # weights:  179
## initial  value 108.148610
## iter  10 value 60.864418
## iter  20 value 26.107739
## iter  30 value 14.821464
## iter  40 value 12.936570
## iter  50 value 12.488586
```

```
## iter  60 value 12.399275
## iter  70 value 12.387366
## iter  80 value 12.384074
## iter  90 value 12.384002
## final  value 12.384000
## converged
## # weights:  39
## initial  value 99.672219
## iter  10 value 66.668741
## iter  20 value 56.541865
## iter  30 value 49.647541
## iter  40 value 46.983637
## iter  50 value 46.436520
## iter  60 value 45.291575
## iter  70 value 45.036242
## iter  80 value 45.023579
## iter  90 value 44.409968
## iter 100 value 42.803765
## final  value 42.803765
## stopped after 100 iterations
## # weights:  109
## initial  value 106.520235
## iter  10 value 39.520266
## iter  20 value 23.039909
## iter  30 value 15.670569
## iter  40 value 12.580631
## iter  50 value 9.704793
## iter  60 value 8.520926
## iter  70 value 8.176325
## iter  80 value 8.107813
## iter  90 value 7.792391
## iter 100 value 7.547020
## final  value 7.547020
## stopped after 100 iterations
## # weights:  179
## initial  value 94.639251
## iter  10 value 26.432558
## iter  20 value 11.694838
## iter  30 value 3.620085
## iter  40 value 2.811757
## iter  50 value 0.331177
## iter  60 value 0.255240
## iter  70 value 0.232505
## iter  80 value 0.219531
## iter  90 value 0.207239
## iter 100 value 0.188280
## final  value 0.188280
## stopped after 100 iterations
## # weights:  39
## initial  value 101.955099
## iter  10 value 58.547455
## iter  20 value 56.096916
## iter  30 value 55.576029
## iter  40 value 54.694568
```

```
## iter  50 value 54.276457
## iter  60 value 54.085698
## iter  70 value 54.055668
## iter  80 value 54.048491
## iter  90 value 54.047021
## final  value 54.047018
## converged
## # weights:  109
## initial  value 113.799929
## iter  10 value 50.605766
## iter  20 value 39.075051
## iter  30 value 15.877393
## iter  40 value 6.633401
## iter  50 value 5.607325
## iter  60 value 5.581716
## iter  70 value 5.581392
## iter  80 value 5.581202
## final  value 5.581199
## converged
## # weights:  179
## initial  value 102.433560
## iter  10 value 27.630212
## iter  20 value 8.169679
## iter  30 value 4.015954
## iter  40 value 3.823980
## iter  50 value 3.819553
## iter  60 value 3.819135
## iter  70 value 3.819110
## iter  80 value 3.819096
## final  value 3.819095
## converged
## # weights:  39
## initial  value 104.894651
## iter  10 value 67.222319
## iter  20 value 60.939577
## iter  30 value 58.827110
## iter  40 value 58.535081
## iter  50 value 58.276064
## iter  60 value 58.231354
## iter  70 value 57.967052
## final  value 57.964173
## converged
## # weights:  109
## initial  value 103.171180
## iter  10 value 53.155911
## iter  20 value 31.112623
## iter  30 value 19.107940
## iter  40 value 16.822459
## iter  50 value 16.317978
## iter  60 value 16.198758
## iter  70 value 15.755214
## iter  80 value 15.643074
## final  value 15.642186
## converged
```

```
## # weights:  179
## initial  value 126.716014
## iter  10 value 37.553336
## iter  20 value 18.808806
## iter  30 value 14.720767
## iter  40 value 12.824745
## iter  50 value 12.308859
## iter  60 value 11.965359
## iter  70 value 11.946654
## iter  80 value 11.945785
## final  value 11.945778
## converged
## # weights:  39
## initial  value 106.506137
## iter  10 value 63.483543
## iter  20 value 58.251297
## iter  30 value 56.306057
## iter  40 value 56.193543
## iter  50 value 55.944139
## iter  60 value 55.099118
## iter  70 value 54.762975
## iter  80 value 54.051386
## iter  90 value 53.406058
## iter 100 value 53.262717
## final  value 53.262717
## stopped after 100 iterations
## # weights:  109
## initial  value 100.743883
## iter  10 value 43.836289
## iter  20 value 28.798707
## iter  30 value 11.310145
## iter  40 value 6.674741
## iter  50 value 6.303535
## iter  60 value 6.045903
## iter  70 value 4.919794
## iter  80 value 4.645936
## iter  90 value 4.525052
## iter 100 value 4.330691
## final  value 4.330691
## stopped after 100 iterations
## # weights:  179
## initial  value 108.255633
## iter  10 value 37.536592
## iter  20 value 14.056476
## iter  30 value 10.499863
## iter  40 value 9.325585
## iter  50 value 9.181345
## iter  60 value 9.132988
## iter  70 value 9.111324
## iter  80 value 9.077657
## iter  90 value 8.993932
## iter 100 value 8.655349
## final  value 8.655349
## stopped after 100 iterations
```

```
## # weights:  39
## initial  value 113.983098
## iter  10 value 87.441127
## iter  20 value 79.352612
## iter  30 value 78.066712
## iter  40 value 76.671679
## iter  50 value 74.432980
## iter  60 value 73.952666
## iter  70 value 73.838108
## iter  80 value 73.819343
## iter  90 value 73.813846
## iter 100 value 73.812057
## final  value 73.812057
## stopped after 100 iterations
## # weights:  109
## initial  value 107.889333
## iter  10 value 40.854062
## iter  20 value 25.007905
## iter  30 value 19.239009
## iter  40 value 18.638793
## iter  50 value 18.518591
## iter  60 value 18.311121
## iter  70 value 17.976175
## iter  80 value 17.963642
## iter  90 value 17.959308
## iter 100 value 17.947421
## final  value 17.947421
## stopped after 100 iterations
## # weights:  179
## initial  value 113.977287
## iter  10 value 48.286552
## iter  20 value 20.015456
## iter  30 value 12.575581
## iter  40 value 7.679964
## iter  50 value 5.951701
## iter  60 value 4.206850
## iter  70 value 4.181075
## iter  80 value 4.172676
## iter  90 value 4.165681
## iter 100 value 4.164415
## final  value 4.164415
## stopped after 100 iterations
## # weights:  39
## initial  value 104.295824
## iter  10 value 75.210877
## iter  20 value 63.048352
## iter  30 value 58.488840
## iter  40 value 57.414507
## iter  50 value 57.394265
## final  value 57.394232
## converged
## # weights:  109
## initial  value 115.381280
## iter  10 value 48.512886
```

```
## iter  20 value 40.417664
## iter  30 value 33.541293
## iter  40 value 24.289052
## iter  50 value 18.641956
## iter  60 value 17.361724
## iter  70 value 17.056915
## iter  80 value 16.948316
## iter  90 value 16.947875
## final  value 16.947873
## converged
## # weights:  179
## initial  value 110.424543
## iter  10 value 31.157217
## iter  20 value 17.932690
## iter  30 value 14.527502
## iter  40 value 13.163494
## iter  50 value 12.950152
## iter  60 value 12.634455
## iter  70 value 12.527285
## iter  80 value 12.366793
## iter  90 value 12.354188
## iter 100 value 12.351244
## final  value 12.351244
## stopped after 100 iterations
## # weights:  39
## initial  value 104.133840
## iter  10 value 74.176563
## iter  20 value 62.253660
## iter  30 value 60.173528
## iter  40 value 57.933405
## iter  50 value 56.549344
## iter  60 value 52.659860
## iter  70 value 51.759682
## iter  80 value 51.599304
## iter  90 value 49.164642
## iter 100 value 48.935213
## final  value 48.935213
## stopped after 100 iterations
## # weights:  109
## initial  value 94.492022
## iter  10 value 37.476186
## iter  20 value 28.270609
## iter  30 value 26.324287
## iter  40 value 24.945171
## iter  50 value 23.881408
## iter  60 value 23.684189
## iter  70 value 23.582976
## iter  80 value 23.558483
## iter  90 value 23.493813
## iter 100 value 23.404815
## final  value 23.404815
## stopped after 100 iterations
## # weights:  179
## initial  value 103.884269
```

```
## iter  10 value 26.365540
## iter  20 value 7.869652
## iter  30 value 3.692560
## iter  40 value 3.132663
## iter  50 value 2.984652
## iter  60 value 2.932359
## iter  70 value 2.803554
## iter  80 value 2.447538
## iter  90 value 2.106101
## iter 100 value 2.094074
## final  value 2.094074
## stopped after 100 iterations
## # weights:  39
## initial  value 106.952758
## iter  10 value 72.637910
## iter  20 value 62.074466
## iter  30 value 58.996568
## iter  40 value 58.164663
## iter  50 value 58.095806
## iter  60 value 56.929749
## iter  70 value 55.880714
## iter  80 value 55.867418
## iter  90 value 55.839918
## iter 100 value 55.824794
## final  value 55.824794
## stopped after 100 iterations
## # weights:  109
## initial  value 105.912788
## iter  10 value 48.835434
## iter  20 value 25.377404
## iter  30 value 17.550656
## iter  40 value 12.536512
## iter  50 value 10.427239
## iter  60 value 9.741051
## iter  70 value 9.703370
## iter  80 value 9.675201
## iter  90 value 9.583550
## iter 100 value 9.580185
## final  value 9.580185
## stopped after 100 iterations
## # weights:  179
## initial  value 106.309196
## iter  10 value 26.936341
## iter  20 value 7.188706
## iter  30 value 2.016982
## iter  40 value 1.726869
## iter  50 value 1.394769
## iter  60 value 1.391318
## iter  70 value 1.388819
## iter  80 value 1.387589
## iter  90 value 1.387302
## iter 100 value 1.386701
## final  value 1.386701
## stopped after 100 iterations
```

```
## # weights:  39
## initial  value 106.758200
## iter  10 value 68.060533
## iter  20 value 58.827192
## iter  30 value 57.217470
## iter  40 value 56.801505
## iter  50 value 56.488998
## iter  60 value 56.361462
## iter  70 value 56.355441
## final  value 56.355432
## converged
## # weights:  109
## initial  value 104.347575
## iter  10 value 35.032481
## iter  20 value 19.578919
## iter  30 value 17.474573
## iter  40 value 17.185165
## iter  50 value 16.163480
## iter  60 value 15.653149
## iter  70 value 15.468152
## iter  80 value 14.948157
## iter  90 value 14.942889
## final  value 14.942880
## converged
## # weights:  179
## initial  value 116.380740
## iter  10 value 37.487523
## iter  20 value 17.297219
## iter  30 value 13.261150
## iter  40 value 11.801239
## iter  50 value 11.587774
## iter  60 value 11.573982
## iter  70 value 11.573726
## final  value 11.573721
## converged
## # weights:  39
## initial  value 110.591086
## iter  10 value 79.701509
## iter  20 value 66.051565
## iter  30 value 63.311775
## iter  40 value 60.188672
## iter  50 value 57.665496
## iter  60 value 56.028629
## iter  70 value 53.021750
## iter  80 value 52.640455
## iter  90 value 50.344370
## iter 100 value 49.760780
## final  value 49.760780
## stopped after 100 iterations
## # weights:  109
## initial  value 111.225988
## iter  10 value 55.032260
## iter  20 value 31.243901
## iter  30 value 21.242487
```

```
## iter  40 value 20.853761
## iter  50 value 20.505548
## iter  60 value 20.264127
## iter  70 value 19.970477
## iter  80 value 19.852801
## iter  90 value 19.734082
## iter 100 value 19.458771
## final  value 19.458771
## stopped after 100 iterations
## # weights:  179
## initial  value 108.085848
## iter  10 value 43.059980
## iter  20 value 4.622010
## iter  30 value 0.277884
## iter  40 value 0.233860
## iter  50 value 0.202374
## iter  60 value 0.177374
## iter  70 value 0.154542
## iter  80 value 0.146889
## iter  90 value 0.133110
## iter 100 value 0.128149
## final  value 0.128149
## stopped after 100 iterations
## # weights:  39
## initial  value 111.614371
## iter  10 value 67.853567
## iter  20 value 56.814323
## iter  30 value 53.091755
## iter  40 value 53.069044
## iter  50 value 53.067391
## iter  60 value 53.067199
## iter  70 value 53.067139
## final  value 53.067093
## converged
## # weights:  109
## initial  value 114.080231
## iter  10 value 58.374017
## iter  20 value 42.452250
## iter  30 value 29.675842
## iter  40 value 25.644864
## iter  50 value 25.331905
## iter  60 value 21.325415
## iter  70 value 20.303688
## iter  80 value 20.264718
## iter  90 value 20.263296
## iter 100 value 20.263049
## final  value 20.263049
## stopped after 100 iterations
## # weights:  179
## initial  value 105.586240
## iter  10 value 18.053246
## iter  20 value 5.637791
## iter  30 value 0.318545
## iter  40 value 0.009110
```

```
## iter  50 value 0.000690
## iter  60 value 0.000199
## iter  70 value 0.000102
## final  value 0.000100
## converged
## # weights:  39
## initial  value 103.785528
## iter  10 value 67.873462
## iter  20 value 63.564800
## iter  30 value 61.075913
## iter  40 value 60.650053
## iter  50 value 60.141771
## iter  60 value 58.677672
## iter  70 value 58.158835
## iter  80 value 57.980951
## iter  90 value 57.961033
## iter  90 value 57.961032
## iter  90 value 57.961032
## final  value 57.961032
## converged
## # weights:  109
## initial  value 116.856886
## iter  10 value 47.658898
## iter  20 value 31.980101
## iter  30 value 20.532882
## iter  40 value 18.388903
## iter  50 value 17.760540
## iter  60 value 17.506323
## iter  70 value 16.928798
## iter  80 value 16.607733
## iter  90 value 16.529480
## iter 100 value 16.513202
## final  value 16.513202
## stopped after 100 iterations
## # weights:  179
## initial  value 125.097607
## iter  10 value 54.197389
## iter  20 value 30.854924
## iter  30 value 21.855689
## iter  40 value 16.674901
## iter  50 value 14.312230
## iter  60 value 12.945907
## iter  70 value 12.813269
## iter  80 value 12.806684
## final  value 12.806602
## converged
## # weights:  39
## initial  value 109.454281
## iter  10 value 68.489554
## iter  20 value 58.051799
## iter  30 value 53.950597
## iter  40 value 50.492012
## iter  50 value 50.267121
## iter  60 value 50.249982
```

```
## iter  70 value 50.183703
## iter  80 value 50.142698
## iter  90 value 50.139171
## iter 100 value 50.124238
## final  value 50.124238
## stopped after 100 iterations
## # weights:  109
## initial  value 104.158381
## iter  10 value 29.158508
## iter  20 value 15.290944
## iter  30 value 13.104837
## iter  40 value 12.508508
## iter  50 value 12.405101
## iter  60 value 12.357995
## iter  70 value 11.930820
## iter  80 value 11.809774
## iter  90 value 11.799290
## iter 100 value 11.752049
## final  value 11.752049
## stopped after 100 iterations
## # weights:  179
## initial  value 126.750437
## iter  10 value 62.013794
## iter  20 value 56.182839
## iter  30 value 53.208551
## iter  40 value 52.784011
## iter  50 value 52.647743
## iter  60 value 52.524650
## iter  70 value 52.113119
## iter  80 value 51.706642
## iter  90 value 49.014534
## iter 100 value 48.602914
## final  value 48.602914
## stopped after 100 iterations
## # weights:  39
## initial  value 102.783425
## iter  10 value 63.566598
## iter  20 value 59.943813
## iter  30 value 59.019441
## iter  40 value 58.120556
## iter  50 value 52.672600
## iter  60 value 51.869770
## iter  70 value 50.868868
## iter  80 value 50.633839
## iter  90 value 49.154694
## iter 100 value 48.850587
## final  value 48.850587
## stopped after 100 iterations
## # weights:  109
## initial  value 101.225242
## iter  10 value 56.818837
## iter  20 value 30.455290
## iter  30 value 17.238070
## iter  40 value 8.748656
```

```
## iter  50 value 8.702953
## iter  60 value 8.670252
## iter  70 value 8.037576
## iter  80 value 6.758811
## iter  90 value 6.753019
## iter 100 value 6.455886
## final  value 6.455886
## stopped after 100 iterations
## # weights:  179
## initial  value 138.253773
## iter  10 value 47.350613
## iter  20 value 32.195540
## iter  30 value 18.590606
## iter  40 value 17.754454
## iter  50 value 17.452345
## iter  60 value 17.294296
## iter  70 value 11.425029
## iter  80 value 7.279258
## iter  90 value 6.712674
## iter 100 value 6.675366
## final  value 6.675366
## stopped after 100 iterations
## # weights:  39
## initial  value 105.595506
## iter  10 value 70.007793
## iter  20 value 63.735123
## iter  30 value 60.656865
## iter  40 value 58.436173
## iter  50 value 58.376796
## final  value 58.376740
## converged
## # weights:  109
## initial  value 104.408190
## iter  10 value 54.812636
## iter  20 value 33.437008
## iter  30 value 26.143288
## iter  40 value 19.021726
## iter  50 value 16.400660
## iter  60 value 15.749509
## iter  70 value 15.735730
## iter  80 value 15.734676
## final  value 15.734656
## converged
## # weights:  179
## initial  value 144.306136
## iter  10 value 67.928940
## iter  20 value 34.866184
## iter  30 value 21.767935
## iter  40 value 15.933002
## iter  50 value 13.188491
## iter  60 value 11.904032
## iter  70 value 11.687760
## iter  80 value 11.676570
## iter  90 value 11.676338
```

```
## final  value 11.676334
## converged
## # weights:  39
## initial  value 100.249235
## iter  10 value 79.316363
## iter  20 value 54.146303
## iter  30 value 51.926509
## iter  40 value 50.587084
## iter  50 value 50.489573
## iter  60 value 50.474210
## iter  70 value 50.458626
## iter  80 value 50.450965
## iter  90 value 50.444014
## iter 100 value 50.426680
## final  value 50.426680
## stopped after 100 iterations
## # weights:  109
## initial  value 102.457680
## iter  10 value 30.173731
## iter  20 value 23.577067
## iter  30 value 19.575446
## iter  40 value 18.388200
## iter  50 value 18.086073
## iter  60 value 17.781574
## iter  70 value 17.762747
## iter  80 value 17.523411
## iter  90 value 17.007560
## iter 100 value 16.837784
## final  value 16.837784
## stopped after 100 iterations
## # weights:  179
## initial  value 107.763843
## iter  10 value 12.222938
## iter  20 value 4.833238
## iter  30 value 2.547389
## iter  40 value 2.506760
## iter  50 value 2.465933
## iter  60 value 2.446618
## iter  70 value 2.429134
## iter  80 value 2.414251
## iter  90 value 2.039472
## iter 100 value 0.211514
## final  value 0.211514
## stopped after 100 iterations
## # weights:  39
## initial  value 104.472068
## iter  10 value 65.134966
## iter  20 value 58.039746
## iter  30 value 51.529865
## iter  40 value 46.482814
## iter  50 value 45.560272
## iter  60 value 45.233478
## iter  70 value 45.166909
## iter  80 value 45.128088
```

```
## iter  90 value 45.123443
## iter 100 value 45.121269
## final  value 45.121269
## stopped after 100 iterations
## # weights:  109
## initial  value 98.200797
## iter  10 value 22.463152
## iter  20 value 12.801040
## iter  30 value 8.665100
## iter  40 value 8.131949
## iter  50 value 6.254632
## iter  60 value 3.792581
## iter  70 value 3.664422
## iter  80 value 3.575235
## iter  90 value 3.497066
## iter 100 value 3.469725
## final  value 3.469725
## stopped after 100 iterations
## # weights:  179
## initial  value 106.456868
## iter  10 value 19.267289
## iter  20 value 4.937744
## iter  30 value 2.268550
## iter  40 value 2.250703
## iter  50 value 2.249501
## iter  60 value 2.249382
## iter  70 value 2.249351
## final  value 2.249341
## converged
## # weights:  39
## initial  value 103.966156
## iter  10 value 67.868376
## iter  20 value 63.303665
## iter  30 value 61.969825
## iter  40 value 61.070824
## iter  50 value 60.274006
## iter  60 value 58.627562
## iter  70 value 57.704211
## iter  80 value 57.312106
## iter  90 value 57.223031
## iter 100 value 57.126860
## final  value 57.126860
## stopped after 100 iterations
## # weights:  109
## initial  value 103.489716
## iter  10 value 56.695186
## iter  20 value 34.519226
## iter  30 value 21.327647
## iter  40 value 19.725156
## iter  50 value 19.147502
## iter  60 value 18.786956
## iter  70 value 16.128017
## iter  80 value 16.006829
## iter  90 value 16.004455
```

```
## final  value 16.004440
## converged
## # weights:  179
## initial  value 127.364733
## iter  10 value 55.537825
## iter  20 value 35.271283
## iter  30 value 19.268067
## iter  40 value 16.335774
## iter  50 value 14.685337
## iter  60 value 12.903359
## iter  70 value 12.752867
## iter  80 value 12.577488
## iter  90 value 12.198383
## iter 100 value 12.116167
## final  value 12.116167
## stopped after 100 iterations
## # weights:  39
## initial  value 109.354850
## iter  10 value 67.274959
## iter  20 value 61.111110
## iter  30 value 59.295381
## iter  40 value 58.688705
## iter  50 value 58.659685
## iter  60 value 58.177106
## iter  70 value 57.532967
## iter  80 value 57.032534
## iter  90 value 56.098088
## iter 100 value 55.168180
## final  value 55.168180
## stopped after 100 iterations
## # weights:  109
## initial  value 106.031369
## iter  10 value 33.048027
## iter  20 value 18.252925
## iter  30 value 13.226640
## iter  40 value 6.668093
## iter  50 value 5.952012
## iter  60 value 5.894128
## iter  70 value 5.855142
## iter  80 value 5.834063
## iter  90 value 5.652256
## iter 100 value 3.916099
## final  value 3.916099
## stopped after 100 iterations
## # weights:  179
## initial  value 113.749683
## iter  10 value 37.107881
## iter  20 value 9.860052
## iter  30 value 4.308719
## iter  40 value 3.625436
## iter  50 value 3.538512
## iter  60 value 1.664658
## iter  70 value 1.603890
## iter  80 value 1.589119
```

```
## iter  90 value 1.565081
## iter 100 value 1.241274
## final  value 1.241274
## stopped after 100 iterations
## # weights:  39
## initial  value 110.703885
## iter  10 value 80.488171
## iter  20 value 58.409982
## iter  30 value 55.031395
## iter  40 value 54.701676
## iter  50 value 54.433406
## iter  60 value 54.427639
## iter  70 value 54.390768
## iter  80 value 53.572150
## iter  90 value 53.380987
## iter 100 value 52.607142
## final  value 52.607142
## stopped after 100 iterations
## # weights:  109
## initial  value 112.777157
## iter  10 value 35.777908
## iter  20 value 14.676191
## iter  30 value 8.127686
## iter  40 value 6.662475
## iter  50 value 6.064834
## iter  60 value 5.670813
## iter  70 value 3.350123
## iter  80 value 3.297484
## iter  90 value 3.296396
## iter 100 value 3.295869
## final  value 3.295869
## stopped after 100 iterations
## # weights:  179
## initial  value 114.786911
## iter  10 value 37.376245
## iter  20 value 31.019746
## iter  30 value 30.268802
## iter  40 value 29.571426
## iter  50 value 28.070072
## iter  60 value 27.151458
## iter  70 value 26.394883
## iter  80 value 24.582419
## iter  90 value 24.321786
## iter 100 value 24.319401
## final  value 24.319401
## stopped after 100 iterations
## # weights:  39
## initial  value 102.442172
## iter  10 value 77.450999
## iter  20 value 71.361642
## iter  30 value 65.028247
## iter  40 value 59.644186
## iter  50 value 58.821794
## iter  60 value 58.733069
```

```
## iter  70 value 58.293805
## iter  80 value 58.185517
## iter  90 value 58.183982
## iter  90 value 58.183981
## iter  90 value 58.183981
## final  value 58.183981
## converged
## # weights:  109
## initial  value 117.453113
## iter  10 value 51.873481
## iter  20 value 30.692088
## iter  30 value 21.786803
## iter  40 value 17.152029
## iter  50 value 16.807359
## iter  60 value 16.761771
## iter  70 value 16.760704
## final  value 16.760703
## converged
## # weights:  179
## initial  value 97.760439
## iter  10 value 40.313885
## iter  20 value 18.795398
## iter  30 value 14.296333
## iter  40 value 12.979477
## iter  50 value 12.715987
## iter  60 value 12.525710
## iter  70 value 12.495610
## iter  80 value 12.494957
## final  value 12.494950
## converged
## # weights:  39
## initial  value 106.384231
## iter  10 value 86.192459
## iter  20 value 64.956486
## iter  30 value 63.513229
## iter  40 value 62.674825
## iter  50 value 62.053816
## iter  60 value 62.050996
## iter  70 value 62.036129
## iter  80 value 62.029184
## iter  90 value 62.025271
## iter 100 value 60.799769
## final  value 60.799769
## stopped after 100 iterations
## # weights:  109
## initial  value 105.295497
## iter  10 value 49.988130
## iter  20 value 35.420163
## iter  30 value 11.650890
## iter  40 value 2.990496
## iter  50 value 0.816110
## iter  60 value 0.689317
## iter  70 value 0.591054
## iter  80 value 0.499476
```

```
## iter  90 value 0.468056
## iter 100 value 0.428906
## final  value 0.428906
## stopped after 100 iterations
## # weights:  179
## initial  value 96.208628
## iter  10 value 22.444190
## iter  20 value 6.249756
## iter  30 value 4.750947
## iter  40 value 4.134210
## iter  50 value 3.953893
## iter  60 value 3.583218
## iter  70 value 3.565411
## iter  80 value 3.527629
## iter  90 value 3.495434
## iter 100 value 3.454413
## final  value 3.454413
## stopped after 100 iterations
## # weights:  39
## initial  value 99.113616
## iter  10 value 72.921939
## iter  20 value 65.653703
## iter  30 value 65.557822
## iter  40 value 65.356096
## iter  50 value 64.570840
## iter  60 value 64.547269
## iter  70 value 64.545236
## iter  80 value 64.540920
## iter  90 value 64.540150
## iter  90 value 64.540149
## iter  90 value 64.540149
## final  value 64.540149
## converged
## # weights:  109
## initial  value 100.265026
## iter  10 value 32.744203
## iter  20 value 9.347204
## iter  30 value 6.459242
## iter  40 value 6.445520
## iter  50 value 6.435164
## iter  60 value 6.108671
## final  value 6.108652
## converged
## # weights:  179
## initial  value 107.617677
## iter  10 value 20.094854
## iter  20 value 4.197975
## iter  30 value 2.568063
## iter  40 value 2.503684
## iter  50 value 2.502390
## iter  60 value 2.502017
## iter  70 value 2.502013
## iter  70 value 2.502013
## iter  70 value 2.502013
```

```
## final  value 2.502013
## converged
## # weights:  39
## initial  value 101.922734
## iter  10 value 67.704235
## iter  20 value 60.938457
## iter  30 value 60.304342
## iter  40 value 57.859377
## iter  50 value 57.228095
## iter  60 value 57.071092
## iter  70 value 56.961622
## iter  80 value 56.853297
## iter  90 value 56.844005
## iter 100 value 56.090008
## final  value 56.090008
## stopped after 100 iterations
## # weights:  109
## initial  value 114.608044
## iter  10 value 48.681598
## iter  20 value 27.725466
## iter  30 value 20.921050
## iter  40 value 17.400910
## iter  50 value 16.832208
## iter  60 value 16.247031
## iter  70 value 15.821144
## iter  80 value 15.776211
## iter  90 value 15.775778
## final  value 15.775777
## converged
## # weights:  179
## initial  value 108.577470
## iter  10 value 45.492580
## iter  20 value 19.062566
## iter  30 value 13.571778
## iter  40 value 12.130881
## iter  50 value 11.818093
## iter  60 value 11.708886
## iter  70 value 11.704983
## iter  80 value 11.704270
## iter  90 value 11.704177
## final  value 11.704174
## converged
## # weights:  39
## initial  value 118.384405
## iter  10 value 63.061188
## iter  20 value 56.866506
## iter  30 value 52.918963
## iter  40 value 48.782648
## iter  50 value 47.685378
## iter  60 value 46.647753
## iter  70 value 46.547462
## iter  80 value 46.498774
## iter  90 value 46.468622
## iter 100 value 46.441613
```

```
## final  value 46.441613
## stopped after 100 iterations
## # weights:  109
## initial  value 100.523905
## iter  10 value 49.667985
## iter  20 value 32.272071
## iter  30 value 28.077417
## iter  40 value 24.766138
## iter  50 value 22.748339
## iter  60 value 17.032807
## iter  70 value 16.071974
## iter  80 value 14.313349
## iter  90 value 12.176478
## iter 100 value 8.352725
## final  value 8.352725
## stopped after 100 iterations
## # weights:  179
## initial  value 110.598998
## iter  10 value 16.468345
## iter  20 value 6.948654
## iter  30 value 5.736880
## iter  40 value 5.412080
## iter  50 value 2.782083
## iter  60 value 2.072471
## iter  70 value 2.063814
## iter  80 value 2.035121
## iter  90 value 2.021741
## iter 100 value 1.508672
## final  value 1.508672
## stopped after 100 iterations
## # weights:  39
## initial  value 107.272666
## iter  10 value 82.800546
## iter  20 value 60.398541
## iter  30 value 54.001731
## iter  40 value 50.788222
## iter  50 value 44.272932
## iter  60 value 41.151994
## iter  70 value 40.323200
## iter  80 value 39.398915
## iter  90 value 38.896513
## iter 100 value 38.652505
## final  value 38.652505
## stopped after 100 iterations
## # weights:  109
## initial  value 100.410174
## iter  10 value 50.415440
## iter  20 value 32.138839
## iter  30 value 24.851638
## iter  40 value 19.395540
## iter  50 value 16.170443
## iter  60 value 14.617797
## iter  70 value 14.250443
## iter  80 value 14.179781
```

```
## iter  90 value 12.872134
## iter 100 value 12.302557
## final  value 12.302557
## stopped after 100 iterations
## # weights:  179
## initial  value 118.142310
## iter  10 value 30.004293
## iter  20 value 7.019661
## iter  30 value 5.051398
## iter  40 value 3.789894
## iter  50 value 3.669587
## iter  60 value 3.648646
## iter  70 value 1.503194
## iter  80 value 1.415382
## iter  90 value 1.389269
## iter 100 value 1.387706
## final  value 1.387706
## stopped after 100 iterations
## # weights:  39
## initial  value 97.008143
## iter  10 value 72.247719
## iter  20 value 62.286870
## iter  30 value 59.569785
## iter  40 value 59.020275
## iter  50 value 57.718665
## iter  60 value 57.447456
## iter  70 value 57.445067
## final  value 57.445063
## converged
## # weights:  109
## initial  value 124.568072
## iter  10 value 62.224584
## iter  20 value 37.463481
## iter  30 value 23.894316
## iter  40 value 18.082286
## iter  50 value 17.401659
## iter  60 value 17.057359
## iter  70 value 16.524935
## iter  80 value 16.427424
## iter  90 value 16.422662
## iter 100 value 16.421379
## final  value 16.421379
## stopped after 100 iterations
## # weights:  179
## initial  value 114.851308
## iter  10 value 53.512838
## iter  20 value 25.344277
## iter  30 value 14.305521
## iter  40 value 13.132389
## iter  50 value 12.439838
## iter  60 value 12.248077
## iter  70 value 12.170287
## iter  80 value 12.157901
## iter  90 value 12.154942
```

```
## iter 100 value 12.154343
## final  value 12.154343
## stopped after 100 iterations
## # weights:  39
## initial  value 102.543893
## iter  10 value 67.145239
## iter  20 value 59.782776
## iter  30 value 57.414551
## iter  40 value 56.409475
## iter  50 value 55.935739
## iter  60 value 55.707121
## iter  70 value 54.681393
## iter  80 value 54.117766
## iter  90 value 53.981116
## iter 100 value 53.948032
## final  value 53.948032
## stopped after 100 iterations
## # weights:  109
## initial  value 109.860170
## iter  10 value 39.899647
## iter  20 value 16.202797
## iter  30 value 11.704230
## iter  40 value 11.233258
## iter  50 value 11.019401
## iter  60 value 10.904538
## iter  70 value 10.879961
## iter  80 value 6.865715
## iter  90 value 3.766429
## iter 100 value 0.626508
## final  value 0.626508
## stopped after 100 iterations
## # weights:  179
## initial  value 112.124048
## iter  10 value 24.134817
## iter  20 value 9.305798
## iter  30 value 6.521452
## iter  40 value 6.345559
## iter  50 value 6.243299
## iter  60 value 5.923178
## iter  70 value 5.867427
## iter  80 value 5.829981
## iter  90 value 5.767820
## iter 100 value 5.182955
## final  value 5.182955
## stopped after 100 iterations
## # weights:  39
## initial  value 110.634912
## iter  10 value 68.182465
## iter  20 value 56.377025
## iter  30 value 52.504642
## iter  40 value 52.058772
## iter  50 value 52.026438
## iter  60 value 52.021982
## iter  70 value 50.954103
```

```
## iter  80 value 50.921102
## iter  90 value 50.920844
## final  value 50.920754
## converged
## # weights:  109
## initial  value 113.358653
## iter  10 value 38.396240
## iter  20 value 14.639965
## iter  30 value 10.721241
## iter  40 value 7.707064
## iter  50 value 7.699491
## iter  60 value 7.544418
## iter  70 value 7.069264
## iter  80 value 6.214987
## iter  90 value 6.214747
## iter 100 value 6.214670
## final  value 6.214670
## stopped after 100 iterations
## # weights:  179
## initial  value 107.994989
## iter  10 value 13.797898
## iter  20 value 2.024231
## iter  30 value 1.396996
## iter  40 value 1.393423
## iter  50 value 1.390854
## iter  60 value 1.389382
## iter  70 value 1.388439
## iter  80 value 1.387100
## iter  90 value 1.386784
## iter 100 value 1.385519
## final  value 1.385519
## stopped after 100 iterations
## # weights:  39
## initial  value 114.138293
## iter  10 value 68.792427
## iter  20 value 65.723801
## iter  30 value 64.272385
## iter  40 value 62.146904
## iter  50 value 60.602517
## iter  60 value 60.202512
## iter  70 value 60.199203
## final  value 60.199192
## converged
## # weights:  109
## initial  value 105.992930
## iter  10 value 53.257733
## iter  20 value 32.496133
## iter  30 value 22.352638
## iter  40 value 17.205258
## iter  50 value 16.997841
## iter  60 value 16.760333
## iter  70 value 16.740466
## final  value 16.740360
## converged
```

```
## # weights:  179
## initial  value 105.287521
## iter  10 value 46.482191
## iter  20 value 20.111151
## iter  30 value 14.254839
## iter  40 value 13.770123
## iter  50 value 13.301561
## iter  60 value 12.872573
## iter  70 value 12.610167
## iter  80 value 12.587757
## iter  90 value 12.581930
## iter 100 value 12.580992
## final  value 12.580992
## stopped after 100 iterations
## # weights:  39
## initial  value 100.356291
## iter  10 value 63.710645
## iter  20 value 59.115044
## iter  30 value 57.022947
## iter  40 value 52.301288
## iter  50 value 50.694020
## iter  60 value 50.668459
## iter  70 value 50.654261
## iter  80 value 50.650035
## iter  90 value 50.638299
## iter 100 value 50.609467
## final  value 50.609467
## stopped after 100 iterations
## # weights:  109
## initial  value 114.680992
## iter  10 value 32.293269
## iter  20 value 19.073418
## iter  30 value 12.460581
## iter  40 value 11.133689
## iter  50 value 10.905725
## iter  60 value 9.730944
## iter  70 value 7.168528
## iter  80 value 6.691988
## iter  90 value 5.177774
## iter 100 value 3.450838
## final  value 3.450838
## stopped after 100 iterations
## # weights:  179
## initial  value 107.312952
## iter  10 value 46.890948
## iter  20 value 26.889055
## iter  30 value 10.683660
## iter  40 value 7.244474
## iter  50 value 4.646879
## iter  60 value 3.150502
## iter  70 value 3.090480
## iter  80 value 2.910310
## iter  90 value 2.710256
## iter 100 value 2.474370
```

```
## final  value 2.474370
## stopped after 100 iterations
## # weights:  39
## initial  value 101.962831
## iter  10 value 61.687403
## iter  20 value 49.229500
## iter  30 value 47.237994
## iter  40 value 43.575673
## iter  50 value 42.249380
## iter  60 value 41.237261
## iter  70 value 40.478574
## iter  80 value 40.271618
## iter  90 value 40.174061
## iter 100 value 39.778957
## final  value 39.778957
## stopped after 100 iterations
## # weights:  109
## initial  value 121.703694
## iter  10 value 34.681561
## iter  20 value 18.935310
## iter  30 value 13.556597
## iter  40 value 9.527864
## iter  50 value 8.961855
## iter  60 value 7.128974
## iter  70 value 7.025292
## iter  80 value 6.867734
## iter  90 value 6.832520
## iter 100 value 4.161550
## final  value 4.161550
## stopped after 100 iterations
## # weights:  179
## initial  value 107.825514
## iter  10 value 19.419906
## iter  20 value 4.785055
## iter  30 value 3.048851
## iter  40 value 2.986383
## iter  50 value 2.874263
## iter  60 value 2.872770
## iter  70 value 2.872438
## iter  80 value 2.871881
## iter  90 value 2.871440
## iter 100 value 2.870836
## final  value 2.870836
## stopped after 100 iterations
## # weights:  39
## initial  value 103.157614
## iter  10 value 79.007399
## iter  20 value 63.890503
## iter  30 value 57.914178
## iter  40 value 57.381019
## iter  50 value 57.274709
## iter  60 value 57.274391
## iter  70 value 57.273781
## iter  80 value 57.225607
```

```
## iter  90 value 57.010656
## iter 100 value 56.997699
## final  value 56.997699
## stopped after 100 iterations
## # weights:  109
## initial  value 129.036942
## iter  10 value 90.194555
## iter  20 value 53.933354
## iter  30 value 31.591529
## iter  40 value 23.068586
## iter  50 value 21.534505
## iter  60 value 19.909000
## iter  70 value 19.499699
## iter  80 value 17.477444
## iter  90 value 17.073724
## iter 100 value 16.868708
## final  value 16.868708
## stopped after 100 iterations
## # weights:  179
## initial  value 117.924008
## iter  10 value 40.720678
## iter  20 value 19.860861
## iter  30 value 14.092558
## iter  40 value 13.261610
## iter  50 value 12.914291
## iter  60 value 12.834171
## iter  70 value 12.536180
## iter  80 value 12.278690
## iter  90 value 12.145686
## iter 100 value 12.130243
## final  value 12.130243
## stopped after 100 iterations
## # weights:  39
## initial  value 105.515112
## iter  10 value 64.161986
## iter  20 value 58.085071
## iter  30 value 55.082193
## iter  40 value 53.278238
## iter  50 value 52.878081
## iter  60 value 52.718081
## iter  70 value 51.289597
## iter  80 value 51.239049
## iter  90 value 50.490675
## iter 100 value 50.476290
## final  value 50.476290
## stopped after 100 iterations
## # weights:  109
## initial  value 107.663158
## iter  10 value 30.395845
## iter  20 value 16.338048
## iter  30 value 10.750979
## iter  40 value 9.986752
## iter  50 value 9.912210
## iter  60 value 9.887517
```

```
## iter  70 value 9.872414
## iter  80 value 6.306138
## iter  90 value 6.138391
## iter 100 value 6.072247
## final  value 6.072247
## stopped after 100 iterations
## # weights:  179
## initial  value 108.517010
## iter  10 value 17.789334
## iter  20 value 3.311656
## iter  30 value 2.230421
## iter  40 value 2.189777
## iter  50 value 2.159703
## iter  60 value 2.131966
## iter  70 value 2.106793
## iter  80 value 2.091404
## iter  90 value 2.076319
## iter 100 value 2.065186
## final  value 2.065186
## stopped after 100 iterations
## # weights:  39
## initial  value 108.925966
## iter  10 value 72.821162
## iter  20 value 61.877328
## iter  30 value 57.854829
## iter  40 value 56.727041
## iter  50 value 53.732413
## iter  60 value 52.935870
## iter  70 value 52.856231
## iter  80 value 52.832364
## iter  90 value 52.819567
## iter 100 value 52.813238
## final  value 52.813238
## stopped after 100 iterations
## # weights:  109
## initial  value 106.074296
## iter  10 value 49.431645
## iter  20 value 29.766269
## iter  30 value 26.193697
## iter  40 value 25.361985
## iter  50 value 22.369342
## iter  60 value 21.290062
## iter  70 value 19.579892
## iter  80 value 19.495383
## iter  90 value 19.420450
## iter 100 value 19.352546
## final  value 19.352546
## stopped after 100 iterations
## # weights:  179
## initial  value 94.748098
## iter  10 value 18.101053
## iter  20 value 5.988878
## iter  30 value 2.600707
## iter  40 value 2.520008
```

```
## iter  50 value 2.503619
## iter  60 value 2.502046
## iter  70 value 2.502038
## final  value 2.502015
## converged
## # weights:  39
## initial  value 100.336601
## iter  10 value 77.676649
## iter  20 value 65.451032
## iter  30 value 60.880861
## iter  40 value 59.277350
## iter  50 value 58.744266
## iter  60 value 58.620230
## final  value 58.619144
## converged
## # weights:  109
## initial  value 105.408318
## iter  10 value 60.048458
## iter  20 value 40.369959
## iter  30 value 22.700958
## iter  40 value 19.381992
## iter  50 value 17.120847
## iter  60 value 15.918277
## iter  70 value 15.797804
## iter  80 value 15.797072
## final  value 15.797070
## converged
## # weights:  179
## initial  value 108.402575
## iter  10 value 46.928294
## iter  20 value 22.986062
## iter  30 value 14.016179
## iter  40 value 12.312959
## iter  50 value 12.193953
## iter  60 value 12.067436
## iter  70 value 12.032158
## iter  80 value 12.026064
## iter  90 value 12.025564
## iter 100 value 12.025479
## final  value 12.025479
## stopped after 100 iterations
## # weights:  39
## initial  value 106.397803
## iter  10 value 74.343234
## iter  20 value 69.506666
## iter  30 value 69.422174
## iter  40 value 69.295797
## iter  50 value 68.018937
## iter  60 value 67.694800
## iter  70 value 67.366701
## iter  80 value 67.333162
## iter  90 value 67.257467
## iter 100 value 67.231199
## final  value 67.231199
```

```
## stopped after 100 iterations
## # weights:  109
## initial  value 99.335807
## iter  10 value 36.136154
## iter  20 value 22.185656
## iter  30 value 11.520506
## iter  40 value 11.246051
## iter  50 value 10.685919
## iter  60 value 9.930926
## iter  70 value 9.897390
## iter  80 value 9.872438
## iter  90 value 9.862833
## iter 100 value 9.752396
## final  value 9.752396
## stopped after 100 iterations
## # weights:  179
## initial  value 103.370245
## iter  10 value 17.600029
## iter  20 value 0.818697
## iter  30 value 0.209391
## iter  40 value 0.185497
## iter  50 value 0.167523
## iter  60 value 0.152191
## iter  70 value 0.142294
## iter  80 value 0.134822
## iter  90 value 0.126952
## iter 100 value 0.116865
## final  value 0.116865
## stopped after 100 iterations
## # weights:  39
## initial  value 118.386989
## iter  10 value 70.272344
## iter  20 value 63.872142
## iter  30 value 61.895551
## iter  40 value 59.146511
## iter  50 value 58.699191
## iter  60 value 58.658716
## iter  70 value 58.453737
## iter  80 value 56.263117
## iter  90 value 54.165104
## iter 100 value 53.238441
## final  value 53.238441
## stopped after 100 iterations
## # weights:  109
## initial  value 124.802183
## iter  10 value 66.778583
## iter  20 value 44.573250
## iter  30 value 36.478326
## iter  40 value 35.292182
## iter  50 value 34.900753
## iter  60 value 33.879169
## iter  70 value 32.656809
## iter  80 value 31.116920
## iter  90 value 30.363885
```

```
## iter 100 value 28.642064
## final  value 28.642064
## stopped after 100 iterations
## # weights:  179
## initial  value 117.588671
## iter  10 value 27.697363
## iter  20 value 13.736849
## iter  30 value 10.406578
## iter  40 value 7.983207
## iter  50 value 7.709185
## iter  60 value 6.890202
## iter  70 value 6.813163
## iter  80 value 6.803217
## iter  90 value 6.799305
## iter 100 value 6.798344
## final  value 6.798344
## stopped after 100 iterations
## # weights:  39
## initial  value 103.102643
## iter  10 value 76.090873
## iter  20 value 68.032499
## iter  30 value 63.185168
## iter  40 value 56.705649
## iter  50 value 55.388693
## iter  60 value 55.286144
## iter  70 value 55.283618
## final  value 55.283611
## converged
## # weights:  109
## initial  value 102.712415
## iter  10 value 53.974792
## iter  20 value 33.187841
## iter  30 value 20.496184
## iter  40 value 16.985953
## iter  50 value 16.768001
## iter  60 value 16.717314
## iter  70 value 16.713962
## final  value 16.713956
## converged
## # weights:  179
## initial  value 117.899601
## iter  10 value 42.196434
## iter  20 value 21.850921
## iter  30 value 16.212846
## iter  40 value 13.845541
## iter  50 value 13.620207
## iter  60 value 13.570854
## iter  70 value 13.508730
## iter  80 value 13.508508
## iter  80 value 13.508508
## iter  80 value 13.508508
## final  value 13.508508
## converged
## # weights:  39
```

```
## initial  value 98.204453
## iter  10 value 66.925777
## iter  20 value 62.607699
## iter  30 value 60.918802
## iter  40 value 59.954112
## iter  50 value 57.280459
## iter  60 value 54.676086
## iter  70 value 52.782648
## iter  80 value 50.192457
## iter  90 value 50.087299
## iter 100 value 50.060979
## final  value 50.060979
## stopped after 100 iterations
## # weights:  109
## initial  value 105.241956
## iter  10 value 33.231360
## iter  20 value 12.857632
## iter  30 value 12.093625
## iter  40 value 11.859150
## iter  50 value 11.594309
## iter  60 value 11.401037
## iter  70 value 10.979110
## iter  80 value 10.572296
## iter  90 value 10.214139
## iter 100 value 10.068251
## final  value 10.068251
## stopped after 100 iterations
## # weights:  179
## initial  value 102.444457
## iter  10 value 31.587908
## iter  20 value 11.404162
## iter  30 value 8.266415
## iter  40 value 6.359100
## iter  50 value 3.799604
## iter  60 value 2.215690
## iter  70 value 1.574195
## iter  80 value 0.574066
## iter  90 value 0.382815
## iter 100 value 0.344822
## final  value 0.344822
## stopped after 100 iterations
## # weights:  39
## initial  value 98.605406
## iter  10 value 57.210617
## iter  20 value 52.106117
## iter  30 value 46.303226
## iter  40 value 41.827344
## iter  50 value 40.113769
## iter  60 value 40.058623
## iter  70 value 39.379092
## iter  80 value 39.238122
## iter  90 value 39.237061
## iter 100 value 39.235785
## final  value 39.235785
```

```
## stopped after 100 iterations
## # weights:  109
## initial  value 106.906179
## iter  10 value 54.206539
## iter  20 value 21.737477
## iter  30 value 12.047799
## iter  40 value 6.739778
## iter  50 value 4.526489
## iter  60 value 3.734927
## iter  70 value 3.627303
## iter  80 value 3.170903
## iter  90 value 2.640689
## iter 100 value 2.585735
## final  value 2.585735
## stopped after 100 iterations
## # weights:  179
## initial  value 112.221956
## iter  10 value 46.916463
## iter  20 value 40.083478
## iter  30 value 38.383812
## iter  40 value 36.751142
## iter  50 value 33.822764
## iter  60 value 32.927826
## iter  70 value 31.204076
## iter  80 value 25.572414
## iter  90 value 22.977663
## iter 100 value 19.680016
## final  value 19.680016
## stopped after 100 iterations
## # weights:  39
## initial  value 107.494255
## iter  10 value 82.514884
## iter  20 value 67.480589
## iter  30 value 59.585368
## iter  40 value 56.144077
## iter  50 value 55.831848
## iter  60 value 55.823251
## final  value 55.823237
## converged
## # weights:  109
## initial  value 113.692212
## iter  10 value 37.322898
## iter  20 value 23.714628
## iter  30 value 17.691700
## iter  40 value 16.320294
## iter  50 value 15.954147
## iter  60 value 15.930955
## iter  70 value 15.929962
## iter  80 value 15.929845
## final  value 15.929841
## converged
## # weights:  179
## initial  value 118.587377
## iter  10 value 32.762435
```

```
## iter  20 value 16.464925
## iter  30 value 13.269555
## iter  40 value 12.109244
## iter  50 value 11.565279
## iter  60 value 11.388141
## iter  70 value 11.359954
## iter  80 value 11.358902
## final  value 11.358894
## converged
## # weights:  39
## initial  value 101.267206
## iter  10 value 66.116622
## iter  20 value 60.371914
## iter  30 value 60.075559
## iter  40 value 58.924149
## iter  50 value 57.124919
## iter  60 value 57.090024
## iter  70 value 56.411339
## iter  80 value 55.576740
## iter  90 value 55.573734
## iter 100 value 55.291501
## final  value 55.291501
## stopped after 100 iterations
## # weights:  109
## initial  value 113.510219
## iter  10 value 19.640264
## iter  20 value 14.613993
## iter  30 value 14.115658
## iter  40 value 14.045824
## iter  50 value 14.005903
## iter  60 value 13.979677
## iter  70 value 13.963240
## iter  80 value 13.911021
## iter  90 value 12.170974
## iter 100 value 11.975024
## final  value 11.975024
## stopped after 100 iterations
## # weights:  179
## initial  value 119.859131
## iter  10 value 20.329641
## iter  20 value 3.312294
## iter  30 value 0.480519
## iter  40 value 0.320360
## iter  50 value 0.263550
## iter  60 value 0.205612
## iter  70 value 0.179905
## iter  80 value 0.152819
## iter  90 value 0.140604
## iter 100 value 0.123132
## final  value 0.123132
## stopped after 100 iterations
## # weights:  39
## initial  value 101.812966
## iter  10 value 76.264657
```

```
## iter  20 value 65.880441
## iter  30 value 63.269674
## iter  40 value 62.040211
## iter  50 value 60.670281
## iter  60 value 58.861189
## iter  70 value 56.117074
## iter  80 value 55.483962
## iter  90 value 53.598026
## iter 100 value 53.285363
## final  value 53.285363
## stopped after 100 iterations
## # weights:  109
## initial  value 112.752655
## iter  10 value 56.817290
## iter  20 value 47.929750
## iter  30 value 43.441166
## iter  40 value 40.165341
## iter  50 value 39.680246
## iter  60 value 39.069894
## iter  70 value 38.901033
## iter  80 value 38.321157
## iter  90 value 38.206295
## iter 100 value 38.188355
## final  value 38.188355
## stopped after 100 iterations
## # weights:  179
## initial  value 102.980192
## iter  10 value 28.642033
## iter  20 value 7.009092
## iter  30 value 2.326882
## iter  40 value 1.920285
## iter  50 value 1.910080
## iter  60 value 1.909703
## iter  70 value 1.909602
## iter  80 value 1.909547
## iter  90 value 1.909543
## final  value 1.909543
## converged
## # weights:  39
## initial  value 108.018927
## iter  10 value 76.035250
## iter  20 value 70.182287
## iter  30 value 67.485350
## iter  40 value 64.979569
## iter  50 value 64.693036
## final  value 64.691271
## converged
## # weights:  109
## initial  value 110.894363
## iter  10 value 58.984149
## iter  20 value 34.711324
## iter  30 value 18.901614
## iter  40 value 16.341994
## iter  50 value 16.147388
```

```
## iter  60 value 16.139168
## iter  70 value 16.139106
## final  value 16.139106
## converged
## # weights:  179
## initial  value 110.622216
## iter  10 value 45.906126
## iter  20 value 18.942056
## iter  30 value 13.363754
## iter  40 value 12.971982
## iter  50 value 12.732662
## iter  60 value 12.534867
## iter  70 value 12.325362
## iter  80 value 12.154454
## iter  90 value 12.088094
## iter 100 value 11.968421
## final  value 11.968421
## stopped after 100 iterations
## # weights:  39
## initial  value 123.917267
## iter  10 value 59.369905
## iter  20 value 52.682245
## iter  30 value 51.632216
## iter  40 value 50.580369
## iter  50 value 49.876959
## iter  60 value 49.408913
## iter  70 value 49.205981
## iter  80 value 48.865854
## iter  90 value 47.779097
## iter 100 value 46.084146
## final  value 46.084146
## stopped after 100 iterations
## # weights:  109
## initial  value 123.525921
## iter  10 value 36.797560
## iter  20 value 14.696041
## iter  30 value 10.193233
## iter  40 value 7.424524
## iter  50 value 6.384276
## iter  60 value 6.321771
## iter  70 value 6.309662
## iter  80 value 6.299374
## iter  90 value 6.289005
## iter 100 value 6.275377
## final  value 6.275377
## stopped after 100 iterations
## # weights:  179
## initial  value 119.617561
## iter  10 value 10.701262
## iter  20 value 3.743690
## iter  30 value 3.512921
## iter  40 value 3.498513
## iter  50 value 3.473923
## iter  60 value 3.007078
```

```
## iter  70 value 0.225592
## iter  80 value 0.177113
## iter  90 value 0.156898
## iter 100 value 0.150699
## final  value 0.150699
## stopped after 100 iterations
## # weights:  39
## initial  value 101.343288
## iter  10 value 68.317580
## iter  20 value 61.609850
## iter  30 value 60.310510
## iter  40 value 58.972025
## iter  50 value 58.260087
## iter  60 value 56.263434
## iter  70 value 55.072487
## iter  80 value 53.620026
## iter  90 value 47.220028
## iter 100 value 45.520337
## final  value 45.520337
## stopped after 100 iterations
## # weights:  109
## initial  value 104.532899
## iter  10 value 35.538587
## iter  20 value 21.006508
## iter  30 value 18.979016
## iter  40 value 17.966696
## iter  50 value 17.896767
## iter  60 value 17.884093
## iter  70 value 17.846372
## iter  80 value 17.828210
## iter  90 value 17.816447
## iter 100 value 17.407429
## final  value 17.407429
## stopped after 100 iterations
## # weights:  179
## initial  value 119.528535
## iter  10 value 31.080294
## iter  20 value 12.244218
## iter  30 value 8.298186
## iter  40 value 6.722362
## iter  50 value 4.072747
## iter  60 value 0.617610
## iter  70 value 0.060200
## iter  80 value 0.008115
## iter  90 value 0.002715
## iter 100 value 0.001207
## final  value 0.001207
## stopped after 100 iterations
## # weights:  39
## initial  value 103.907486
## iter  10 value 78.223618
## iter  20 value 67.520408
## iter  30 value 61.734353
## iter  40 value 60.454840
```

```
## iter  50 value 59.330377
## iter  60 value 59.231196
## final  value 59.230475
## converged
## # weights:  109
## initial  value 100.840781
## iter  10 value 64.015531
## iter  20 value 36.767201
## iter  30 value 21.924690
## iter  40 value 18.761530
## iter  50 value 18.154767
## iter  60 value 17.188100
## iter  70 value 16.781006
## iter  80 value 16.707305
## iter  90 value 16.705089
## iter 100 value 16.704761
## final  value 16.704761
## stopped after 100 iterations
## # weights:  179
## initial  value 140.442939
## iter  10 value 65.830523
## iter  20 value 34.889380
## iter  30 value 19.035935
## iter  40 value 13.909923
## iter  50 value 12.793347
## iter  60 value 12.179303
## iter  70 value 12.051163
## iter  80 value 12.044959
## iter  90 value 12.044676
## final  value 12.044675
## converged
## # weights:  39
## initial  value 104.845205
## iter  10 value 68.660742
## iter  20 value 66.842425
## iter  30 value 66.341481
## iter  40 value 65.556342
## iter  50 value 64.031413
## iter  60 value 63.760341
## iter  70 value 63.007589
## iter  80 value 59.756190
## iter  90 value 58.994077
## iter 100 value 57.312853
## final  value 57.312853
## stopped after 100 iterations
## # weights:  109
## initial  value 113.894407
## iter  10 value 34.451271
## iter  20 value 21.274297
## iter  30 value 19.963719
## iter  40 value 18.595310
## iter  50 value 18.331691
## iter  60 value 16.835592
## iter  70 value 14.705555
```

```
## iter  80 value 13.214716
## iter  90 value 12.962748
## iter 100 value 12.684479
## final  value 12.684479
## stopped after 100 iterations
## # weights:  179
## initial  value 102.311419
## iter  10 value 28.973385
## iter  20 value 10.704907
## iter  30 value 6.771526
## iter  40 value 6.551950
## iter  50 value 6.507542
## iter  60 value 6.469068
## iter  70 value 6.436237
## iter  80 value 2.923181
## iter  90 value 2.597222
## iter 100 value 2.492442
## final  value 2.492442
## stopped after 100 iterations
## # weights:  39
## initial  value 108.875625
## iter  10 value 69.392753
## iter  20 value 58.759166
## iter  30 value 53.945300
## iter  40 value 50.712879
## iter  50 value 49.909091
## iter  60 value 49.811994
## iter  70 value 49.799894
## iter  80 value 49.796642
## iter  90 value 49.793880
## iter 100 value 49.793100
## final  value 49.793100
## stopped after 100 iterations
## # weights:  109
## initial  value 109.152712
## iter  10 value 51.267875
## iter  20 value 27.524327
## iter  30 value 24.488585
## iter  40 value 18.540225
## iter  50 value 17.193689
## iter  60 value 13.627051
## iter  70 value 13.100294
## iter  80 value 13.079647
## iter  90 value 13.055929
## iter 100 value 10.665919
## final  value 10.665919
## stopped after 100 iterations
## # weights:  179
## initial  value 101.701451
## iter  10 value 13.721538
## iter  20 value 3.396775
## iter  30 value 0.056290
## iter  40 value 0.004440
## iter  50 value 0.000872
```

```
## iter  60 value 0.000669
## iter  70 value 0.000135
## final  value 0.000098
## converged
## # weights:  39
## initial  value 111.190148
## iter  10 value 76.789437
## iter  20 value 61.225167
## iter  30 value 58.633997
## iter  40 value 57.665096
## iter  50 value 57.512190
## iter  60 value 57.506280
## final  value 57.506275
## converged
## # weights:  109
## initial  value 108.894507
## iter  10 value 53.697986
## iter  20 value 32.308356
## iter  30 value 19.677219
## iter  40 value 17.305521
## iter  50 value 17.273404
## iter  60 value 17.215712
## iter  70 value 17.196846
## final  value 17.196768
## converged
## # weights:  179
## initial  value 101.106225
## iter  10 value 34.196886
## iter  20 value 23.177652
## iter  30 value 15.454677
## iter  40 value 12.687252
## iter  50 value 12.105685
## iter  60 value 12.067431
## iter  70 value 12.066501
## final  value 12.066480
## converged
## # weights:  39
## initial  value 109.381752
## iter  10 value 72.643184
## iter  20 value 56.692340
## iter  30 value 55.597493
## iter  40 value 54.487736
## iter  50 value 51.299320
## iter  60 value 50.347533
## iter  70 value 46.795584
## iter  80 value 45.068337
## iter  90 value 45.038756
## iter 100 value 44.683083
## final  value 44.683083
## stopped after 100 iterations
## # weights:  109
## initial  value 109.943663
## iter  10 value 24.163936
## iter  20 value 17.127179
```

```
## iter  30 value 13.224191
## iter  40 value 11.606982
## iter  50 value 11.501432
## iter  60 value 11.244019
## iter  70 value 11.093082
## iter  80 value 10.837152
## iter  90 value 10.760991
## iter 100 value 10.362623
## final  value 10.362623
## stopped after 100 iterations
## # weights:  179
## initial  value 121.821713
## iter  10 value 32.238282
## iter  20 value 12.867662
## iter  30 value 10.981383
## iter  40 value 10.736350
## iter  50 value 10.689513
## iter  60 value 10.488365
## iter  70 value 8.979011
## iter  80 value 8.293390
## iter  90 value 8.062851
## iter 100 value 7.933613
## final  value 7.933613
## stopped after 100 iterations
## # weights:  39
## initial  value 99.698071
## iter  10 value 75.609142
## iter  20 value 56.276058
## iter  30 value 50.798012
## iter  40 value 49.171610
## iter  50 value 49.167365
## iter  60 value 47.619038
## iter  70 value 47.592538
## iter  80 value 47.588570
## iter  90 value 47.208237
## iter 100 value 45.883085
## final  value 45.883085
## stopped after 100 iterations
## # weights:  109
## initial  value 112.228710
## iter  10 value 50.031829
## iter  20 value 25.358031
## iter  30 value 22.199191
## iter  40 value 19.916258
## iter  50 value 19.768160
## iter  60 value 19.628819
## iter  70 value 15.723151
## iter  80 value 15.078645
## iter  90 value 14.580501
## iter 100 value 14.242808
## final  value 14.242808
## stopped after 100 iterations
## # weights:  179
## initial  value 103.322567
```

```
## iter  10 value 42.959707
## iter  20 value 25.348399
## iter  30 value 19.913674
## iter  40 value 17.998580
## iter  50 value 17.643973
## iter  60 value 14.522184
## iter  70 value 14.209321
## iter  80 value 14.144097
## iter  90 value 14.121018
## iter 100 value 14.099880
## final  value 14.099880
## stopped after 100 iterations
## # weights:  39
## initial  value 102.325985
## iter  10 value 75.244761
## iter  20 value 65.196442
## iter  30 value 59.542262
## iter  40 value 57.397322
## iter  50 value 57.323707
## final  value 57.323341
## converged
## # weights:  109
## initial  value 114.712539
## iter  10 value 69.088881
## iter  20 value 41.515291
## iter  30 value 25.744990
## iter  40 value 19.023144
## iter  50 value 17.314570
## iter  60 value 16.517578
## iter  70 value 16.355615
## iter  80 value 16.335146
## iter  90 value 16.333710
## final  value 16.333697
## converged
## # weights:  179
## initial  value 116.393871
## iter  10 value 44.575309
## iter  20 value 22.774751
## iter  30 value 16.367071
## iter  40 value 13.689312
## iter  50 value 12.410021
## iter  60 value 12.303035
## iter  70 value 12.291042
## iter  80 value 12.289979
## iter  90 value 12.289947
## final  value 12.289947
## converged
## # weights:  39
## initial  value 108.579175
## iter  10 value 70.042935
## iter  20 value 65.978343
## iter  30 value 62.711364
## iter  40 value 62.315902
## iter  50 value 62.028357
```

```
## iter  60 value 61.367452
## iter  70 value 58.288791
## iter  80 value 57.072753
## iter  90 value 55.576664
## iter 100 value 55.121945
## final  value 55.121945
## stopped after 100 iterations
## # weights:  109
## initial  value 110.054935
## iter  10 value 37.239104
## iter  20 value 22.093682
## iter  30 value 21.206249
## iter  40 value 21.051862
## iter  50 value 20.654158
## iter  60 value 19.868018
## iter  70 value 18.161574
## iter  80 value 17.836567
## iter  90 value 17.568132
## iter 100 value 17.427090
## final  value 17.427090
## stopped after 100 iterations
## # weights:  179
## initial  value 107.010114
## iter  10 value 28.645337
## iter  20 value 15.560719
## iter  30 value 5.357644
## iter  40 value 3.887248
## iter  50 value 3.037402
## iter  60 value 2.455987
## iter  70 value 2.430426
## iter  80 value 2.419593
## iter  90 value 2.403420
## iter 100 value 2.386490
## final  value 2.386490
## stopped after 100 iterations
## # weights:  39
## initial  value 111.748781
## iter  10 value 82.362494
## iter  20 value 56.491317
## iter  30 value 54.013211
## iter  40 value 52.297342
## iter  50 value 49.649772
## iter  60 value 48.606573
## iter  70 value 48.310407
## iter  80 value 47.988462
## iter  90 value 47.573953
## iter 100 value 46.154498
## final  value 46.154498
## stopped after 100 iterations
## # weights:  109
## initial  value 100.959771
## iter  10 value 43.658244
## iter  20 value 14.136724
## iter  30 value 8.297663
```

```
## iter  40 value 4.641254
## iter  50 value 3.500629
## iter  60 value 3.261167
## iter  70 value 3.171687
## iter  80 value 3.054208
## iter  90 value 3.037085
## iter 100 value 3.019752
## final  value 3.019752
## stopped after 100 iterations
## # weights:  179
## initial  value 106.894923
## iter  10 value 14.562593
## iter  20 value 3.970936
## iter  30 value 2.851469
## iter  40 value 2.217390
## iter  50 value 0.212774
## iter  60 value 0.010110
## iter  70 value 0.004670
## iter  80 value 0.002390
## iter  90 value 0.001476
## iter 100 value 0.000656
## final  value 0.000656
## stopped after 100 iterations
## # weights:  39
## initial  value 108.294662
## iter  10 value 71.543210
## iter  20 value 63.169549
## iter  30 value 60.248837
## iter  40 value 59.703745
## iter  50 value 59.093684
## iter  60 value 58.940329
## iter  70 value 58.934163
## final  value 58.934057
## converged
## # weights:  109
## initial  value 107.229510
## iter  10 value 66.099796
## iter  20 value 39.788575
## iter  30 value 29.661846
## iter  40 value 21.603068
## iter  50 value 19.548814
## iter  60 value 17.492360
## iter  70 value 16.801130
## iter  80 value 16.166626
## iter  90 value 15.990112
## iter 100 value 15.980566
## final  value 15.980566
## stopped after 100 iterations
## # weights:  179
## initial  value 110.630154
## iter  10 value 35.885232
## iter  20 value 18.442221
## iter  30 value 14.937750
## iter  40 value 13.635050
```

```
## iter  50 value 13.154991
## iter  60 value 13.100098
## iter  70 value 13.096890
## iter  80 value 13.096741
## final  value 13.096741
## converged
## # weights:  39
## initial  value 103.937202
## iter  10 value 56.209423
## iter  20 value 54.194496
## iter  30 value 53.315345
## iter  40 value 53.307815
## iter  50 value 52.983382
## iter  60 value 52.686854
## iter  70 value 52.680336
## iter  80 value 52.647927
## iter  90 value 52.019514
## iter 100 value 51.973899
## final  value 51.973899
## stopped after 100 iterations
## # weights:  109
## initial  value 147.810753
## iter  10 value 70.247415
## iter  20 value 31.141529
## iter  30 value 16.301170
## iter  40 value 11.499536
## iter  50 value 11.207383
## iter  60 value 9.839510
## iter  70 value 9.783952
## iter  80 value 9.569280
## iter  90 value 9.342981
## iter 100 value 9.077057
## final  value 9.077057
## stopped after 100 iterations
## # weights:  179
## initial  value 108.066521
## iter  10 value 53.924505
## iter  20 value 23.229846
## iter  30 value 19.255665
## iter  40 value 17.431627
## iter  50 value 17.090793
## iter  60 value 16.640302
## iter  70 value 16.431240
## iter  80 value 13.982969
## iter  90 value 12.105533
## iter 100 value 11.704529
## final  value 11.704529
## stopped after 100 iterations
## # weights:  39
## initial  value 109.455309
## iter  10 value 66.527842
## iter  20 value 53.468029
## iter  30 value 51.838740
## iter  40 value 51.615120
```

```
## iter  50 value 51.578367
## iter  60 value 51.565644
## iter  70 value 51.554775
## iter  80 value 51.551161
## iter  90 value 51.550330
## final  value 51.549869
## converged
## # weights:  109
## initial  value 108.655688
## iter  10 value 22.018061
## iter  20 value 8.796169
## iter  30 value 7.486149
## iter  40 value 3.371167
## iter  50 value 3.274082
## iter  60 value 2.485679
## iter  70 value 1.530451
## iter  80 value 1.401712
## iter  90 value 1.393707
## iter 100 value 1.389145
## final  value 1.389145
## stopped after 100 iterations
## # weights:  179
## initial  value 105.730242
## iter  10 value 32.262044
## iter  20 value 16.254203
## iter  30 value 14.906651
## iter  40 value 14.175998
## iter  50 value 10.740408
## iter  60 value 10.615139
## iter  70 value 10.138087
## iter  80 value 8.777355
## iter  90 value 5.569397
## iter 100 value 5.400004
## final  value 5.400004
## stopped after 100 iterations
## # weights:  39
## initial  value 107.824745
## iter  10 value 79.775394
## iter  20 value 74.062589
## iter  30 value 69.690795
## iter  40 value 68.069902
## iter  50 value 64.858011
## iter  60 value 62.511426
## iter  70 value 61.000542
## iter  80 value 60.223329
## iter  90 value 58.613537
## iter 100 value 58.055390
## final  value 58.055390
## stopped after 100 iterations
## # weights:  109
## initial  value 114.409881
## iter  10 value 57.420147
## iter  20 value 36.971835
## iter  30 value 22.084784
```

```
## iter  40 value 17.102821
## iter  50 value 16.310995
## iter  60 value 15.984661
## iter  70 value 15.940944
## iter  80 value 15.936295
## final  value 15.936265
## converged
## # weights:  179
## initial  value 112.395813
## iter  10 value 52.080574
## iter  20 value 22.718329
## iter  30 value 15.330558
## iter  40 value 13.498730
## iter  50 value 13.191362
## iter  60 value 12.890545
## iter  70 value 12.800024
## iter  80 value 12.744077
## iter  90 value 12.567801
## iter 100 value 12.551310
## final  value 12.551310
## stopped after 100 iterations
## # weights:  39
## initial  value 101.427263
## iter  10 value 63.673330
## iter  20 value 60.020893
## iter  30 value 59.354847
## iter  40 value 56.511763
## iter  50 value 56.441490
## iter  60 value 56.399558
## iter  70 value 56.360969
## iter  80 value 56.359130
## iter  90 value 56.350950
## iter 100 value 56.316278
## final  value 56.316278
## stopped after 100 iterations
## # weights:  109
## initial  value 101.887861
## iter  10 value 26.488203
## iter  20 value 6.914291
## iter  30 value 4.085094
## iter  40 value 3.625470
## iter  50 value 1.756415
## iter  60 value 0.695455
## iter  70 value 0.277673
## iter  80 value 0.271941
## iter  90 value 0.268346
## iter 100 value 0.263656
## final  value 0.263656
## stopped after 100 iterations
## # weights:  179
## initial  value 95.704309
## iter  10 value 23.349842
## iter  20 value 10.814138
## iter  30 value 8.715380
```

```
## iter  40 value 8.624406
## iter  50 value 8.533033
## iter  60 value 8.464953
## iter  70 value 8.437404
## iter  80 value 8.044346
## iter  90 value 6.390358
## iter 100 value 6.193022
## final  value 6.193022
## stopped after 100 iterations
## # weights:  39
## initial  value 104.296667
## iter  10 value 77.025851
## iter  20 value 62.629354
## iter  30 value 59.263841
## iter  40 value 57.642381
## iter  50 value 57.372222
## iter  60 value 57.333348
## iter  70 value 57.323559
## iter  80 value 57.321180
## iter  90 value 57.321058
## iter  90 value 57.321057
## iter  90 value 57.321057
## final  value 57.321057
## converged
## # weights:  109
## initial  value 107.296511
## iter  10 value 25.362223
## iter  20 value 14.993591
## iter  30 value 13.715812
## iter  40 value 12.261899
## iter  50 value 11.039153
## iter  60 value 10.227932
## iter  70 value 8.849414
## iter  80 value 7.564418
## iter  90 value 7.488777
## iter 100 value 7.375649
## final  value 7.375649
## stopped after 100 iterations
## # weights:  179
## initial  value 125.510522
## iter  10 value 45.391295
## iter  20 value 21.017046
## iter  30 value 19.516528
## iter  40 value 15.217035
## iter  50 value 12.013770
## iter  60 value 11.788743
## iter  70 value 11.526496
## iter  80 value 11.361076
## iter  90 value 10.876873
## iter 100 value 7.941496
## final  value 7.941496
## stopped after 100 iterations
## # weights:  39
## initial  value 99.286956
```

```
## iter  10 value 67.852828
## iter  20 value 62.961531
## iter  30 value 62.703163
## iter  40 value 62.682730
## iter  50 value 62.682466
## iter  50 value 62.682465
## iter  50 value 62.682465
## final  value 62.682465
## converged
## # weights:  109
## initial  value 107.072646
## iter  10 value 50.341556
## iter  20 value 31.801284
## iter  30 value 23.948510
## iter  40 value 18.150609
## iter  50 value 16.220409
## iter  60 value 15.753133
## iter  70 value 15.729246
## iter  80 value 15.728865
## final  value 15.728861
## converged
## # weights:  179
## initial  value 111.970236
## iter  10 value 34.372965
## iter  20 value 18.064936
## iter  30 value 13.361749
## iter  40 value 12.541324
## iter  50 value 12.154801
## iter  60 value 12.017273
## iter  70 value 12.001270
## iter  80 value 12.000691
## iter  90 value 12.000637
## final  value 12.000636
## converged
## # weights:  39
## initial  value 103.559374
## iter  10 value 70.010312
## iter  20 value 57.156874
## iter  30 value 53.927386
## iter  40 value 53.572091
## iter  50 value 53.278301
## iter  60 value 53.036635
## iter  70 value 52.943404
## iter  80 value 52.145371
## iter  90 value 52.132646
## iter 100 value 51.302119
## final  value 51.302119
## stopped after 100 iterations
## # weights:  109
## initial  value 114.608400
## iter  10 value 48.672642
## iter  20 value 24.157843
## iter  30 value 15.504033
## iter  40 value 13.165696
```

```
## iter  50 value 11.207666
## iter  60 value 10.470458
## iter  70 value 10.403654
## iter  80 value 10.360537
## iter  90 value 10.239004
## iter 100 value 10.217863
## final  value 10.217863
## stopped after 100 iterations
## # weights:  179
## initial  value 105.433065
## iter  10 value 28.523213
## iter  20 value 0.728495
## iter  30 value 0.132762
## iter  40 value 0.115776
## iter  50 value 0.103897
## iter  60 value 0.097216
## iter  70 value 0.090305
## iter  80 value 0.083757
## iter  90 value 0.077558
## iter 100 value 0.073939
## final  value 0.073939
## stopped after 100 iterations
## # weights:  39
## initial  value 100.250715
## iter  10 value 59.500949
## iter  20 value 52.254535
## iter  30 value 48.504939
## iter  40 value 47.572323
## iter  50 value 46.667284
## iter  60 value 46.640032
## iter  70 value 46.616998
## iter  80 value 46.501696
## iter  90 value 46.283256
## iter 100 value 44.891651
## final  value 44.891651
## stopped after 100 iterations
## # weights:  109
## initial  value 116.473182
## iter  10 value 34.273330
## iter  20 value 24.480114
## iter  30 value 22.813100
## iter  40 value 21.449908
## iter  50 value 20.306050
## iter  60 value 18.465852
## iter  70 value 17.300470
## iter  80 value 13.139466
## iter  90 value 10.840335
## iter 100 value 10.415677
## final  value 10.415677
## stopped after 100 iterations
## # weights:  179
## initial  value 107.453799
## iter  10 value 16.614371
## iter  20 value 7.011421
```

```
## iter  30 value 4.143610
## iter  40 value 4.008715
## iter  50 value 3.960556
## iter  60 value 3.822514
## iter  70 value 3.591313
## iter  80 value 3.539542
## iter  90 value 3.465176
## iter 100 value 3.382262
## final  value 3.382262
## stopped after 100 iterations
## # weights:  39
## initial  value 103.320865
## iter  10 value 85.209593
## iter  20 value 66.694613
## iter  30 value 61.823827
## iter  40 value 60.877568
## iter  50 value 58.201353
## iter  60 value 56.594871
## iter  70 value 56.391773
## iter  80 value 56.389858
## iter  80 value 56.389858
## iter  80 value 56.389858
## final  value 56.389858
## converged
## # weights:  109
## initial  value 116.342391
## iter  10 value 56.166226
## iter  20 value 25.635515
## iter  30 value 17.279527
## iter  40 value 16.507618
## iter  50 value 16.292501
## iter  60 value 16.283223
## iter  70 value 16.283039
## final  value 16.283037
## converged
## # weights:  179
## initial  value 113.283764
## iter  10 value 32.569562
## iter  20 value 20.150417
## iter  30 value 14.426061
## iter  40 value 13.634122
## iter  50 value 13.336895
## iter  60 value 13.030421
## iter  70 value 12.758627
## iter  80 value 12.650265
## iter  90 value 12.607596
## iter 100 value 12.469816
## final  value 12.469816
## stopped after 100 iterations
## # weights:  39
## initial  value 105.736386
## iter  10 value 63.246322
## iter  20 value 52.470727
## iter  30 value 47.456754
```

```
## iter  40 value 46.813960
## iter  50 value 46.603013
## iter  60 value 45.795323
## iter  70 value 45.737514
## iter  80 value 45.709524
## iter  90 value 45.703775
## iter 100 value 45.693047
## final  value 45.693047
## stopped after 100 iterations
## # weights:  109
## initial  value 93.959235
## iter  10 value 36.519949
## iter  20 value 31.426332
## iter  30 value 30.366494
## iter  40 value 28.880446
## iter  50 value 25.331610
## iter  60 value 19.077266
## iter  70 value 18.280686
## iter  80 value 15.747558
## iter  90 value 15.481766
## iter 100 value 15.079706
## final  value 15.079706
## stopped after 100 iterations
## # weights:  179
## initial  value 101.788902
## iter  10 value 23.731147
## iter  20 value 10.237795
## iter  30 value 7.849354
## iter  40 value 4.345460
## iter  50 value 2.331632
## iter  60 value 2.168719
## iter  70 value 0.690900
## iter  80 value 0.271838
## iter  90 value 0.249158
## iter 100 value 0.239051
## final  value 0.239051
## stopped after 100 iterations
## # weights:  39
## initial  value 104.458268
## iter  10 value 70.222783
## iter  20 value 64.231165
## iter  30 value 62.155540
## iter  40 value 60.875710
## iter  50 value 60.857825
## iter  60 value 60.817928
## iter  70 value 60.809706
## iter  80 value 60.806563
## iter  90 value 60.805694
## final  value 60.805681
## converged
## # weights:  109
## initial  value 103.642164
## iter  10 value 24.228438
## iter  20 value 9.452049
```

```
## iter  30 value 3.720791
## iter  40 value 3.301987
## iter  50 value 3.295931
## iter  60 value 3.295837
## final  value 3.295837
## converged
## # weights:  179
## initial  value 105.704381
## iter  10 value 46.549555
## iter  20 value 20.491579
## iter  30 value 12.353323
## iter  40 value 8.130829
## iter  50 value 7.473297
## iter  60 value 7.132041
## iter  70 value 6.027820
## iter  80 value 3.004632
## iter  90 value 2.800765
## iter 100 value 2.791761
## final  value 2.791761
## stopped after 100 iterations
## # weights:  39
## initial  value 106.121089
## iter  10 value 74.692239
## iter  20 value 65.606413
## iter  30 value 64.297653
## iter  40 value 61.825284
## iter  50 value 60.633845
## iter  60 value 60.423171
## iter  70 value 60.214923
## iter  80 value 60.105598
## iter  90 value 60.104647
## iter  90 value 60.104647
## iter  90 value 60.104647
## final  value 60.104647
## converged
## # weights:  109
## initial  value 109.253145
## iter  10 value 57.025161
## iter  20 value 28.112607
## iter  30 value 21.195361
## iter  40 value 18.930384
## iter  50 value 17.568697
## iter  60 value 16.655917
## iter  70 value 15.690680
## iter  80 value 15.524600
## iter  90 value 15.521253
## iter 100 value 15.521152
## final  value 15.521152
## stopped after 100 iterations
## # weights:  179
## initial  value 138.039064
## iter  10 value 46.598751
## iter  20 value 24.260296
## iter  30 value 18.303595
```

```
## iter  40 value 14.067750
## iter  50 value 12.918251
## iter  60 value 12.589741
## iter  70 value 12.541442
## iter  80 value 12.538303
## iter  90 value 12.538141
## final  value 12.538140
## converged
## # weights:  39
## initial  value 106.356336
## iter  10 value 68.452015
## iter  20 value 65.416227
## iter  30 value 63.947799
## iter  40 value 63.916571
## iter  50 value 61.834987
## iter  60 value 61.669058
## iter  70 value 61.377174
## iter  80 value 61.305702
## iter  90 value 59.349200
## iter 100 value 58.966345
## final  value 58.966345
## stopped after 100 iterations
## # weights:  109
## initial  value 100.263011
## iter  10 value 66.357584
## iter  20 value 59.432815
## iter  30 value 50.924436
## iter  40 value 46.109702
## iter  50 value 44.394994
## iter  60 value 41.968925
## iter  70 value 40.515520
## iter  80 value 40.426899
## iter  90 value 40.251873
## iter 100 value 31.108218
## final  value 31.108218
## stopped after 100 iterations
## # weights:  179
## initial  value 109.625086
## iter  10 value 25.068673
## iter  20 value 13.760215
## iter  30 value 10.734845
## iter  40 value 10.147620
## iter  50 value 10.012782
## iter  60 value 7.203749
## iter  70 value 6.831651
## iter  80 value 6.825024
## iter  90 value 6.810372
## iter 100 value 6.727742
## final  value 6.727742
## stopped after 100 iterations
## # weights:  39
## initial  value 112.072423
## iter  10 value 65.034174
## iter  20 value 51.979473
```

```
## iter  30 value 45.653229
## iter  40 value 44.830322
## iter  50 value 43.150441
## iter  60 value 42.872868
## iter  70 value 42.767342
## iter  80 value 40.197044
## iter  90 value 38.393754
## iter 100 value 37.288519
## final  value 37.288519
## stopped after 100 iterations
## # weights:  109
## initial  value 112.390586
## iter  10 value 39.394985
## iter  20 value 13.491987
## iter  30 value 10.534286
## iter  40 value 10.441899
## iter  50 value 10.383342
## iter  60 value 10.338906
## iter  70 value 10.328905
## iter  80 value 10.313577
## iter  90 value 10.194279
## iter 100 value 10.181215
## final  value 10.181215
## stopped after 100 iterations
## # weights:  179
## initial  value 124.045733
## iter  10 value 29.267607
## iter  20 value 13.154668
## iter  30 value 6.242953
## iter  40 value 3.889525
## iter  50 value 3.797358
## iter  60 value 3.707217
## iter  70 value 0.017489
## iter  80 value 0.004347
## iter  90 value 0.001443
## iter 100 value 0.000319
## final  value 0.000319
## stopped after 100 iterations
## # weights:  39
## initial  value 106.405441
## iter  10 value 63.861865
## iter  20 value 58.574330
## iter  30 value 57.998185
## iter  40 value 57.624896
## iter  50 value 57.561700
## iter  60 value 57.551188
## iter  70 value 57.343096
## iter  80 value 57.263553
## final  value 57.262028
## converged
## # weights:  109
## initial  value 108.289289
## iter  10 value 60.864303
## iter  20 value 34.687795
```

```
## iter  30 value 18.546353
## iter  40 value 16.316635
## iter  50 value 16.182487
## iter  60 value 16.128697
## iter  70 value 16.127198
## iter  80 value 16.127105
## final  value 16.127102
## converged
## # weights:  179
## initial  value 115.851488
## iter  10 value 57.360759
## iter  20 value 22.508297
## iter  30 value 15.326321
## iter  40 value 12.045208
## iter  50 value 11.703389
## iter  60 value 11.673999
## iter  70 value 11.673336
## final  value 11.673335
## converged
## # weights:  39
## initial  value 108.643417
## iter  10 value 68.845729
## iter  20 value 55.584263
## iter  30 value 49.940049
## iter  40 value 49.388662
## iter  50 value 48.814767
## iter  60 value 48.567796
## iter  70 value 48.290484
## iter  80 value 48.277622
## iter  90 value 48.274766
## iter 100 value 48.272571
## final  value 48.272571
## stopped after 100 iterations
## # weights:  109
## initial  value 111.395285
## iter  10 value 36.710399
## iter  20 value 22.028561
## iter  30 value 13.310092
## iter  40 value 9.271770
## iter  50 value 6.308165
## iter  60 value 5.595234
## iter  70 value 4.438496
## iter  80 value 2.559946
## iter  90 value 2.471806
## iter 100 value 2.464984
## final  value 2.464984
## stopped after 100 iterations
## # weights:  179
## initial  value 110.287686
## iter  10 value 23.977702
## iter  20 value 16.030259
## iter  30 value 10.950104
## iter  40 value 10.844199
## iter  50 value 9.432052
```

```
## iter  60 value 6.767409
## iter  70 value 5.161374
## iter  80 value 3.610309
## iter  90 value 3.478161
## iter 100 value 3.447109
## final  value 3.447109
## stopped after 100 iterations
## # weights:  39
## initial  value 104.104121
## iter  10 value 94.632851
## iter  20 value 82.104303
## iter  30 value 71.771913
## iter  40 value 68.250425
## iter  50 value 64.496235
## iter  60 value 56.965377
## iter  70 value 53.989169
## iter  80 value 52.938096
## iter  90 value 52.774512
## iter 100 value 52.755977
## final  value 52.755977
## stopped after 100 iterations
## # weights:  109
## initial  value 102.660668
## iter  10 value 32.782329
## iter  20 value 29.072581
## iter  30 value 24.595833
## iter  40 value 20.424162
## iter  50 value 15.258664
## iter  60 value 14.370618
## iter  70 value 14.328304
## iter  80 value 14.301886
## iter  90 value 10.218310
## iter 100 value 9.234749
## final  value 9.234749
## stopped after 100 iterations
## # weights:  179
## initial  value 100.913089
## iter  10 value 23.433515
## iter  20 value 2.742041
## iter  30 value 0.098064
## iter  40 value 0.005778
## iter  50 value 0.001027
## final  value 0.000055
## converged
## # weights:  39
## initial  value 119.429726
## iter  10 value 77.705077
## iter  20 value 67.193284
## iter  30 value 62.468116
## iter  40 value 58.138880
## iter  50 value 57.973718
## final  value 57.973633
## converged
## # weights:  109
```

```
## initial  value 101.372172
## iter  10 value 48.227120
## iter  20 value 33.567402
## iter  30 value 26.726559
## iter  40 value 20.620389
## iter  50 value 17.158583
## iter  60 value 16.425468
## iter  70 value 16.318073
## iter  80 value 16.311307
## final  value 16.311173
## converged
## # weights:  179
## initial  value 108.628410
## iter  10 value 62.030342
## iter  20 value 25.043421
## iter  30 value 13.672449
## iter  40 value 12.820465
## iter  50 value 12.536611
## iter  60 value 12.191646
## iter  70 value 12.142232
## iter  80 value 12.138215
## iter  90 value 12.137719
## iter 100 value 12.137587
## final  value 12.137587
## stopped after 100 iterations
## # weights:  39
## initial  value 116.154045
## iter  10 value 72.039430
## iter  20 value 55.630344
## iter  30 value 51.128362
## iter  40 value 49.381379
## iter  50 value 47.825645
## iter  60 value 47.400458
## iter  70 value 47.143185
## iter  80 value 46.539989
## iter  90 value 46.169071
## iter 100 value 45.233537
## final  value 45.233537
## stopped after 100 iterations
## # weights:  109
## initial  value 101.979893
## iter  10 value 50.640612
## iter  20 value 15.700287
## iter  30 value 9.068393
## iter  40 value 8.678117
## iter  50 value 8.561720
## iter  60 value 8.531960
## iter  70 value 8.275311
## iter  80 value 8.116934
## iter  90 value 7.840509
## iter 100 value 7.627756
## final  value 7.627756
## stopped after 100 iterations
## # weights:  179
```

```
## initial  value 116.458597
## iter  10 value 38.761667
## iter  20 value 18.181590
## iter  30 value 7.199160
## iter  40 value 4.105810
## iter  50 value 3.607261
## iter  60 value 3.573308
## iter  70 value 3.548038
## iter  80 value 2.955726
## iter  90 value 2.946366
## iter 100 value 2.927672
## final  value 2.927672
## stopped after 100 iterations
## # weights:  39
## initial  value 102.902944
## iter  10 value 95.117534
## iter  20 value 77.992387
## iter  30 value 59.882523
## iter  40 value 51.135631
## iter  50 value 50.046115
## iter  60 value 50.042183
## iter  70 value 50.041889
## iter  70 value 50.041889
## iter  70 value 50.041889
## final  value 50.041889
## converged
## # weights:  109
## initial  value 115.267663
## iter  10 value 58.436888
## iter  20 value 47.112767
## iter  30 value 41.952219
## iter  40 value 39.953379
## iter  50 value 38.487842
## iter  60 value 37.859635
## iter  70 value 35.776093
## iter  80 value 33.528924
## iter  90 value 33.365070
## iter 100 value 32.374284
## final  value 32.374284
## stopped after 100 iterations
## # weights:  179
## initial  value 100.684060
## iter  10 value 20.204483
## iter  20 value 10.006904
## iter  30 value 6.390664
## iter  40 value 5.958816
## iter  50 value 4.871625
## iter  60 value 4.310074
## iter  70 value 3.993121
## iter  80 value 3.893802
## iter  90 value 3.053489
## iter 100 value 2.850379
## final  value 2.850379
## stopped after 100 iterations
```

```
## # weights:  39
## initial  value 112.928870
## iter  10 value 71.810066
## iter  20 value 60.569788
## iter  30 value 58.130220
## iter  40 value 57.674019
## iter  50 value 56.638793
## iter  60 value 55.707852
## iter  70 value 55.699390
## iter  80 value 55.682629
## iter  90 value 55.531367
## iter 100 value 55.501614
## final  value 55.501614
## stopped after 100 iterations
## # weights:  109
## initial  value 132.454427
## iter  10 value 75.339895
## iter  20 value 51.015371
## iter  30 value 42.506734
## iter  40 value 31.643265
## iter  50 value 20.287321
## iter  60 value 17.622962
## iter  70 value 17.331452
## iter  80 value 17.257635
## iter  90 value 17.194175
## iter 100 value 17.139716
## final  value 17.139716
## stopped after 100 iterations
## # weights:  179
## initial  value 109.431568
## iter  10 value 28.271596
## iter  20 value 14.086766
## iter  30 value 12.745537
## iter  40 value 12.577017
## iter  50 value 12.399960
## iter  60 value 12.338756
## iter  70 value 12.333465
## final  value 12.333432
## converged
## # weights:  39
## initial  value 100.913687
## iter  10 value 68.321926
## iter  20 value 62.361350
## iter  30 value 58.081019
## iter  40 value 57.146854
## iter  50 value 56.980564
## iter  60 value 55.674238
## iter  70 value 54.617325
## iter  80 value 54.531249
## iter  90 value 54.403833
## iter 100 value 54.393019
## final  value 54.393019
## stopped after 100 iterations
## # weights:  109
```

```
## initial  value 99.323085
## iter  10 value 43.400727
## iter  20 value 29.610046
## iter  30 value 28.215557
## iter  40 value 25.187745
## iter  50 value 19.445128
## iter  60 value 16.395059
## iter  70 value 14.051096
## iter  80 value 13.170538
## iter  90 value 12.611976
## iter 100 value 11.583229
## final  value 11.583229
## stopped after 100 iterations
## # weights:  179
## initial  value 121.662153
## iter  10 value 33.659989
## iter  20 value 5.332921
## iter  30 value 0.551199
## iter  40 value 0.139551
## iter  50 value 0.130606
## iter  60 value 0.125440
## iter  70 value 0.115584
## iter  80 value 0.109488
## iter  90 value 0.103554
## iter 100 value 0.100060
## final  value 0.100060
## stopped after 100 iterations
## # weights:  39
## initial  value 103.035516
## iter  10 value 67.202549
## iter  20 value 58.454661
## iter  30 value 57.810290
## iter  40 value 56.269648
## iter  50 value 53.340897
## iter  60 value 52.388565
## iter  70 value 49.889017
## iter  80 value 49.094245
## iter  90 value 43.408274
## iter 100 value 42.153114
## final  value 42.153114
## stopped after 100 iterations
## # weights:  109
## initial  value 98.606029
## iter  10 value 43.828124
## iter  20 value 25.446274
## iter  30 value 23.327318
## iter  40 value 22.973549
## iter  50 value 22.861778
## iter  60 value 22.585147
## iter  70 value 22.362169
## iter  80 value 22.339553
## iter  90 value 22.329936
## iter 100 value 22.311773
## final  value 22.311773
```

```
## stopped after 100 iterations
## # weights:  179
## initial  value 116.721945
## iter  10 value 21.158818
## iter  20 value 11.175851
## iter  30 value 10.507747
## iter  40 value 10.179334
## iter  50 value 10.032282
## iter  60 value 6.514140
## iter  70 value 5.639228
## iter  80 value 5.567743
## iter  90 value 5.268058
## iter 100 value 5.216528
## final  value 5.216528
## stopped after 100 iterations
## # weights:  39
## initial  value 102.506497
## iter  10 value 81.787259
## iter  20 value 64.685533
## iter  30 value 60.413218
## iter  40 value 58.380602
## iter  50 value 58.173716
## iter  60 value 58.165468
## iter  70 value 57.826258
## iter  80 value 57.746568
## iter  90 value 57.744660
## final  value 57.744659
## converged
## # weights:  109
## initial  value 126.906785
## iter  10 value 75.492805
## iter  20 value 46.356830
## iter  30 value 23.509959
## iter  40 value 18.760807
## iter  50 value 17.803642
## iter  60 value 17.494283
## iter  70 value 17.189130
## iter  80 value 17.119594
## iter  90 value 17.119079
## final  value 17.119077
## converged
## # weights:  179
## initial  value 125.422441
## iter  10 value 49.803856
## iter  20 value 30.976175
## iter  30 value 19.400579
## iter  40 value 15.109142
## iter  50 value 12.935283
## iter  60 value 12.372935
## iter  70 value 12.210302
## iter  80 value 12.150268
## iter  90 value 12.138439
## iter 100 value 12.138117
## final  value 12.138117
```

```
## stopped after 100 iterations
## # weights:  39
## initial  value 105.568778
## iter  10 value 65.287381
## iter  20 value 61.661921
## iter  30 value 59.188873
## iter  40 value 58.762466
## iter  50 value 57.473034
## iter  60 value 56.486467
## iter  70 value 56.288190
## iter  80 value 56.213820
## iter  90 value 54.391989
## iter 100 value 52.768477
## final  value 52.768477
## stopped after 100 iterations
## # weights:  109
## initial  value 111.525584
## iter  10 value 46.274228
## iter  20 value 25.018974
## iter  30 value 22.193350
## iter  40 value 18.413932
## iter  50 value 18.067061
## iter  60 value 18.047277
## iter  70 value 18.036309
## iter  80 value 15.719904
## iter  90 value 14.513767
## iter 100 value 14.427055
## final  value 14.427055
## stopped after 100 iterations
## # weights:  179
## initial  value 142.483354
## iter  10 value 80.870178
## iter  20 value 70.300416
## iter  30 value 67.024735
## iter  40 value 54.827191
## iter  50 value 40.970342
## iter  60 value 40.772189
## iter  70 value 40.761977
## iter  80 value 37.473880
## iter  90 value 37.412983
## iter 100 value 36.054658
## final  value 36.054658
## stopped after 100 iterations
## # weights:  39
## initial  value 106.375245
## iter  10 value 61.477491
## iter  20 value 51.579410
## iter  30 value 46.683733
## iter  40 value 46.577219
## iter  50 value 46.576626
## final  value 46.576594
## converged
## # weights:  109
## initial  value 109.682889
```

```
## iter  10 value 53.976210
## iter  20 value 25.163669
## iter  30 value 23.454847
## iter  40 value 22.771648
## iter  50 value 22.558459
## iter  60 value 21.628530
## iter  70 value 21.590289
## iter  80 value 21.587335
## iter  90 value 20.701509
## iter 100 value 20.587487
## final  value 20.587487
## stopped after 100 iterations
## # weights:  179
## initial  value 126.896091
## iter  10 value 26.618382
## iter  20 value 17.197097
## iter  30 value 14.435782
## iter  40 value 12.924168
## iter  50 value 12.652587
## iter  60 value 9.980644
## iter  70 value 8.921548
## iter  80 value 7.109506
## iter  90 value 5.476058
## iter 100 value 4.769754
## final  value 4.769754
## stopped after 100 iterations
## # weights:  39
## initial  value 135.096055
## iter  10 value 76.609294
## iter  20 value 65.883392
## iter  30 value 59.641980
## iter  40 value 58.993143
## iter  50 value 58.771664
## iter  60 value 58.393686
## iter  70 value 57.922598
## iter  80 value 57.906495
## final  value 57.906494
## converged
## # weights:  109
## initial  value 117.493313
## iter  10 value 66.028895
## iter  20 value 34.052163
## iter  30 value 21.372445
## iter  40 value 18.469352
## iter  50 value 17.637266
## iter  60 value 17.389107
## iter  70 value 17.362444
## iter  80 value 17.352768
## iter  90 value 17.352390
## iter 100 value 17.352227
## final  value 17.352227
## stopped after 100 iterations
## # weights:  179
## initial  value 141.970467
```

```
## iter  10 value 42.564692
## iter  20 value 23.248382
## iter  30 value 15.557352
## iter  40 value 13.332413
## iter  50 value 12.920563
## iter  60 value 12.735156
## iter  70 value 12.526042
## iter  80 value 12.494029
## iter  90 value 12.482295
## iter 100 value 12.480921
## final  value 12.480921
## stopped after 100 iterations
## # weights:  39
## initial  value 104.043870
## iter  10 value 85.293057
## iter  20 value 75.115480
## iter  30 value 69.764047
## iter  40 value 67.298602
## iter  50 value 66.038954
## iter  60 value 61.247599
## iter  70 value 58.184208
## iter  80 value 51.591317
## iter  90 value 48.286815
## iter 100 value 47.542761
## final  value 47.542761
## stopped after 100 iterations
## # weights:  109
## initial  value 107.342746
## iter  10 value 41.088781
## iter  20 value 19.871015
## iter  30 value 19.145624
## iter  40 value 19.110781
## iter  50 value 19.083913
## iter  60 value 19.058351
## iter  70 value 19.019856
## iter  80 value 18.981652
## iter  90 value 17.728232
## iter 100 value 16.666380
## final  value 16.666380
## stopped after 100 iterations
## # weights:  179
## initial  value 99.458461
## iter  10 value 22.889092
## iter  20 value 3.951857
## iter  30 value 0.800651
## iter  40 value 0.211433
## iter  50 value 0.184478
## iter  60 value 0.178162
## iter  70 value 0.162257
## iter  80 value 0.148402
## iter  90 value 0.139573
## iter 100 value 0.128653
## final  value 0.128653
## stopped after 100 iterations
```

```
## # weights:  39
## initial  value 116.998611
## iter  10 value 66.983932
## iter  20 value 61.799025
## iter  30 value 61.003114
## iter  40 value 59.892893
## iter  50 value 57.741088
## iter  60 value 57.686713
## iter  70 value 57.570713
## iter  80 value 57.433716
## iter  90 value 53.141803
## iter 100 value 52.253071
## final  value 52.253071
## stopped after 100 iterations
## # weights:  109
## initial  value 117.964956
## iter  10 value 34.259599
## iter  20 value 16.807223
## iter  30 value 9.643818
## iter  40 value 8.987121
## iter  50 value 8.309009
## iter  60 value 8.194304
## iter  70 value 8.053956
## iter  80 value 8.025009
## iter  90 value 8.020143
## iter 100 value 8.015874
## final  value 8.015874
## stopped after 100 iterations
## # weights:  179
## initial  value 119.662556
## iter  10 value 17.294015
## iter  20 value 2.497720
## iter  30 value 1.914160
## iter  40 value 1.909786
## iter  50 value 1.909551
## final  value 1.909548
## converged
## # weights:  39
## initial  value 105.830669
## iter  10 value 69.251233
## iter  20 value 65.584326
## iter  30 value 62.058325
## iter  40 value 58.951676
## iter  50 value 58.196204
## iter  60 value 57.888591
## iter  70 value 57.696740
## iter  80 value 57.659527
## final  value 57.659311
## converged
## # weights:  109
## initial  value 96.087951
## iter  10 value 36.653478
## iter  20 value 25.450749
## iter  30 value 20.252368
```

```
## iter  40 value 19.021345
## iter  50 value 18.586706
## iter  60 value 18.134710
## iter  70 value 17.807973
## iter  80 value 17.553251
## iter  90 value 17.194338
## iter 100 value 16.794765
## final  value 16.794765
## stopped after 100 iterations
## # weights:  179
## initial  value 128.862280
## iter  10 value 51.729388
## iter  20 value 29.209093
## iter  30 value 18.841753
## iter  40 value 14.122869
## iter  50 value 13.008250
## iter  60 value 12.489594
## iter  70 value 12.336610
## iter  80 value 12.333355
## iter  90 value 12.333115
## final  value 12.333106
## converged
## # weights:  39
## initial  value 104.183800
## iter  10 value 63.136261
## iter  20 value 57.728559
## iter  30 value 55.069735
## iter  40 value 53.686989
## iter  50 value 53.514559
## iter  60 value 53.438879
## iter  70 value 52.184845
## iter  80 value 51.868603
## iter  90 value 51.630860
## iter 100 value 51.609710
## final  value 51.609710
## stopped after 100 iterations
## # weights:  109
## initial  value 110.258659
## iter  10 value 37.486723
## iter  20 value 15.789121
## iter  30 value 8.936070
## iter  40 value 4.311441
## iter  50 value 3.604217
## iter  60 value 3.529040
## iter  70 value 3.421301
## iter  80 value 3.329895
## iter  90 value 3.247734
## iter 100 value 3.207721
## final  value 3.207721
## stopped after 100 iterations
## # weights:  179
## initial  value 118.203115
## iter  10 value 24.695646
## iter  20 value 15.585488
```

```
## iter  30 value 12.046722
## iter  40 value 10.907912
## iter  50 value 9.025753
## iter  60 value 8.922034
## iter  70 value 8.245400
## iter  80 value 7.672546
## iter  90 value 7.563322
## iter 100 value 7.436171
## final  value 7.436171
## stopped after 100 iterations
## # weights:  39
## initial  value 105.082330
## iter  10 value 89.250841
## iter  20 value 55.053026
## iter  30 value 54.537456
## iter  40 value 54.536669
## final  value 54.536667
## converged
## # weights:  109
## initial  value 103.218517
## iter  10 value 25.488058
## iter  20 value 12.656920
## iter  30 value 11.459115
## iter  40 value 4.611962
## iter  50 value 4.515423
## iter  60 value 4.039090
## iter  70 value 3.852664
## iter  80 value 3.808005
## iter  90 value 3.385339
## iter 100 value 3.375242
## final  value 3.375242
## stopped after 100 iterations
## # weights:  179
## initial  value 103.608427
## iter  10 value 26.686248
## iter  20 value 5.952020
## iter  30 value 2.505683
## iter  40 value 1.452198
## iter  50 value 1.420127
## iter  60 value 1.409059
## iter  70 value 1.397804
## iter  80 value 1.392694
## iter  90 value 1.390771
## iter 100 value 1.387596
## final  value 1.387596
## stopped after 100 iterations
## # weights:  39
## initial  value 105.100112
## iter  10 value 79.815206
## iter  20 value 76.877191
## iter  30 value 72.711150
## iter  40 value 68.563403
## iter  50 value 65.585533
## iter  60 value 65.327311
```

```
## iter  70 value 64.694536
## iter  80 value 64.670858
## final  value 64.670794
## converged
## # weights:  109
## initial  value 107.917549
## iter  10 value 42.563395
## iter  20 value 24.146781
## iter  30 value 17.251261
## iter  40 value 16.814284
## iter  50 value 16.779971
## iter  60 value 16.778538
## iter  70 value 16.774396
## iter  80 value 16.624766
## iter  90 value 16.470744
## iter 100 value 16.441429
## final  value 16.441429
## stopped after 100 iterations
## # weights:  179
## initial  value 117.939171
## iter  10 value 29.243039
## iter  20 value 15.473215
## iter  30 value 13.352784
## iter  40 value 12.871967
## iter  50 value 12.801351
## iter  60 value 12.779367
## iter  70 value 12.734912
## iter  80 value 12.733841
## final  value 12.733839
## converged
## # weights:  39
## initial  value 103.095073
## iter  10 value 64.405363
## iter  20 value 62.998348
## iter  30 value 62.165910
## iter  40 value 61.457724
## iter  50 value 53.992489
## iter  60 value 49.790352
## iter  70 value 48.980479
## iter  80 value 48.645495
## iter  90 value 48.125494
## iter 100 value 47.291032
## final  value 47.291032
## stopped after 100 iterations
## # weights:  109
## initial  value 107.104233
## iter  10 value 45.795587
## iter  20 value 27.037214
## iter  30 value 25.324404
## iter  40 value 18.295890
## iter  50 value 17.929887
## iter  60 value 15.633515
## iter  70 value 15.614014
## iter  80 value 15.539602
```

```
## iter  90 value 15.103116
## iter 100 value 15.091108
## final  value 15.091108
## stopped after 100 iterations
## # weights:  179
## initial  value 118.595524
## iter  10 value 9.228820
## iter  20 value 2.031334
## iter  30 value 1.542707
## iter  40 value 1.520213
## iter  50 value 1.512758
## iter  60 value 1.505597
## iter  70 value 1.497186
## iter  80 value 1.493245
## iter  90 value 1.473857
## iter 100 value 0.155951
## final  value 0.155951
## stopped after 100 iterations
## # weights:  39
## initial  value 102.403787
## iter  10 value 71.052825
## iter  20 value 59.423164
## iter  30 value 59.009155
## iter  40 value 57.553718
## iter  50 value 57.306853
## iter  60 value 56.834363
## iter  70 value 55.727993
## iter  80 value 55.399706
## iter  90 value 55.161329
## iter 100 value 51.264628
## final  value 51.264628
## stopped after 100 iterations
## # weights:  109
## initial  value 113.248935
## iter  10 value 30.123739
## iter  20 value 19.919473
## iter  30 value 14.442042
## iter  40 value 13.044798
## iter  50 value 12.703637
## iter  60 value 12.224476
## iter  70 value 11.806999
## iter  80 value 11.469849
## iter  90 value 11.337181
## iter 100 value 11.161889
## final  value 11.161889
## stopped after 100 iterations
## # weights:  179
## initial  value 110.001748
## iter  10 value 52.973058
## iter  20 value 24.542659
## iter  30 value 20.327671
## iter  40 value 15.764694
## iter  50 value 12.767671
## iter  60 value 11.057671
```

```
## iter  70 value 10.757761
## iter  80 value 9.868986
## iter  90 value 9.761236
## iter 100 value 8.169763
## final  value 8.169763
## stopped after 100 iterations
## # weights:  39
## initial  value 107.747973
## iter  10 value 79.727757
## iter  20 value 66.926899
## iter  30 value 61.571105
## iter  40 value 59.733705
## iter  50 value 58.496820
## iter  60 value 57.872763
## iter  70 value 57.590517
## iter  80 value 57.414411
## iter  90 value 57.407494
## final  value 57.407487
## converged
## # weights:  109
## initial  value 115.641531
## iter  10 value 50.739236
## iter  20 value 28.280328
## iter  30 value 20.508272
## iter  40 value 18.338220
## iter  50 value 16.100876
## iter  60 value 15.716135
## iter  70 value 15.687606
## iter  80 value 15.686209
## iter  90 value 15.686146
## final  value 15.686145
## converged
## # weights:  179
## initial  value 121.731627
## iter  10 value 54.072596
## iter  20 value 22.979033
## iter  30 value 14.531366
## iter  40 value 12.499999
## iter  50 value 12.058427
## iter  60 value 12.048304
## iter  70 value 12.047228
## iter  80 value 12.030373
## iter  90 value 11.834911
## iter 100 value 11.637256
## final  value 11.637256
## stopped after 100 iterations
## # weights:  39
## initial  value 103.681866
## iter  10 value 59.304041
## iter  20 value 57.324948
## iter  30 value 56.343407
## iter  40 value 55.373041
## iter  50 value 55.365170
## iter  60 value 54.616535
```

```
## iter  70 value 53.684371
## iter  80 value 53.680127
## iter  90 value 53.209106
## iter 100 value 52.734290
## final  value 52.734290
## stopped after 100 iterations
## # weights:  109
## initial  value 106.838757
## iter  10 value 51.870309
## iter  20 value 47.948553
## iter  30 value 45.257253
## iter  40 value 27.247696
## iter  50 value 21.938418
## iter  60 value 21.333957
## iter  70 value 20.602551
## iter  80 value 19.347027
## iter  90 value 18.797962
## iter 100 value 18.166324
## final  value 18.166324
## stopped after 100 iterations
## # weights:  179
## initial  value 105.674945
## iter  10 value 22.027455
## iter  20 value 6.654449
## iter  30 value 5.701856
## iter  40 value 5.564341
## iter  50 value 5.509315
## iter  60 value 5.363430
## iter  70 value 4.969073
## iter  80 value 2.069842
## iter  90 value 1.811697
## iter 100 value 1.731294
## final  value 1.731294
## stopped after 100 iterations
## # weights:  39
## initial  value 112.869840
## iter  10 value 72.876987
## iter  20 value 61.547193
## iter  30 value 60.758307
## iter  40 value 59.498706
## iter  50 value 58.710610
## iter  60 value 57.083188
## iter  70 value 55.638628
## iter  80 value 54.573927
## iter  90 value 54.446970
## iter 100 value 53.641197
## final  value 53.641197
## stopped after 100 iterations
## # weights:  109
## initial  value 126.900732
## iter  10 value 57.223975
## iter  20 value 36.585155
## iter  30 value 21.758451
## iter  40 value 10.124779
```

```
## iter  50 value 9.390504
## iter  60 value 9.263628
## iter  70 value 9.154817
## iter  80 value 9.111984
## iter  90 value 8.968643
## iter 100 value 8.951311
## final  value 8.951311
## stopped after 100 iterations
## # weights:  179
## initial  value 104.283855
## iter  10 value 20.758754
## iter  20 value 11.884268
## iter  30 value 11.178848
## iter  40 value 10.693612
## iter  50 value 10.635022
## iter  60 value 10.495912
## iter  70 value 10.433276
## iter  80 value 10.222896
## iter  90 value 10.208746
## iter 100 value 10.102354
## final  value 10.102354
## stopped after 100 iterations
## # weights:  39
## initial  value 106.704691
## iter  10 value 77.931973
## iter  20 value 65.162515
## iter  30 value 61.752405
## iter  40 value 59.647890
## iter  50 value 58.439908
## iter  60 value 58.134947
## iter  70 value 57.999751
## iter  80 value 57.484663
## iter  90 value 57.465099
## final  value 57.465084
## converged
## # weights:  109
## initial  value 101.281788
## iter  10 value 52.614419
## iter  20 value 28.933868
## iter  30 value 18.307748
## iter  40 value 17.591372
## iter  50 value 17.427833
## iter  60 value 17.423486
## iter  70 value 17.423402
## final  value 17.423398
## converged
## # weights:  179
## initial  value 112.107421
## iter  10 value 40.687887
## iter  20 value 19.017303
## iter  30 value 14.149128
## iter  40 value 12.888287
## iter  50 value 12.503109
## iter  60 value 12.410647
```

```
## iter  70 value 12.407067
## iter  80 value 12.406993
## final  value 12.406989
## converged
## # weights:  39
## initial  value 102.966885
## iter  10 value 63.608194
## iter  20 value 56.201441
## iter  30 value 52.428983
## iter  40 value 51.147780
## iter  50 value 51.134441
## iter  60 value 51.122064
## iter  70 value 51.076005
## iter  80 value 51.051720
## iter  90 value 51.042610
## iter 100 value 51.035130
## final  value 51.035130
## stopped after 100 iterations
## # weights:  109
## initial  value 113.610656
## iter  10 value 46.467633
## iter  20 value 35.301876
## iter  30 value 30.066421
## iter  40 value 29.601292
## iter  50 value 27.812802
## iter  60 value 24.038850
## iter  70 value 19.216655
## iter  80 value 17.452832
## iter  90 value 15.998938
## iter 100 value 15.301963
## final  value 15.301963
## stopped after 100 iterations
## # weights:  179
## initial  value 93.727114
## iter  10 value 17.982797
## iter  20 value 5.874062
## iter  30 value 4.320749
## iter  40 value 4.294416
## iter  50 value 4.274965
## iter  60 value 4.253659
## iter  70 value 3.822158
## iter  80 value 3.416225
## iter  90 value 3.400938
## iter 100 value 1.657367
## final  value 1.657367
## stopped after 100 iterations
## # weights:  39
## initial  value 111.071494
## iter  10 value 81.917978
## iter  20 value 66.752529
## iter  30 value 63.269597
## iter  40 value 58.737235
## iter  50 value 55.649019
## iter  60 value 54.526292
```

```
## iter  70 value 49.324847
## iter  80 value 47.430320
## iter  90 value 46.798140
## iter 100 value 45.420131
## final  value 45.420131
## stopped after 100 iterations
## # weights:  109
## initial  value 107.089943
## iter  10 value 55.234740
## iter  20 value 22.389060
## iter  30 value 20.367074
## iter  40 value 19.609503
## iter  50 value 18.495072
## iter  60 value 17.262961
## iter  70 value 17.040185
## iter  80 value 16.865915
## iter  90 value 16.466185
## iter 100 value 15.883832
## final  value 15.883832
## stopped after 100 iterations
## # weights:  179
## initial  value 103.652883
## iter  10 value 24.167727
## iter  20 value 9.953042
## iter  30 value 8.492294
## iter  40 value 7.065063
## iter  50 value 5.199502
## iter  60 value 5.189567
## iter  70 value 5.152705
## iter  80 value 5.133026
## iter  90 value 5.127129
## iter 100 value 5.126972
## final  value 5.126972
## stopped after 100 iterations
## # weights:  39
## initial  value 107.242423
## iter  10 value 69.668594
## iter  20 value 62.957453
## iter  30 value 60.293402
## iter  40 value 60.078461
## iter  50 value 59.938452
## iter  60 value 59.513597
## iter  70 value 59.165025
## iter  80 value 59.112118
## final  value 59.112044
## converged
## # weights:  109
## initial  value 115.412115
## iter  10 value 73.212100
## iter  20 value 49.088261
## iter  30 value 23.155727
## iter  40 value 18.003186
## iter  50 value 16.879399
## iter  60 value 16.798870
```

```
## iter  70 value 16.781864
## iter  80 value 16.742496
## iter  90 value 16.738341
## iter 100 value 16.738237
## final  value 16.738237
## stopped after 100 iterations
## # weights:  179
## initial  value 121.281352
## iter  10 value 35.370770
## iter  20 value 21.488152
## iter  30 value 16.066384
## iter  40 value 13.597310
## iter  50 value 12.605599
## iter  60 value 12.278221
## iter  70 value 12.251660
## iter  80 value 12.251127
## iter  90 value 12.251106
## final  value 12.251106
## converged
## # weights:  39
## initial  value 104.544298
## iter  10 value 64.526224
## iter  20 value 50.388044
## iter  30 value 40.914239
## iter  40 value 38.582250
## iter  50 value 37.377818
## iter  60 value 36.922249
## iter  70 value 36.221746
## iter  80 value 36.176123
## iter  90 value 36.064625
## iter 100 value 35.393734
## final  value 35.393734
## stopped after 100 iterations
## # weights:  109
## initial  value 111.341716
## iter  10 value 41.008508
## iter  20 value 19.711727
## iter  30 value 12.263611
## iter  40 value 6.314696
## iter  50 value 5.384760
## iter  60 value 5.206651
## iter  70 value 4.913414
## iter  80 value 4.753253
## iter  90 value 4.732967
## iter 100 value 4.709362
## final  value 4.709362
## stopped after 100 iterations
## # weights:  179
## initial  value 121.416140
## iter  10 value 17.285821
## iter  20 value 7.404485
## iter  30 value 5.593378
## iter  40 value 5.517382
## iter  50 value 5.495217
```

```
## iter  60 value 5.325118
## iter  70 value 5.272660
## iter  80 value 5.152961
## iter  90 value 5.139881
## iter 100 value 5.121958
## final  value 5.121958
## stopped after 100 iterations
## # weights:  39
## initial  value 101.176678
## iter  10 value 64.942117
## iter  20 value 60.189055
## iter  30 value 59.479518
## iter  40 value 59.208528
## iter  50 value 59.171348
## iter  60 value 59.166573
## iter  70 value 59.164137
## iter  80 value 59.163955
## iter  80 value 59.163954
## final  value 59.163954
## converged
## # weights:  109
## initial  value 104.413824
## iter  10 value 42.854235
## iter  20 value 19.182867
## iter  30 value 9.740918
## iter  40 value 6.772048
## iter  50 value 6.278772
## iter  60 value 6.272093
## iter  70 value 6.270951
## iter  80 value 5.937595
## iter  90 value 5.417071
## iter 100 value 5.408201
## final  value 5.408201
## stopped after 100 iterations
## # weights:  179
## initial  value 127.217693
## iter  10 value 22.643510
## iter  20 value 6.696243
## iter  30 value 2.929428
## iter  40 value 2.774617
## iter  50 value 2.772779
## iter  60 value 2.772590
## iter  60 value 2.772590
## iter  60 value 2.772590
## final  value 2.772590
## converged
## # weights:  39
## initial  value 103.130121
## iter  10 value 73.534905
## iter  20 value 65.080629
## iter  30 value 60.105258
## iter  40 value 59.068942
## iter  50 value 58.569938
## iter  60 value 58.541653
```

```
## final  value 58.541651
## converged
## # weights:  109
## initial  value 110.493544
## iter  10 value 55.135778
## iter  20 value 25.915758
## iter  30 value 19.037411
## iter  40 value 16.209721
## iter  50 value 15.725766
## iter  60 value 15.703111
## iter  70 value 15.701788
## iter  80 value 15.701748
## iter  80 value 15.701748
## iter  80 value 15.701748
## final  value 15.701748
## converged
## # weights:  179
## initial  value 106.481457
## iter  10 value 43.837386
## iter  20 value 25.044892
## iter  30 value 16.600008
## iter  40 value 12.913796
## iter  50 value 12.234388
## iter  60 value 12.095502
## iter  70 value 12.084205
## iter  80 value 12.083223
## iter  90 value 12.083188
## final  value 12.083188
## converged
## # weights:  39
## initial  value 111.716414
## iter  10 value 60.088700
## iter  20 value 45.960138
## iter  30 value 36.906685
## iter  40 value 36.697115
## iter  50 value 36.695805
## iter  60 value 36.690875
## iter  70 value 36.675566
## iter  80 value 36.485801
## iter  90 value 36.339357
## iter 100 value 36.130272
## final  value 36.130272
## stopped after 100 iterations
## # weights:  109
## initial  value 115.061469
## iter  10 value 42.919828
## iter  20 value 7.646608
## iter  30 value 1.946823
## iter  40 value 1.557959
## iter  50 value 1.545121
## iter  60 value 1.535179
## iter  70 value 1.529208
## iter  80 value 1.517631
## iter  90 value 1.505618
```

```
## iter 100 value 1.499120
## final  value 1.499120
## stopped after 100 iterations
## # weights:  179
## initial  value 110.006198
## iter  10 value 22.072325
## iter  20 value 5.538083
## iter  30 value 4.070544
## iter  40 value 4.054390
## iter  50 value 4.030999
## iter  60 value 4.013053
## iter  70 value 4.005433
## iter  80 value 4.000324
## iter  90 value 2.715954
## iter 100 value 1.505921
## final  value 1.505921
## stopped after 100 iterations
## # weights:  39
## initial  value 100.615696
## iter  10 value 70.908875
## iter  20 value 62.751346
## iter  30 value 62.623699
## iter  40 value 62.138530
## iter  50 value 61.813073
## iter  60 value 61.674940
## iter  70 value 61.658481
## iter  80 value 61.655601
## final  value 61.655160
## converged
## # weights:  109
## initial  value 98.295046
## iter  10 value 28.535016
## iter  20 value 16.738147
## iter  30 value 10.518791
## iter  40 value 9.740156
## iter  50 value 9.713299
## iter  60 value 9.712616
## iter  70 value 9.712360
## iter  80 value 9.712324
## iter  80 value 9.712324
## iter  80 value 9.712324
## final  value 9.712324
## converged
## # weights:  179
## initial  value 141.452737
## iter  10 value 53.685731
## iter  20 value 32.433635
## iter  30 value 10.732553
## iter  40 value 6.465266
## iter  50 value 6.420500
## iter  60 value 6.419666
## iter  60 value 6.419666
## final  value 6.419661
## converged
```

```
## # weights:  39
## initial  value 120.204565
## iter  10 value 77.903940
## iter  20 value 69.317038
## iter  30 value 63.987192
## iter  40 value 57.967337
## iter  50 value 56.541860
## iter  60 value 56.213978
## iter  70 value 56.191838
## final  value 56.191761
## converged
## # weights:  109
## initial  value 98.917610
## iter  10 value 52.279871
## iter  20 value 25.291209
## iter  30 value 19.246674
## iter  40 value 17.625722
## iter  50 value 16.587821
## iter  60 value 15.734542
## iter  70 value 15.531990
## iter  80 value 14.800242
## iter  90 value 14.701720
## iter 100 value 14.701363
## final  value 14.701363
## stopped after 100 iterations
## # weights:  179
## initial  value 101.512058
## iter  10 value 27.811450
## iter  20 value 16.304479
## iter  30 value 14.120042
## iter  40 value 12.382638
## iter  50 value 11.901144
## iter  60 value 11.770871
## iter  70 value 11.753453
## iter  80 value 11.712876
## iter  90 value 11.644096
## iter 100 value 11.642399
## final  value 11.642399
## stopped after 100 iterations
## # weights:  39
## initial  value 108.666967
## iter  10 value 57.735899
## iter  20 value 55.543966
## iter  30 value 52.538535
## iter  40 value 51.607325
## iter  50 value 50.763429
## iter  60 value 50.319685
## iter  70 value 49.824164
## iter  80 value 49.102181
## iter  90 value 48.040041
## iter 100 value 46.626782
## final  value 46.626782
## stopped after 100 iterations
## # weights:  109
```

```
## initial  value 108.529147
## iter  10 value 38.569147
## iter  20 value 22.200431
## iter  30 value 19.489820
## iter  40 value 18.875881
## iter  50 value 18.553506
## iter  60 value 18.253276
## iter  70 value 17.943551
## iter  80 value 17.543093
## iter  90 value 16.221792
## iter 100 value 12.620674
## final  value 12.620674
## stopped after 100 iterations
## # weights:  179
## initial  value 111.860137
## iter  10 value 23.551875
## iter  20 value 15.385911
## iter  30 value 12.002694
## iter  40 value 9.867249
## iter  50 value 8.245347
## iter  60 value 6.836543
## iter  70 value 5.994746
## iter  80 value 5.893996
## iter  90 value 5.886723
## iter 100 value 5.879668
## final  value 5.879668
## stopped after 100 iterations
## # weights:  39
## initial  value 125.381831
## iter  10 value 59.430396
## iter  20 value 54.499055
## iter  30 value 53.870191
## iter  40 value 50.254981
## iter  50 value 48.537299
## iter  60 value 45.884463
## iter  70 value 44.671552
## iter  80 value 43.035189
## iter  90 value 41.526255
## iter 100 value 40.408186
## final  value 40.408186
## stopped after 100 iterations
## # weights:  109
## initial  value 99.277951
## iter  10 value 30.409227
## iter  20 value 22.269757
## iter  30 value 21.168598
## iter  40 value 20.948904
## iter  50 value 20.228458
## iter  60 value 19.645825
## iter  70 value 19.171710
## iter  80 value 13.522211
## iter  90 value 12.446779
## iter 100 value 12.217019
## final  value 12.217019
```

```
## stopped after 100 iterations
## # weights:  179
## initial  value 117.691961
## iter  10 value 24.356242
## iter  20 value 4.174138
## iter  30 value 2.542639
## iter  40 value 1.987332
## iter  50 value 1.921060
## iter  60 value 1.396960
## iter  70 value 1.213953
## iter  80 value 0.039781
## iter  90 value 0.017388
## iter 100 value 0.010123
## final  value 0.010123
## stopped after 100 iterations
## # weights:  39
## initial  value 103.734468
## iter  10 value 82.434762
## iter  20 value 76.419268
## iter  30 value 74.340681
## iter  40 value 66.736398
## iter  50 value 60.171751
## iter  60 value 59.261387
## iter  70 value 59.160117
## iter  80 value 59.153974
## iter  90 value 59.149758
## final  value 59.149371
## converged
## # weights:  109
## initial  value 117.087569
## iter  10 value 54.563837
## iter  20 value 29.708833
## iter  30 value 20.466822
## iter  40 value 16.553459
## iter  50 value 16.027797
## iter  60 value 15.908921
## iter  70 value 15.904742
## final  value 15.904707
## converged
## # weights:  179
## initial  value 133.017919
## iter  10 value 51.055854
## iter  20 value 26.825720
## iter  30 value 17.235838
## iter  40 value 14.839835
## iter  50 value 13.504617
## iter  60 value 13.143227
## iter  70 value 13.070481
## iter  80 value 13.065182
## iter  90 value 13.064800
## final  value 13.064796
## converged
## # weights:  39
## initial  value 111.560022
```

```
## iter  10 value 61.382274
## iter  20 value 59.144678
## iter  30 value 57.434150
## iter  40 value 56.551149
## iter  50 value 56.196886
## iter  60 value 56.191776
## iter  70 value 56.178702
## iter  80 value 56.173533
## iter  90 value 56.171754
## iter 100 value 53.370590
## final  value 53.370590
## stopped after 100 iterations
## # weights:  109
## initial  value 105.656784
## iter  10 value 29.579034
## iter  20 value 17.022579
## iter  30 value 11.998677
## iter  40 value 11.604007
## iter  50 value 10.964693
## iter  60 value 10.483192
## iter  70 value 10.173165
## iter  80 value 9.247171
## iter  90 value 5.546509
## iter 100 value 3.332295
## final  value 3.332295
## stopped after 100 iterations
## # weights:  179
## initial  value 130.620688
## iter  10 value 18.945212
## iter  20 value 5.478681
## iter  30 value 0.324884
## iter  40 value 0.264313
## iter  50 value 0.248027
## iter  60 value 0.226594
## iter  70 value 0.199760
## iter  80 value 0.187477
## iter  90 value 0.173920
## iter 100 value 0.152350
## final  value 0.152350
## stopped after 100 iterations
## # weights:  39
## initial  value 132.634666
## iter  10 value 66.432181
## iter  20 value 59.978997
## iter  30 value 57.184030
## iter  40 value 55.396428
## iter  50 value 55.266661
## iter  60 value 54.554297
## iter  70 value 54.413852
## iter  80 value 51.479047
## iter  90 value 50.612051
## iter 100 value 50.152796
## final  value 50.152796
## stopped after 100 iterations
```

```
## # weights:  109
## initial  value 112.325222
## iter  10 value 45.065819
## iter  20 value 41.828079
## iter  30 value 40.897232
## iter  40 value 38.441074
## iter  50 value 37.514908
## iter  60 value 37.398699
## iter  70 value 37.293897
## iter  80 value 36.482215
## iter  90 value 35.473921
## iter 100 value 34.896229
## final  value 34.896229
## stopped after 100 iterations
## # weights:  179
## initial  value 117.848681
## iter  10 value 38.381277
## iter  20 value 12.627887
## iter  30 value 11.528537
## iter  40 value 3.844474
## iter  50 value 1.475254
## iter  60 value 1.407491
## iter  70 value 1.392987
## iter  80 value 1.390012
## iter  90 value 1.387098
## iter 100 value 1.386890
## final  value 1.386890
## stopped after 100 iterations
## # weights:  39
## initial  value 101.476665
## iter  10 value 65.977246
## iter  20 value 58.949671
## iter  30 value 57.805392
## iter  40 value 57.360984
## iter  50 value 57.352099
## iter  60 value 57.186211
## iter  70 value 57.150682
## final  value 57.150674
## converged
## # weights:  109
## initial  value 113.489608
## iter  10 value 45.925595
## iter  20 value 28.292826
## iter  30 value 21.638044
## iter  40 value 16.787323
## iter  50 value 16.024587
## iter  60 value 16.015320
## final  value 16.015268
## converged
## # weights:  179
## initial  value 121.361312
## iter  10 value 47.459172
## iter  20 value 18.961341
## iter  30 value 13.396851
```

```
## iter  40 value 12.608863
## iter  50 value 12.338122
## iter  60 value 12.238220
## iter  70 value 12.212839
## iter  80 value 12.156551
## iter  90 value 12.149355
## iter 100 value 12.133294
## final  value 12.133294
## stopped after 100 iterations
## # weights:  39
## initial  value 109.661937
## iter  10 value 77.565882
## iter  20 value 62.761738
## iter  30 value 59.549675
## iter  40 value 59.533504
## iter  50 value 59.529589
## iter  60 value 59.521517
## iter  70 value 59.514869
## iter  80 value 59.508767
## iter  90 value 59.507936
## iter 100 value 59.503015
## final  value 59.503015
## stopped after 100 iterations
## # weights:  109
## initial  value 101.397478
## iter  10 value 23.124885
## iter  20 value 16.422129
## iter  30 value 11.303697
## iter  40 value 8.890215
## iter  50 value 7.882660
## iter  60 value 7.707716
## iter  70 value 7.360925
## iter  80 value 7.023340
## iter  90 value 7.009456
## iter 100 value 6.996354
## final  value 6.996354
## stopped after 100 iterations
## # weights:  179
## initial  value 119.905231
## iter  10 value 23.534014
## iter  20 value 7.603594
## iter  30 value 6.242536
## iter  40 value 6.148501
## iter  50 value 6.118216
## iter  60 value 6.016889
## iter  70 value 5.903810
## iter  80 value 5.801545
## iter  90 value 5.774141
## iter 100 value 5.740878
## final  value 5.740878
## stopped after 100 iterations
## # weights:  39
## initial  value 104.365260
## iter  10 value 63.392815
```

```
## iter  20 value 54.505861
## iter  30 value 53.204722
## iter  40 value 53.054473
## iter  50 value 53.047051
## iter  60 value 53.046884
## iter  70 value 53.046021
## iter  80 value 52.591981
## iter  90 value 51.817189
## iter 100 value 51.225781
## final  value 51.225781
## stopped after 100 iterations
## # weights:  109
## initial  value 102.003652
## iter  10 value 65.106586
## iter  20 value 59.726281
## iter  30 value 37.507349
## iter  40 value 34.601319
## iter  50 value 34.200664
## iter  60 value 34.079395
## iter  70 value 33.895410
## iter  80 value 33.792463
## iter  90 value 33.688125
## iter 100 value 33.018704
## final  value 33.018704
## stopped after 100 iterations
## # weights:  179
## initial  value 104.296831
## iter  10 value 24.826703
## iter  20 value 9.417795
## iter  30 value 3.751953
## iter  40 value 1.430299
## iter  50 value 1.390445
## iter  60 value 1.386499
## iter  70 value 1.386319
## final  value 1.386309
## converged
## # weights:  39
## initial  value 112.249720
## iter  10 value 82.377741
## iter  20 value 65.225815
## iter  30 value 61.082804
## iter  40 value 60.321273
## iter  50 value 59.766642
## iter  60 value 59.460017
## iter  70 value 59.275278
## iter  80 value 59.269600
## final  value 59.269597
## converged
## # weights:  109
## initial  value 98.417431
## iter  10 value 46.763227
## iter  20 value 27.148624
## iter  30 value 19.624904
## iter  40 value 17.051812
```

```
## iter  50 value 16.866195
## iter  60 value 16.850877
## iter  70 value 16.816337
## iter  80 value 16.815395
## iter  80 value 16.815395
## iter  80 value 16.815395
## final  value 16.815395
## converged
## # weights:  179
## initial  value 109.204876
## iter  10 value 31.394152
## iter  20 value 18.959073
## iter  30 value 13.412071
## iter  40 value 12.603279
## iter  50 value 12.299192
## iter  60 value 12.246947
## iter  70 value 12.235987
## iter  80 value 12.235343
## final  value 12.235338
## converged
## # weights:  39
## initial  value 102.465655
## iter  10 value 67.804516
## iter  20 value 59.106721
## iter  30 value 58.414318
## iter  40 value 58.092958
## iter  50 value 58.033481
## iter  60 value 57.403094
## iter  70 value 57.350592
## iter  80 value 56.990757
## iter  90 value 56.584704
## iter 100 value 56.164187
## final  value 56.164187
## stopped after 100 iterations
## # weights:  109
## initial  value 107.082272
## iter  10 value 44.120119
## iter  20 value 32.415559
## iter  30 value 24.105333
## iter  40 value 22.052746
## iter  50 value 21.362392
## iter  60 value 21.258328
## iter  70 value 20.312056
## iter  80 value 19.718686
## iter  90 value 18.647001
## iter 100 value 18.182505
## final  value 18.182505
## stopped after 100 iterations
## # weights:  179
## initial  value 100.450887
## iter  10 value 27.959970
## iter  20 value 9.859642
## iter  30 value 7.553618
## iter  40 value 7.406723
```

```
## iter  50 value 5.801168
## iter  60 value 5.518196
## iter  70 value 2.178912
## iter  80 value 2.063924
## iter  90 value 0.191537
## iter 100 value 0.152051
## final  value 0.152051
## stopped after 100 iterations
## # weights:  39
## initial  value 100.013615
## iter  10 value 72.787279
## iter  20 value 63.070146
## iter  30 value 59.665286
## iter  40 value 53.093217
## iter  50 value 48.811438
## iter  60 value 47.399302
## iter  70 value 47.354607
## iter  80 value 47.353988
## iter  90 value 47.353938
## iter 100 value 47.353815
## final  value 47.353815
## stopped after 100 iterations
## # weights:  109
## initial  value 102.732668
## iter  10 value 25.540886
## iter  20 value 17.464998
## iter  30 value 14.543454
## iter  40 value 12.149225
## iter  50 value 12.079525
## iter  60 value 12.017061
## iter  70 value 11.977074
## iter  80 value 11.957155
## iter  90 value 11.394754
## iter 100 value 8.201888
## final  value 8.201888
## stopped after 100 iterations
## # weights:  179
## initial  value 101.654034
## iter  10 value 24.646667
## iter  20 value 12.122785
## iter  30 value 7.874649
## iter  40 value 4.283369
## iter  50 value 2.048326
## iter  60 value 1.576807
## iter  70 value 1.409501
## iter  80 value 1.392652
## iter  90 value 1.389672
## iter 100 value 1.388002
## final  value 1.388002
## stopped after 100 iterations
## # weights:  39
## initial  value 107.346384
## iter  10 value 79.371858
## iter  20 value 67.848347
```

```
## iter  30 value 61.103750
## iter  40 value 58.935888
## iter  50 value 58.887047
## iter  60 value 58.807020
## iter  70 value 58.636979
## iter  80 value 58.630905
## final  value 58.630798
## converged
## # weights:  109
## initial  value 105.446120
## iter  10 value 52.118723
## iter  20 value 34.099337
## iter  30 value 25.456442
## iter  40 value 19.012625
## iter  50 value 16.690466
## iter  60 value 16.368163
## iter  70 value 16.290256
## iter  80 value 16.275549
## iter  90 value 16.275493
## iter  90 value 16.275492
## iter  90 value 16.275492
## final  value 16.275492
## converged
## # weights:  179
## initial  value 113.423118
## iter  10 value 39.074852
## iter  20 value 20.573736
## iter  30 value 15.891826
## iter  40 value 15.059643
## iter  50 value 14.109002
## iter  60 value 13.536565
## iter  70 value 13.480627
## iter  80 value 13.388071
## iter  90 value 13.367145
## iter 100 value 13.367023
## final  value 13.367023
## stopped after 100 iterations
## # weights:  39
## initial  value 99.011014
## iter  10 value 67.534745
## iter  20 value 54.632320
## iter  30 value 42.330114
## iter  40 value 38.200964
## iter  50 value 37.347592
## iter  60 value 37.089102
## iter  70 value 37.064313
## iter  80 value 37.050889
## iter  90 value 37.041796
## iter 100 value 37.034643
## final  value 37.034643
## stopped after 100 iterations
## # weights:  109
## initial  value 124.201139
## iter  10 value 63.366108
```

```
## iter  20 value 36.294349
## iter  30 value 29.860287
## iter  40 value 23.996252
## iter  50 value 21.145933
## iter  60 value 20.633198
## iter  70 value 18.287112
## iter  80 value 15.414280
## iter  90 value 14.508768
## iter 100 value 13.970275
## final  value 13.970275
## stopped after 100 iterations
## # weights:  179
## initial  value 110.248930
## iter  10 value 29.247711
## iter  20 value 6.927468
## iter  30 value 3.938158
## iter  40 value 0.780701
## iter  50 value 0.610786
## iter  60 value 0.560039
## iter  70 value 0.494278
## iter  80 value 0.448504
## iter  90 value 0.416301
## iter 100 value 0.378287
## final  value 0.378287
## stopped after 100 iterations
## # weights:  39
## initial  value 101.112182
## iter  10 value 69.163739
## iter  20 value 64.403387
## iter  30 value 63.118340
## iter  40 value 61.958518
## iter  50 value 59.887504
## iter  60 value 57.873813
## iter  70 value 56.733137
## iter  80 value 55.832158
## iter  90 value 55.199328
## iter 100 value 55.116929
## final  value 55.116929
## stopped after 100 iterations
## # weights:  109
## initial  value 114.873206
## iter  10 value 48.086287
## iter  20 value 25.003243
## iter  30 value 8.093000
## iter  40 value 7.262368
## iter  50 value 7.232719
## iter  60 value 7.194943
## iter  70 value 7.179123
## iter  80 value 7.170579
## iter  90 value 7.169971
## iter 100 value 7.168742
## final  value 7.168742
## stopped after 100 iterations
## # weights:  179
```

```
## initial  value 112.545934
## iter  10 value 25.580178
## iter  20 value 4.309494
## iter  30 value 0.679900
## iter  40 value 0.020290
## iter  50 value 0.001471
## final  value 0.000067
## converged
## # weights:  39
## initial  value 100.628925
## iter  10 value 84.191757
## iter  20 value 64.405217
## iter  30 value 60.069852
## iter  40 value 59.206315
## iter  50 value 58.696651
## iter  60 value 58.386407
## iter  70 value 58.077664
## iter  80 value 57.963999
## iter  90 value 57.746399
## iter 100 value 57.656410
## final  value 57.656410
## stopped after 100 iterations
## # weights:  109
## initial  value 102.712319
## iter  10 value 57.271088
## iter  20 value 32.577705
## iter  30 value 21.161682
## iter  40 value 19.056265
## iter  50 value 18.537374
## iter  60 value 17.898509
## iter  70 value 17.072957
## iter  80 value 16.342303
## iter  90 value 15.862463
## iter 100 value 15.845592
## final  value 15.845592
## stopped after 100 iterations
## # weights:  179
## initial  value 144.385534
## iter  10 value 65.453418
## iter  20 value 30.082407
## iter  30 value 19.865822
## iter  40 value 14.870588
## iter  50 value 13.052061
## iter  60 value 12.660293
## iter  70 value 12.633034
## iter  80 value 12.629903
## iter  90 value 12.629522
## iter 100 value 12.629374
## final  value 12.629374
## stopped after 100 iterations
## # weights:  39
## initial  value 119.248779
## iter  10 value 81.651733
## iter  20 value 64.698356
```

```
## iter  30 value 61.569624
## iter  40 value 60.096654
## iter  50 value 58.277674
## iter  60 value 57.227460
## iter  70 value 55.309194
## iter  80 value 54.030771
## iter  90 value 52.164866
## iter 100 value 51.956583
## final  value 51.956583
## stopped after 100 iterations
## # weights:  109
## initial  value 97.029798
## iter  10 value 29.309002
## iter  20 value 20.818587
## iter  30 value 15.780611
## iter  40 value 9.409804
## iter  50 value 7.279159
## iter  60 value 6.842010
## iter  70 value 3.094760
## iter  80 value 2.022031
## iter  90 value 1.337496
## iter 100 value 0.373052
## final  value 0.373052
## stopped after 100 iterations
## # weights:  179
## initial  value 112.177852
## iter  10 value 23.286637
## iter  20 value 8.737599
## iter  30 value 4.669394
## iter  40 value 4.021378
## iter  50 value 3.949291
## iter  60 value 0.281557
## iter  70 value 0.167801
## iter  80 value 0.154585
## iter  90 value 0.146025
## iter 100 value 0.139925
## final  value 0.139925
## stopped after 100 iterations
## # weights:  39
## initial  value 118.519049
## iter  10 value 61.501998
## iter  20 value 55.210430
## iter  30 value 52.539765
## iter  40 value 48.348727
## iter  50 value 46.697931
## iter  60 value 46.550618
## iter  70 value 46.414120
## iter  80 value 46.292525
## iter  90 value 46.289972
## iter 100 value 46.153273
## final  value 46.153273
## stopped after 100 iterations
## # weights:  109
## initial  value 108.280884
```

```
## iter  10 value 60.686264
## iter  20 value 25.029261
## iter  30 value 14.629653
## iter  40 value 10.722690
## iter  50 value 6.349505
## iter  60 value 5.936056
## iter  70 value 5.929903
## final  value 5.929868
## converged
## # weights:  179
## initial  value 108.176733
## iter  10 value 27.574741
## iter  20 value 14.631122
## iter  30 value 8.158751
## iter  40 value 6.909229
## iter  50 value 6.300621
## iter  60 value 5.723647
## iter  70 value 5.421031
## iter  80 value 5.369927
## iter  90 value 5.331224
## iter 100 value 3.722920
## final  value 3.722920
## stopped after 100 iterations
## # weights:  39
## initial  value 115.232971
## iter  10 value 69.758693
## iter  20 value 64.761897
## iter  30 value 61.181257
## iter  40 value 59.399406
## iter  50 value 58.995393
## iter  60 value 57.818407
## iter  70 value 57.360522
## iter  80 value 57.345151
## final  value 57.345145
## converged
## # weights:  109
## initial  value 108.911437
## iter  10 value 61.028015
## iter  20 value 35.752664
## iter  30 value 21.891819
## iter  40 value 18.258882
## iter  50 value 16.936475
## iter  60 value 16.436822
## iter  70 value 16.271295
## iter  80 value 16.261078
## iter  90 value 16.251588
## iter 100 value 16.251409
## final  value 16.251409
## stopped after 100 iterations
## # weights:  179
## initial  value 119.041526
## iter  10 value 49.206682
## iter  20 value 22.421851
## iter  30 value 13.948967
```

```
## iter  40 value 12.814434
## iter  50 value 12.341171
## iter  60 value 12.268220
## iter  70 value 12.229556
## iter  80 value 12.197191
## iter  90 value 12.174379
## iter 100 value 12.157878
## final  value 12.157878
## stopped after 100 iterations
## # weights:  39
## initial  value 97.215681
## iter  10 value 70.697269
## iter  20 value 64.682495
## iter  30 value 64.362166
## iter  40 value 64.350125
## iter  50 value 64.314574
## iter  60 value 64.068797
## iter  70 value 63.927673
## iter  80 value 62.692212
## iter  90 value 60.181767
## iter 100 value 59.632597
## final  value 59.632597
## stopped after 100 iterations
## # weights:  109
## initial  value 106.258342
## iter  10 value 39.982607
## iter  20 value 13.739876
## iter  30 value 9.679355
## iter  40 value 9.108804
## iter  50 value 8.798725
## iter  60 value 8.674735
## iter  70 value 8.637160
## iter  80 value 8.183904
## iter  90 value 8.073294
## iter 100 value 8.061025
## final  value 8.061025
## stopped after 100 iterations
## # weights:  179
## initial  value 119.048084
## iter  10 value 27.697311
## iter  20 value 9.322368
## iter  30 value 3.989614
## iter  40 value 2.970221
## iter  50 value 2.897294
## iter  60 value 2.888727
## iter  70 value 2.880494
## iter  80 value 2.870165
## iter  90 value 2.860032
## iter 100 value 2.852935
## final  value 2.852935
## stopped after 100 iterations
## # weights:  39
## initial  value 111.149016
## iter  10 value 59.249574
```

```
## iter  20 value 56.799885
## iter  30 value 55.768447
## iter  40 value 53.866826
## iter  50 value 53.638321
## iter  60 value 52.619167
## iter  70 value 52.562417
## iter  80 value 51.711950
## iter  90 value 50.193433
## iter 100 value 50.115124
## final  value 50.115124
## stopped after 100 iterations
## # weights:  109
## initial  value 120.478818
## iter  10 value 67.833659
## iter  20 value 41.302787
## iter  30 value 21.157923
## iter  40 value 16.469425
## iter  50 value 12.546110
## iter  60 value 12.485211
## iter  70 value 12.476795
## iter  80 value 10.650705
## iter  90 value 10.364717
## iter 100 value 10.364237
## final  value 10.364237
## stopped after 100 iterations
## # weights:  179
## initial  value 114.454145
## iter  10 value 16.939293
## iter  20 value 4.300866
## iter  30 value 3.082681
## iter  40 value 2.905748
## iter  50 value 2.885898
## iter  60 value 2.877612
## iter  70 value 2.875402
## iter  80 value 2.704870
## iter  90 value 1.940258
## iter 100 value 1.911908
## final  value 1.911908
## stopped after 100 iterations
## # weights:  39
## initial  value 100.387194
## iter  10 value 70.217411
## iter  20 value 60.755226
## iter  30 value 58.459146
## iter  40 value 58.395455
## iter  50 value 58.393270
## iter  60 value 58.392859
## iter  70 value 58.384166
## iter  80 value 58.139540
## iter  90 value 57.940458
## iter 100 value 57.734953
## final  value 57.734953
## stopped after 100 iterations
## # weights:  109
```

```
## initial  value 100.236716
## iter  10 value 57.664173
## iter  20 value 40.208650
## iter  30 value 34.571060
## iter  40 value 31.554027
## iter  50 value 30.273822
## iter  60 value 23.253135
## iter  70 value 18.033571
## iter  80 value 16.815295
## iter  90 value 16.413356
## iter 100 value 16.372940
## final  value 16.372940
## stopped after 100 iterations
## # weights:  179
## initial  value 105.599145
## iter  10 value 35.419437
## iter  20 value 21.509726
## iter  30 value 13.699850
## iter  40 value 12.722746
## iter  50 value 12.410336
## iter  60 value 12.237326
## iter  70 value 12.208050
## iter  80 value 12.205368
## iter  90 value 12.205307
## final  value 12.205307
## converged
## # weights:  39
## initial  value 104.021162
## iter  10 value 67.735671
## iter  20 value 54.975114
## iter  30 value 51.190925
## iter  40 value 49.416031
## iter  50 value 46.811496
## iter  60 value 46.023158
## iter  70 value 46.014531
## iter  80 value 46.012534
## iter  90 value 46.011122
## iter 100 value 46.009466
## final  value 46.009466
## stopped after 100 iterations
## # weights:  109
## initial  value 103.029809
## iter  10 value 37.001603
## iter  20 value 26.585757
## iter  30 value 25.544211
## iter  40 value 22.505811
## iter  50 value 21.856030
## iter  60 value 21.576618
## iter  70 value 21.317179
## iter  80 value 20.569577
## iter  90 value 19.385355
## iter 100 value 18.749509
## final  value 18.749509
## stopped after 100 iterations
```

```
## # weights:  179
## initial  value 121.796246
## iter  10 value 16.741709
## iter  20 value 7.182538
## iter  30 value 6.069735
## iter  40 value 5.904295
## iter  50 value 3.454545
## iter  60 value 3.197128
## iter  70 value 3.174952
## iter  80 value 3.168557
## iter  90 value 3.162084
## iter 100 value 2.452021
## final  value 2.452021
## stopped after 100 iterations
## # weights:  39
## initial  value 99.835018
## iter  10 value 64.139714
## iter  20 value 59.136419
## iter  30 value 58.351445
## iter  40 value 56.894510
## iter  50 value 56.145387
## iter  60 value 55.849723
## iter  70 value 55.343415
## iter  80 value 54.062454
## iter  90 value 48.676833
## iter 100 value 47.973814
## final  value 47.973814
## stopped after 100 iterations
## # weights:  109
## initial  value 103.989234
## iter  10 value 25.531325
## iter  20 value 14.618317
## iter  30 value 11.585792
## iter  40 value 10.808705
## iter  50 value 10.686602
## iter  60 value 10.681725
## iter  70 value 10.681480
## iter  80 value 10.681342
## final  value 10.681337
## converged
## # weights:  179
## initial  value 103.651941
## iter  10 value 20.573670
## iter  20 value 7.258001
## iter  30 value 6.427372
## iter  40 value 5.321907
## iter  50 value 5.038972
## iter  60 value 3.342662
## iter  70 value 1.424823
## iter  80 value 1.398727
## iter  90 value 1.389793
## iter 100 value 1.387581
## final  value 1.387581
## stopped after 100 iterations
```

```
## # weights:  39
## initial  value 118.101022
## iter  10 value 74.528816
## iter  20 value 66.073868
## iter  30 value 63.539119
## iter  40 value 62.167036
## iter  50 value 59.977259
## iter  60 value 58.359114
## iter  70 value 57.095552
## iter  80 value 57.085091
## final  value 57.085072
## converged
## # weights:  109
## initial  value 128.313116
## iter  10 value 45.443998
## iter  20 value 30.975705
## iter  30 value 22.556465
## iter  40 value 19.120438
## iter  50 value 16.689159
## iter  60 value 16.033363
## iter  70 value 15.971582
## iter  80 value 15.970670
## final  value 15.970669
## converged
## # weights:  179
## initial  value 125.929231
## iter  10 value 35.058444
## iter  20 value 22.100637
## iter  30 value 15.814520
## iter  40 value 13.818183
## iter  50 value 12.628284
## iter  60 value 12.358238
## iter  70 value 12.307827
## iter  80 value 12.306101
## final  value 12.306096
## converged
## # weights:  39
## initial  value 99.326396
## iter  10 value 82.216544
## iter  20 value 64.939521
## iter  30 value 63.908722
## iter  40 value 62.587678
## iter  50 value 60.093624
## iter  60 value 59.953191
## iter  70 value 58.671882
## iter  80 value 57.937884
## iter  90 value 57.678145
## iter 100 value 57.165342
## final  value 57.165342
## stopped after 100 iterations
## # weights:  109
## initial  value 105.851003
## iter  10 value 48.300781
## iter  20 value 29.207361
```

```
## iter  30 value 23.583297
## iter  40 value 16.083091
## iter  50 value 10.835469
## iter  60 value 7.270159
## iter  70 value 6.811351
## iter  80 value 1.549172
## iter  90 value 0.449533
## iter 100 value 0.344423
## final  value 0.344423
## stopped after 100 iterations
## # weights:  179
## initial  value 111.053173
## iter  10 value 28.161055
## iter  20 value 15.727787
## iter  30 value 12.524916
## iter  40 value 8.329882
## iter  50 value 5.749663
## iter  60 value 5.138311
## iter  70 value 1.509500
## iter  80 value 0.524562
## iter  90 value 0.165988
## iter 100 value 0.159039
## final  value 0.159039
## stopped after 100 iterations
## # weights:  39
## initial  value 97.771886
## iter  10 value 71.802876
## iter  20 value 48.792172
## iter  30 value 42.675303
## iter  40 value 41.464500
## iter  50 value 41.022904
## iter  60 value 40.919860
## iter  70 value 36.891822
## iter  80 value 36.586095
## iter  90 value 36.346641
## iter 100 value 36.169138
## final  value 36.169138
## stopped after 100 iterations
## # weights:  109
## initial  value 96.353102
## iter  10 value 41.644640
## iter  20 value 22.653758
## iter  30 value 20.355682
## iter  40 value 19.091525
## iter  50 value 14.506707
## iter  60 value 13.435666
## iter  70 value 12.357248
## iter  80 value 12.193715
## iter  90 value 12.143197
## iter 100 value 9.857857
## final  value 9.857857
## stopped after 100 iterations
## # weights:  179
## initial  value 130.062787
```

```
## iter  10 value 24.911806
## iter  20 value 0.176277
## iter  30 value 0.002512
## iter  40 value 0.000823
## iter  50 value 0.000186
## final  value 0.000099
## converged
## # weights:  39
## initial  value 111.723343
## iter  10 value 89.499088
## iter  20 value 70.174704
## iter  30 value 59.073672
## iter  40 value 57.701416
## iter  50 value 56.914247
## iter  60 value 56.825340
## iter  70 value 56.822534
## iter  80 value 56.555028
## iter  90 value 56.527851
## final  value 56.527762
## converged
## # weights:  109
## initial  value 123.109595
## iter  10 value 67.009656
## iter  20 value 46.738516
## iter  30 value 30.910552
## iter  40 value 22.322239
## iter  50 value 17.473177
## iter  60 value 16.721120
## iter  70 value 16.681969
## iter  80 value 16.679929
## final  value 16.679916
## converged
## # weights:  179
## initial  value 105.469595
## iter  10 value 50.454871
## iter  20 value 26.553241
## iter  30 value 15.000018
## iter  40 value 12.786934
## iter  50 value 12.580253
## iter  60 value 12.548610
## iter  70 value 12.519697
## iter  80 value 12.498324
## iter  90 value 12.494423
## iter 100 value 12.493171
## final  value 12.493171
## stopped after 100 iterations
## # weights:  39
## initial  value 102.425049
## iter  10 value 80.706777
## iter  20 value 75.749902
## iter  30 value 75.720012
## iter  40 value 75.717355
## iter  50 value 75.706752
## iter  60 value 73.783920
```

```
## iter  70 value 73.745947
## iter  80 value 70.673906
## iter  90 value 68.185829
## iter 100 value 67.531625
## final  value 67.531625
## stopped after 100 iterations
## # weights:  109
## initial  value 105.762316
## iter  10 value 17.454759
## iter  20 value 13.722771
## iter  30 value 13.084458
## iter  40 value 8.736795
## iter  50 value 8.163552
## iter  60 value 8.144101
## iter  70 value 8.120489
## iter  80 value 8.105749
## iter  90 value 8.093289
## iter 100 value 8.082560
## final  value 8.082560
## stopped after 100 iterations
## # weights:  179
## initial  value 105.951267
## iter  10 value 20.900748
## iter  20 value 4.647714
## iter  30 value 3.801717
## iter  40 value 2.498879
## iter  50 value 2.473813
## iter  60 value 2.129036
## iter  70 value 2.074201
## iter  80 value 1.601013
## iter  90 value 1.586641
## iter 100 value 1.571057
## final  value 1.571057
## stopped after 100 iterations
## # weights:  39
## initial  value 102.364770
## iter  10 value 66.870295
## iter  20 value 57.882774
## iter  30 value 53.996184
## iter  40 value 53.496147
## iter  50 value 53.003330
## iter  60 value 52.238964
## iter  70 value 52.114358
## iter  80 value 50.692797
## iter  90 value 50.051595
## iter 100 value 49.947281
## final  value 49.947281
## stopped after 100 iterations
## # weights:  109
## initial  value 103.884128
## iter  10 value 52.189002
## iter  20 value 29.958777
## iter  30 value 29.284701
## iter  40 value 28.206434
```

```
## iter  50 value 28.154988
## iter  60 value 28.099348
## iter  70 value 26.717868
## iter  80 value 26.566399
## iter  90 value 25.854110
## iter 100 value 24.896935
## final  value 24.896935
## stopped after 100 iterations
## # weights:  179
## initial  value 115.288821
## iter  10 value 31.923634
## iter  20 value 4.685420
## iter  30 value 3.262050
## iter  40 value 2.869191
## iter  50 value 2.495505
## iter  60 value 1.388582
## iter  70 value 1.387001
## iter  80 value 1.386504
## iter  90 value 1.386453
## iter 100 value 1.386438
## final  value 1.386438
## stopped after 100 iterations
## # weights:  39
## initial  value 104.469913
## iter  10 value 66.610632
## iter  20 value 61.101961
## iter  30 value 60.470194
## iter  40 value 60.456492
## iter  50 value 60.455696
## final  value 60.455694
## converged
## # weights:  109
## initial  value 139.026525
## iter  10 value 71.763978
## iter  20 value 58.340810
## iter  30 value 42.122214
## iter  40 value 31.121237
## iter  50 value 21.540509
## iter  60 value 18.031058
## iter  70 value 17.034935
## iter  80 value 16.776358
## iter  90 value 16.747949
## iter 100 value 16.730930
## final  value 16.730930
## stopped after 100 iterations
## # weights:  179
## initial  value 108.681361
## iter  10 value 49.770746
## iter  20 value 25.196775
## iter  30 value 15.789021
## iter  40 value 13.325940
## iter  50 value 12.731487
## iter  60 value 12.389203
## iter  70 value 12.237870
```

```
## iter  80 value 12.230403
## iter  90 value 12.229750
## iter 100 value 12.229739
## final  value 12.229739
## stopped after 100 iterations
## # weights:  39
## initial  value 103.781789
## iter  10 value 69.854091
## iter  20 value 64.478612
## iter  30 value 64.455133
## iter  40 value 64.447088
## iter  50 value 64.246679
## iter  60 value 63.881565
## iter  70 value 60.092844
## iter  80 value 58.724277
## iter  90 value 58.414304
## iter 100 value 57.871346
## final  value 57.871346
## stopped after 100 iterations
## # weights:  109
## initial  value 110.858254
## iter  10 value 29.001877
## iter  20 value 16.789302
## iter  30 value 7.506211
## iter  40 value 6.219350
## iter  50 value 6.161157
## iter  60 value 4.059504
## iter  70 value 3.457172
## iter  80 value 3.435059
## iter  90 value 3.424010
## iter 100 value 3.317053
## final  value 3.317053
## stopped after 100 iterations
## # weights:  179
## initial  value 110.282140
## iter  10 value 28.800328
## iter  20 value 6.689439
## iter  30 value 4.789840
## iter  40 value 4.408558
## iter  50 value 4.382627
## iter  60 value 4.362895
## iter  70 value 4.331598
## iter  80 value 4.256061
## iter  90 value 4.225633
## iter 100 value 4.197079
## final  value 4.197079
## stopped after 100 iterations
## # weights:  39
## initial  value 104.199667
## iter  10 value 97.135992
## iter  20 value 56.562187
## iter  30 value 53.550246
## iter  40 value 52.804511
## iter  50 value 52.711283
```

```
## iter  60 value 51.891958
## final  value 51.890736
## converged
## # weights:  109
## initial  value 105.783987
## iter  10 value 36.051260
## iter  20 value 22.872095
## iter  30 value 20.441291
## iter  40 value 18.904560
## iter  50 value 16.815182
## iter  60 value 14.170870
## iter  70 value 13.590886
## iter  80 value 13.285516
## iter  90 value 12.084669
## iter 100 value 11.653061
## final  value 11.653061
## stopped after 100 iterations
## # weights:  179
## initial  value 96.573742
## iter  10 value 12.426671
## iter  20 value 2.603671
## iter  30 value 1.917845
## iter  40 value 1.910446
## iter  50 value 1.909701
## iter  60 value 1.909643
## iter  70 value 1.909593
## iter  80 value 1.909558
## final  value 1.909547
## converged
## # weights:  39
## initial  value 101.891132
## iter  10 value 69.822588
## iter  20 value 61.578350
## iter  30 value 60.159555
## iter  40 value 60.018445
## iter  50 value 59.867250
## iter  60 value 59.428108
## iter  70 value 58.797558
## iter  80 value 58.706134
## final  value 58.706132
## converged
## # weights:  109
## initial  value 110.075670
## iter  10 value 34.387351
## iter  20 value 24.792969
## iter  30 value 17.717945
## iter  40 value 16.213801
## iter  50 value 16.092456
## iter  60 value 16.084662
## iter  70 value 16.047551
## iter  80 value 16.037774
## iter  90 value 16.037331
## final  value 16.037330
## converged
```

```
## # weights:  179
## initial  value 115.708334
## iter  10 value 42.720787
## iter  20 value 20.745700
## iter  30 value 14.462041
## iter  40 value 12.080624
## iter  50 value 11.655244
## iter  60 value 11.635620
## iter  70 value 11.635378
## final  value 11.635378
## converged
## # weights:  39
## initial  value 106.069473
## iter  10 value 60.522302
## iter  20 value 54.527704
## iter  30 value 52.284471
## iter  40 value 52.245304
## iter  50 value 52.220860
## iter  60 value 52.217541
## iter  70 value 52.211214
## iter  80 value 52.199208
## iter  90 value 52.196297
## iter 100 value 51.913035
## final  value 51.913035
## stopped after 100 iterations
## # weights:  109
## initial  value 100.772932
## iter  10 value 29.274090
## iter  20 value 14.998718
## iter  30 value 9.514034
## iter  40 value 5.471462
## iter  50 value 3.668361
## iter  60 value 1.731531
## iter  70 value 1.034792
## iter  80 value 0.361360
## iter  90 value 0.240437
## iter 100 value 0.229935
## final  value 0.229935
## stopped after 100 iterations
## # weights:  179
## initial  value 131.203469
## iter  10 value 5.399975
## iter  20 value 1.865071
## iter  30 value 1.654823
## iter  40 value 1.633759
## iter  50 value 1.616382
## iter  60 value 0.897032
## iter  70 value 0.375729
## iter  80 value 0.288597
## iter  90 value 0.269633
## iter 100 value 0.244476
## final  value 0.244476
## stopped after 100 iterations
## # weights:  39
```

```
## initial  value 106.725442
## iter  10 value 67.053000
## iter  20 value 56.918741
## iter  30 value 46.879204
## iter  40 value 44.334662
## iter  50 value 42.518050
## iter  60 value 40.093907
## iter  70 value 38.287869
## iter  80 value 38.150847
## iter  90 value 38.133178
## iter 100 value 36.251203
## final  value 36.251203
## stopped after 100 iterations
## # weights:  109
## initial  value 99.236726
## iter  10 value 44.895310
## iter  20 value 21.492675
## iter  30 value 17.203205
## iter  40 value 13.691408
## iter  50 value 13.322819
## iter  60 value 13.232507
## iter  70 value 13.132122
## iter  80 value 13.099709
## iter  90 value 12.887211
## iter 100 value 12.884616
## final  value 12.884616
## stopped after 100 iterations
## # weights:  179
## initial  value 111.511383
## iter  10 value 18.072316
## iter  20 value 5.464337
## iter  30 value 3.728225
## iter  40 value 2.450664
## iter  50 value 2.254004
## iter  60 value 0.036160
## iter  70 value 0.011363
## iter  80 value 0.006209
## iter  90 value 0.004781
## iter 100 value 0.001038
## final  value 0.001038
## stopped after 100 iterations
## # weights:  39
## initial  value 100.861818
## iter  10 value 84.419478
## iter  20 value 67.939160
## iter  30 value 60.947374
## iter  40 value 57.497592
## iter  50 value 57.031335
## iter  60 value 56.438293
## iter  70 value 56.277117
## iter  80 value 55.736112
## iter  90 value 55.373229
## iter 100 value 54.703824
## final  value 54.703824
```

```
## stopped after 100 iterations
## # weights:  109
## initial  value 104.752870
## iter  10 value 44.024183
## iter  20 value 20.712667
## iter  30 value 19.062730
## iter  40 value 18.680577
## iter  50 value 18.546841
## iter  60 value 17.398069
## iter  70 value 15.545792
## iter  80 value 15.291764
## iter  90 value 15.287046
## final  value 15.287042
## converged
## # weights:  179
## initial  value 102.107527
## iter  10 value 41.754701
## iter  20 value 21.796409
## iter  30 value 14.222965
## iter  40 value 12.493327
## iter  50 value 11.733633
## iter  60 value 11.502781
## iter  70 value 11.442943
## iter  80 value 11.436353
## iter  90 value 11.435682
## iter 100 value 11.435662
## final  value 11.435662
## stopped after 100 iterations
## # weights:  39
## initial  value 108.891915
## iter  10 value 63.108813
## iter  20 value 55.576404
## iter  30 value 50.921987
## iter  40 value 50.207962
## iter  50 value 47.339088
## iter  60 value 44.101552
## iter  70 value 43.799540
## iter  80 value 43.781113
## iter  90 value 43.654310
## iter 100 value 38.693899
## final  value 38.693899
## stopped after 100 iterations
## # weights:  109
## initial  value 110.952063
## iter  10 value 37.488567
## iter  20 value 30.185653
## iter  30 value 29.821775
## iter  40 value 29.396215
## iter  50 value 27.824730
## iter  60 value 26.626484
## iter  70 value 22.601763
## iter  80 value 15.203914
## iter  90 value 13.401902
## iter 100 value 11.330811
```

```
## final  value 11.330811
## stopped after 100 iterations
## # weights:  179
## initial  value 99.249948
## iter  10 value 32.736158
## iter  20 value 3.701963
## iter  30 value 2.149204
## iter  40 value 2.120049
## iter  50 value 2.102357
## iter  60 value 2.084592
## iter  70 value 2.069249
## iter  80 value 2.057716
## iter  90 value 2.036711
## iter 100 value 1.525674
## final  value 1.525674
## stopped after 100 iterations
## # weights:  39
## initial  value 103.216005
## iter  10 value 74.740566
## iter  20 value 60.956468
## iter  30 value 57.996337
## iter  40 value 56.196639
## iter  50 value 55.792579
## iter  60 value 55.737553
## iter  70 value 55.725442
## iter  80 value 55.723004
## iter  90 value 55.722208
## iter 100 value 55.722007
## final  value 55.722007
## stopped after 100 iterations
## # weights:  109
## initial  value 99.992490
## iter  10 value 29.219300
## iter  20 value 18.717110
## iter  30 value 13.955319
## iter  40 value 9.876802
## iter  50 value 3.627456
## iter  60 value 2.611170
## iter  70 value 2.286633
## iter  80 value 2.072900
## iter  90 value 1.975204
## iter 100 value 1.944077
## final  value 1.944077
## stopped after 100 iterations
## # weights:  179
## initial  value 110.017516
## iter  10 value 21.954782
## iter  20 value 4.025205
## iter  30 value 0.244180
## iter  40 value 0.026057
## iter  50 value 0.012079
## iter  60 value 0.004546
## iter  70 value 0.001620
## iter  80 value 0.000766
```

```
## iter  90 value 0.000462
## iter 100 value 0.000211
## final  value 0.000211
## stopped after 100 iterations
## # weights:  39
## initial  value 107.890868
## iter  10 value 78.820789
## iter  20 value 72.753054
## iter  30 value 67.916754
## iter  40 value 61.769060
## iter  50 value 59.796064
## iter  60 value 58.088285
## iter  70 value 58.019691
## final  value 58.019672
## converged
## # weights:  109
## initial  value 111.946860
## iter  10 value 48.955522
## iter  20 value 26.266252
## iter  30 value 18.749171
## iter  40 value 17.163630
## iter  50 value 16.666293
## iter  60 value 16.574378
## iter  70 value 16.568674
## final  value 16.568664
## converged
## # weights:  179
## initial  value 120.143642
## iter  10 value 33.821112
## iter  20 value 21.411552
## iter  30 value 14.814050
## iter  40 value 13.566355
## iter  50 value 12.211218
## iter  60 value 11.840829
## iter  70 value 11.834729
## iter  80 value 11.834604
## final  value 11.834603
## converged
## # weights:  39
## initial  value 99.321827
## iter  10 value 64.839847
## iter  20 value 55.493800
## iter  30 value 47.528062
## iter  40 value 43.593625
## iter  50 value 41.135095
## iter  60 value 40.483243
## iter  70 value 39.581304
## iter  80 value 37.838053
## iter  90 value 37.656372
## iter 100 value 37.570377
## final  value 37.570377
## stopped after 100 iterations
## # weights:  109
## initial  value 98.614268
```

```
## iter  10 value 35.386405
## iter  20 value 27.307056
## iter  30 value 10.182678
## iter  40 value 6.478050
## iter  50 value 5.518198
## iter  60 value 5.451700
## iter  70 value 5.337942
## iter  80 value 5.211909
## iter  90 value 5.140635
## iter 100 value 5.128243
## final  value 5.128243
## stopped after 100 iterations
## # weights:  179
## initial  value 104.556780
## iter  10 value 28.861421
## iter  20 value 16.359042
## iter  30 value 12.171576
## iter  40 value 9.095570
## iter  50 value 7.948036
## iter  60 value 6.018246
## iter  70 value 4.617903
## iter  80 value 3.868424
## iter  90 value 2.484282
## iter 100 value 2.076188
## final  value 2.076188
## stopped after 100 iterations
## # weights:  39
## initial  value 108.809362
## iter  10 value 82.282259
## iter  20 value 79.054473
## iter  30 value 76.648013
## iter  40 value 73.668901
## iter  50 value 68.440641
## iter  60 value 64.459788
## iter  70 value 62.144393
## iter  80 value 61.681460
## iter  90 value 60.005582
## iter 100 value 55.357053
## final  value 55.357053
## stopped after 100 iterations
## # weights:  109
## initial  value 105.132695
## iter  10 value 28.650164
## iter  20 value 13.742007
## iter  30 value 10.921882
## iter  40 value 10.882696
## iter  50 value 10.882002
## iter  60 value 10.881369
## iter  70 value 10.229645
## iter  80 value 10.227415
## final  value 10.227412
## converged
## # weights:  179
## initial  value 109.845005
```

```
## iter  10 value 60.807257
## iter  20 value 26.762643
## iter  30 value 16.621174
## iter  40 value 13.121577
## iter  50 value 6.575265
## iter  60 value 5.898170
## iter  70 value 4.484082
## iter  80 value 4.023736
## iter  90 value 4.004326
## iter 100 value 3.979873
## final  value 3.979873
## stopped after 100 iterations
## # weights:  39
## initial  value 105.537692
## iter  10 value 69.110092
## iter  20 value 62.716633
## iter  30 value 60.195828
## iter  40 value 59.201423
## iter  50 value 58.486384
## iter  60 value 58.282270
## iter  70 value 57.819131
## final  value 57.808905
## converged
## # weights:  109
## initial  value 105.149562
## iter  10 value 51.660696
## iter  20 value 34.190558
## iter  30 value 24.122861
## iter  40 value 18.121648
## iter  50 value 17.216555
## iter  60 value 17.125182
## iter  70 value 16.624065
## iter  80 value 16.427706
## iter  90 value 16.333064
## iter 100 value 16.318269
## final  value 16.318269
## stopped after 100 iterations
## # weights:  179
## initial  value 121.698118
## iter  10 value 57.422570
## iter  20 value 26.810319
## iter  30 value 16.653453
## iter  40 value 14.301596
## iter  50 value 13.403715
## iter  60 value 12.803918
## iter  70 value 12.610607
## iter  80 value 12.594299
## iter  90 value 12.589890
## iter 100 value 12.588611
## final  value 12.588611
## stopped after 100 iterations
## # weights:  39
## initial  value 106.626626
## iter  10 value 74.087800
```

```
## iter  20 value 62.536005
## iter  30 value 55.653646
## iter  40 value 51.206462
## iter  50 value 47.699505
## iter  60 value 47.402029
## iter  70 value 47.358950
## iter  80 value 47.354316
## iter  90 value 47.353375
## iter 100 value 47.352791
## final  value 47.352791
## stopped after 100 iterations
## # weights:  109
## initial  value 97.909507
## iter  10 value 32.940182
## iter  20 value 16.448580
## iter  30 value 11.752310
## iter  40 value 10.351772
## iter  50 value 9.825231
## iter  60 value 8.384007
## iter  70 value 8.220313
## iter  80 value 7.837716
## iter  90 value 7.736864
## iter 100 value 7.616654
## final  value 7.616654
## stopped after 100 iterations
## # weights:  179
## initial  value 110.939234
## iter  10 value 18.896341
## iter  20 value 6.357458
## iter  30 value 5.017966
## iter  40 value 3.604925
## iter  50 value 3.498478
## iter  60 value 3.478419
## iter  70 value 2.912463
## iter  80 value 2.137091
## iter  90 value 2.104093
## iter 100 value 2.090416
## final  value 2.090416
## stopped after 100 iterations
## # weights:  39
## initial  value 107.431463
## iter  10 value 94.081265
## iter  20 value 74.152160
## iter  30 value 73.072557
## iter  40 value 70.888173
## iter  50 value 69.574502
## iter  60 value 66.841615
## iter  70 value 66.360837
## iter  80 value 60.878642
## iter  90 value 59.911318
## iter 100 value 59.751474
## final  value 59.751474
## stopped after 100 iterations
## # weights:  109
```

```
## initial  value 119.777607
## iter  10 value 38.426096
## iter  20 value 13.419502
## iter  30 value 12.927932
## iter  40 value 12.715726
## iter  50 value 10.540310
## iter  60 value 10.017055
## iter  70 value 6.891419
## iter  80 value 6.776533
## iter  90 value 6.773448
## iter 100 value 6.772103
## final  value 6.772103
## stopped after 100 iterations
## # weights:  179
## initial  value 103.608488
## iter  10 value 13.368798
## iter  20 value 0.634417
## iter  30 value 0.012090
## final  value 0.000063
## converged
## # weights:  39
## initial  value 99.676914
## iter  10 value 66.641104
## iter  20 value 61.282028
## iter  30 value 59.915630
## iter  40 value 59.679407
## iter  50 value 58.891108
## iter  60 value 58.070548
## iter  70 value 57.102715
## iter  80 value 56.908231
## iter  90 value 56.904636
## final  value 56.904624
## converged
## # weights:  109
## initial  value 111.619633
## iter  10 value 64.198248
## iter  20 value 40.050037
## iter  30 value 27.964938
## iter  40 value 18.581947
## iter  50 value 16.362595
## iter  60 value 15.816054
## iter  70 value 15.632172
## iter  80 value 15.613596
## iter  90 value 15.612880
## iter 100 value 15.612768
## final  value 15.612768
## stopped after 100 iterations
## # weights:  179
## initial  value 119.434561
## iter  10 value 33.830236
## iter  20 value 16.722051
## iter  30 value 13.713529
## iter  40 value 13.425083
## iter  50 value 13.070572
```

```
## iter  60 value 12.398017
## iter  70 value 12.326190
## iter  80 value 12.324373
## final  value 12.324340
## converged
## # weights:  39
## initial  value 111.185498
## iter  10 value 67.513777
## iter  20 value 59.708386
## iter  30 value 56.224334
## iter  40 value 55.837657
## iter  50 value 55.779602
## iter  60 value 55.668235
## iter  70 value 55.571100
## iter  80 value 55.510237
## iter  90 value 54.470742
## iter 100 value 54.270373
## final  value 54.270373
## stopped after 100 iterations
## # weights:  109
## initial  value 95.403886
## iter  10 value 25.218678
## iter  20 value 9.718044
## iter  30 value 9.239404
## iter  40 value 9.204647
## iter  50 value 9.115589
## iter  60 value 9.005080
## iter  70 value 8.971842
## iter  80 value 8.826047
## iter  90 value 8.819690
## iter 100 value 8.588028
## final  value 8.588028
## stopped after 100 iterations
## # weights:  179
## initial  value 124.887593
## iter  10 value 34.242865
## iter  20 value 12.542742
## iter  30 value 11.147125
## iter  40 value 10.449822
## iter  50 value 5.399940
## iter  60 value 2.657580
## iter  70 value 2.576438
## iter  80 value 2.537059
## iter  90 value 2.501625
## iter 100 value 1.645524
## final  value 1.645524
## stopped after 100 iterations
## # weights:  39
## initial  value 108.058228
## iter  10 value 66.576457
## iter  20 value 59.831923
## iter  30 value 55.867867
## iter  40 value 55.145270
## iter  50 value 54.504772
```

```
## iter  60 value 53.764545
## iter  70 value 53.190535
## iter  80 value 52.611680
## iter  90 value 51.930103
## iter 100 value 51.594752
## final  value 51.594752
## stopped after 100 iterations
## # weights:  109
## initial  value 108.108231
## iter  10 value 34.286724
## iter  20 value 21.783733
## iter  30 value 16.753119
## iter  40 value 12.993231
## iter  50 value 10.432526
## iter  60 value 10.348286
## iter  70 value 10.342348
## iter  80 value 10.341741
## iter  90 value 10.341601
## final  value 10.341593
## converged
## # weights:  179
## initial  value 109.183174
## iter  10 value 26.022158
## iter  20 value 6.976148
## iter  30 value 6.169617
## iter  40 value 6.159280
## iter  50 value 5.085302
## iter  60 value 2.780161
## iter  70 value 2.774497
## iter  80 value 2.773641
## iter  90 value 2.773408
## iter 100 value 2.770845
## final  value 2.770845
## stopped after 100 iterations
## # weights:  39
## initial  value 104.882029
## iter  10 value 79.226375
## iter  20 value 66.130154
## iter  30 value 62.480330
## iter  40 value 60.452157
## iter  50 value 59.870426
## iter  60 value 59.529400
## iter  70 value 59.512856
## iter  80 value 59.372216
## iter  90 value 59.074647
## iter 100 value 59.011622
## final  value 59.011622
## stopped after 100 iterations
## # weights:  109
## initial  value 108.260308
## iter  10 value 71.546898
## iter  20 value 46.979786
## iter  30 value 25.038661
## iter  40 value 18.233025
```

```
## iter  50 value 17.165942
## iter  60 value 17.103759
## iter  70 value 17.097545
## iter  80 value 17.097418
## final  value 17.097416
## converged
## # weights:  179
## initial  value 108.514646
## iter  10 value 40.516515
## iter  20 value 17.317074
## iter  30 value 13.212413
## iter  40 value 12.735248
## iter  50 value 12.601368
## iter  60 value 12.534321
## iter  70 value 12.439698
## iter  80 value 12.402127
## iter  90 value 12.401633
## final  value 12.401632
## converged
## # weights:  39
## initial  value 107.236716
## iter  10 value 61.606762
## iter  20 value 54.433158
## iter  30 value 51.623683
## iter  40 value 51.602323
## iter  50 value 51.592410
## iter  60 value 51.582496
## iter  70 value 51.579357
## iter  80 value 51.568045
## iter  90 value 51.566858
## iter 100 value 51.561059
## final  value 51.561059
## stopped after 100 iterations
## # weights:  109
## initial  value 110.666515
## iter  10 value 55.952169
## iter  20 value 20.488263
## iter  30 value 7.286823
## iter  40 value 4.323604
## iter  50 value 4.307191
## iter  60 value 4.289647
## iter  70 value 4.279134
## iter  80 value 4.266235
## iter  90 value 4.258850
## iter 100 value 2.057594
## final  value 2.057594
## stopped after 100 iterations
## # weights:  179
## initial  value 116.198662
## iter  10 value 44.484663
## iter  20 value 16.848190
## iter  30 value 14.185958
## iter  40 value 13.854471
## iter  50 value 13.762603
```

```
## iter  60 value 13.622751
## iter  70 value 13.530163
## iter  80 value 13.336184
## iter  90 value 13.225257
## iter 100 value 12.918183
## final  value 12.918183
## stopped after 100 iterations
## # weights:  179
## initial  value 136.763563
## iter  10 value 41.095424
## iter  20 value 22.265719
## iter  30 value 14.637937
## iter  40 value 13.449071
## iter  50 value 12.927608
## iter  60 value 12.774159
## iter  70 value 12.768531
## iter  80 value 12.767823
## iter  90 value 12.767793
## final  value 12.767792
## converged
```

```
## NB
nb_fit <- train(`PAM50.mRNA`~., data = data_norm, method = "nb",
               trControl = fitControl)
## rf
rf_fit<- train(`PAM50.mRNA`~., data = data_norm, method = "rf",
               trControl = fitControl)
```

```
print(svm_fit)
```

```
## Support Vector Machines with Linear Kernel
##
## 80 samples
## 30 predictors
##  4 classes: 'Basal.like', 'HER2.enriched', 'Luminal.A', 'Luminal.B'
##
## No pre-processing
## Resampling: Cross-Validated (10 fold, repeated 10 times)
## Summary of sample sizes: 72, 71, 73, 72, 74, 71, ...
## Resampling results:
##
##   Accuracy  Kappa      Mean_F1    Mean_Sensitivity  Mean_Specificity
##   0.773627  0.6904643  0.8352319  0.75375           0.9240625
##   Mean_Pos_Pred_Value  Mean_Neg_Pred_Value  Mean_Precision  Mean_Recall
##   0.8312189            0.9320476            0.8312189       0.75375
##   Mean_Detection_Rate  Mean_Balanced_Accuracy
##   0.1934067            0.8389062
##
## Tuning parameter 'C' was held constant at a value of 1
```

```
print(nn_fit)
```

```
## Neural Network
```

```
##
## 80 samples
## 30 predictors
##  4 classes: 'Basal.like', 'HER2.enriched', 'Luminal.A', 'Luminal.B'
##
## No pre-processing
## Resampling: Cross-Validated (10 fold, repeated 10 times)
## Summary of sample sizes: 73, 72, 73, 72, 71, 71, ...
## Resampling results across tuning parameters:
##
##   size  decay  Accuracy   Kappa      Mean_F1    Mean_Sensitivity
##   1     0e+00  0.4472341  0.2358024        NaN  0.4129167
##   1     1e-04  0.4605357  0.2544349  0.7333333  0.4229167
##   1     1e-01  0.4891270  0.2907450        NaN  0.4345833
##   3     0e+00  0.6687024  0.5472742  0.8074968  0.6454167
##   3     1e-04  0.6853690  0.5716715  0.8136905  0.6675000
##   3     1e-01  0.7526468  0.6616359  0.8332393  0.7362500
##   5     0e+00  0.7288532  0.6291137  0.8144093  0.7095833
##   5     1e-04  0.7279405  0.6288051  0.8103571  0.7141667
##   5     1e-01  0.7535198  0.6617535  0.8208433  0.7362500
##   Mean_Specificity  Mean_Pos_Pred_Value  Mean_Neg_Pred_Value  Mean_Precision
##   0.8095685         0.2013889            0.8430345            0.2013889
##   0.8140060         0.3437500            0.8453052            0.3437500
##   0.8236101               NaN            0.8503482                  NaN
##   0.8889226         0.7077381            0.8997837            0.7077381
##   0.8952708         0.7687147            0.9034683            0.7687147
##   0.9169792         0.8092857            0.9243720            0.8092857
##   0.9088750         0.7972854            0.9175198            0.7972854
##   0.9085863         0.7939394            0.9170089            0.7939394
##   0.9163363         0.8301329            0.9250337            0.8301329
##   Mean_Recall  Mean_Detection_Rate  Mean_Balanced_Accuracy
##   0.4129167    0.1118085            0.6112426
##   0.4229167    0.1151339            0.6184613
##   0.4345833    0.1222817            0.6290967
##   0.6454167    0.1671756            0.7671696
##   0.6675000    0.1713423            0.7813854
##   0.7362500    0.1881617            0.8266146
##   0.7095833    0.1822133            0.8092292
##   0.7141667    0.1819851            0.8113765
##   0.7362500    0.1883800            0.8262932
##
## Accuracy was used to select the optimal model using the largest value.
## The final values used for the model were size = 5 and decay = 0.1.
```

```
print(nb_fit)
```

```
## Naive Bayes
##
## 80 samples
## 30 predictors
##  4 classes: 'Basal.like', 'HER2.enriched', 'Luminal.A', 'Luminal.B'
##
## No pre-processing
## Resampling: Cross-Validated (10 fold, repeated 10 times)
```

```
## Summary of sample sizes: 73, 72, 72, 71, 73, 72, ...
## Resampling results across tuning parameters:
##
##   usekernel  Accuracy   Kappa      Mean_F1    Mean_Sensitivity
##   FALSE      0.8373254  0.7768836  0.8669276  0.8158333
##    TRUE      0.7897500  0.7110541  0.8270833  0.7725000
##   Mean_Specificity  Mean_Pos_Pred_Value  Mean_Neg_Pred_Value  Mean_Precision
##   0.9461488         0.8716564            0.9516062            0.8716564
##   0.9291667         0.8435065            0.9370962            0.8435065
##   Mean_Recall  Mean_Detection_Rate  Mean_Balanced_Accuracy
##   0.8158333    0.2093313            0.8809911
##   0.7725000    0.1974375            0.8508333
##
## Tuning parameter 'fL' was held constant at a value of 0
## Tuning
##  parameter 'adjust' was held constant at a value of 1
## Accuracy was used to select the optimal model using the largest value.
## The final values used for the model were fL = 0, usekernel = FALSE and adjust
##  = 1.
```

```
print(rf_fit)
```

```
## Random Forest
##
## 80 samples
## 30 predictors
##  4 classes: 'Basal.like', 'HER2.enriched', 'Luminal.A', 'Luminal.B'
##
## No pre-processing
## Resampling: Cross-Validated (10 fold, repeated 10 times)
## Summary of sample sizes: 72, 72, 73, 71, 72, 72, ...
## Resampling results across tuning parameters:
##
##   mtry  Accuracy   Kappa      Mean_F1    Mean_Sensitivity  Mean_Specificity
##    2    0.7795238  0.6920946  0.8228571  0.7362500         0.9227470
##   16    0.7430873  0.6407666  0.8059382  0.6979167         0.9101488
##   30    0.7337460  0.6283982  0.7890110  0.6891667         0.9067500
##   Mean_Pos_Pred_Value  Mean_Neg_Pred_Value  Mean_Precision  Mean_Recall
##   0.8804167            0.9350367            0.8804167       0.7362500
##   0.8441123            0.9238899            0.8441123       0.6979167
##   0.8331349            0.9207579            0.8331349       0.6891667
##   Mean_Detection_Rate  Mean_Balanced_Accuracy
##   0.1948810            0.8294985
##   0.1857718            0.8040327
##   0.1834365            0.7979583
##
## Accuracy was used to select the optimal model using the largest value.
## The final value used for the model was mtry = 2.
```

Before, K-fold cross validation, The SVM model achieved a accuracy of 76% The neural networks model achieved accuracy of 71% The naive bayes model achieved a accuracy of 76%

k-Fold Cross Validation is done for the whole dataset. I have used k = 10 which means 10 folds take place along with 10 repetitions. For testing the data, I have used 3 models to test the k-fold CV

(10 fold, repeated 10 times)

1. SVM :

Accuracy - 0.773627 Kappa - 0.6904643
Mean_F1 - 0.8352319 Mean_Sensitivity - 0.75375
Mean_Specificity - 0.9240625 Mean_Precision - 0.8312189 Mean_Recall - 0.75375

There's no much change after applying k-fold cross validation

2. Neural Networks :

Accuracy - 0.7786581 Kappa - 0.6980310
Mean_F1 - 0.7569600 Mean_Sensitivity - 0.7568452
Mean_Specificity - 0.9250575 Mean_Precision - 0.7997022 Mean_Recall - 0.7568452

3. Naive baye's : Accuracy - 0.7535198 Kappa - 0.6617535
   Mean_F1 - 0.8208433 Mean_Sensitivity - 0.7362500
   Mean_Specificity - 0.8410706 Mean_Precision - 0.9163363 Mean_Recall - 0.7362500

4. Random Forests:

Accuracy - 0.7795238 Kappa - 0.6920946 Mean_F1 - 0.8228571 Mean_Sensitivity - 0.7362500
Mean_Specificity - 0.9227470 Mean_Precision - 0.8331349
Mean_Recall - 0.6891667

HYPERPARAMETER TUNING

1. SVM

The tuning and training of an SVM with a linear kernel is demonstrated in the code below, which also controls crossvalidation for tuning the hyperparameter C.

```
set.seed(10)
#Configuring train control for cross validation and hyperparameter calibration
train_control <- trainControl(method="repeatedcv", number=10, repeats=10, savePredictions = TRUE, summa
#Tunegrid for various C values
grid <- expand.grid(C = seq(0.000001,0.15,0.002))
set.seed(10)
svm.lin.mod <- train(PAM50.mRNA ~ ., data=data_norm[samp,], trControl=train_control, method="svmLinear"
svm.predicts <- predict(svm.lin.mod, newdata = data_norm[-samp,])
confusionMatrix(svm.predicts, factor(data_norm$PAM50.mRNA[-samp]), mode = "everything")
```

```
## Confusion Matrix and Statistics
##
##                Reference
## Prediction      Basal.like HER2.enriched Luminal.A Luminal.B
##   Basal.like             5             2         0         0
##   HER2.enriched          0             1         0         0
##   Luminal.A              0             0         5         1
##   Luminal.B              0             0         1         6
```

```
##
## Overall Statistics
##
##                Accuracy : 0.8095
##                  95% CI : (0.5809, 0.9455)
##     No Information Rate : 0.3333
##     P-Value [Acc > NIR] : 1.026e-05
##
##                   Kappa : 0.7358
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Basal.like Class: HER2.enriched Class: Luminal.A
## Sensitivity                     1.0000              0.33333           0.8333
## Specificity                     0.8750              1.00000           0.9333
## Pos Pred Value                  0.7143              1.00000           0.8333
## Neg Pred Value                  1.0000              0.90000           0.9333
## Precision                       0.7143              1.00000           0.8333
## Recall                          1.0000              0.33333           0.8333
## F1                              0.8333              0.50000           0.8333
## Prevalence                      0.2381              0.14286           0.2857
## Detection Rate                  0.2381              0.04762           0.2381
## Detection Prevalence            0.3333              0.04762           0.2857
## Balanced Accuracy               0.9375              0.66667           0.8833
##                      Class: Luminal.B
## Sensitivity                    0.8571
## Specificity                    0.9286
## Pos Pred Value                 0.8571
## Neg Pred Value                 0.9286
## Precision                      0.8571
## Recall                         0.8571
## F1                             0.8571
## Prevalence                     0.3333
## Detection Rate                 0.2857
## Detection Prevalence           0.3333
## Balanced Accuracy              0.8929
```

The SVM model achieved accuracy of 80% after hyper-parameter tuning. Therefore, no much change after tuning

NN

```
set.seed(5000)
cctrlR <- trainControl(method = "repeatedcv", number=10, repeats=10, returnResamp = "all", search = "ra
nn <- train(PAM50.mRNA ~., data= data_norm[samp,],
               method = "nnet",
               trControl = cctrlR,
               preProc = c("center", "scale"),
               trace = FALSE)
```

```r
nnpred <- predict(nn, newdata= data_norm[-samp,])
#viewing confusion matrix
confusionMatrix(nnpred, factor(data_norm$PAM50.mRNA[-samp]), mode = "everything")
```

```
## Confusion Matrix and Statistics
##
##               Reference
## Prediction      Basal.like HER2.enriched Luminal.A Luminal.B
##   Basal.like             5             1         0         0
##   HER2.enriched          0             1         0         0
##   Luminal.A              0             0         6         2
##   Luminal.B              0             1         0         5
##
## Overall Statistics
##
##                Accuracy : 0.8095
##                  95% CI : (0.5809, 0.9455)
##     No Information Rate : 0.3333
##     P-Value [Acc > NIR] : 1.026e-05
##
##                   Kappa : 0.7358
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Basal.like Class: HER2.enriched Class: Luminal.A
## Sensitivity                     1.0000              0.33333           1.0000
## Specificity                     0.9375              1.00000           0.8667
## Pos Pred Value                  0.8333              1.00000           0.7500
## Neg Pred Value                  1.0000              0.90000           1.0000
## Precision                       0.8333              1.00000           0.7500
## Recall                          1.0000              0.33333           1.0000
## F1                              0.9091              0.50000           0.8571
## Prevalence                      0.2381              0.14286           0.2857
## Detection Rate                  0.2381              0.04762           0.2857
## Detection Prevalence            0.2857              0.04762           0.3810
## Balanced Accuracy               0.9688              0.66667           0.9333
##                      Class: Luminal.B
## Sensitivity                    0.7143
## Specificity                    0.9286
## Pos Pred Value                 0.8333
## Neg Pred Value                 0.8667
## Precision                      0.8333
## Recall                         0.7143
## F1                             0.7692
## Prevalence                     0.3333
## Detection Rate                 0.2381
## Detection Prevalence           0.2857
## Balanced Accuracy              0.8214
```

The model achieved accuracy of 80.1% after hyper parameter tuning

```r
nb1 <- train(`PAM50.mRNA`~., data = data_norm[samp,], method = "nb",
               trControl = trainControl(method = "repeatedcv", number=10, repeats=10),
               tuneGrid = data.frame(usekernel = TRUE, fL = 0.5, adjust = 5))
bps <- predict(nb1, newdata=data_norm[-samp,])
nbpred <- predict(nb1, newdata= data_norm[-samp,])

#viewing confusion matrix
confusionMatrix(nbpred, factor(data_norm$PAM50.mRNA[-samp]), mode = "everything")
```

```
## Confusion Matrix and Statistics
##
##                Reference
## Prediction      Basal.like HER2.enriched Luminal.A Luminal.B
##   Basal.like             5             3         0         1
##   HER2.enriched          0             0         0         0
##   Luminal.A              0             0         5         1
##   Luminal.B              0             0         1         5
##
## Overall Statistics
##
##                Accuracy : 0.7143
##                  95% CI : (0.4782, 0.8872)
##     No Information Rate : 0.3333
##     P-Value [Acc > NIR] : 0.0004045
##
##                   Kappa : 0.6038
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Basal.like Class: HER2.enriched Class: Luminal.A
## Sensitivity                     1.0000               0.0000           0.8333
## Specificity                     0.7500               1.0000           0.9333
## Pos Pred Value                  0.5556                  NaN           0.8333
## Neg Pred Value                  1.0000               0.8571           0.9333
## Precision                       0.5556                   NA           0.8333
## Recall                          1.0000               0.0000           0.8333
## F1                              0.7143                   NA           0.8333
## Prevalence                      0.2381               0.1429           0.2857
## Detection Rate                  0.2381               0.0000           0.2381
## Detection Prevalence            0.4286               0.0000           0.2857
## Balanced Accuracy               0.8750               0.5000           0.8833
##                      Class: Luminal.B
## Sensitivity                    0.7143
## Specificity                    0.9286
## Pos Pred Value                 0.8333
## Neg Pred Value                 0.8667
## Precision                      0.8333
## Recall                         0.7143
## F1                             0.7692
## Prevalence                     0.3333
## Detection Rate                 0.2381
```

```
## Detection Prevalence           0.2857
## Balanced Accuracy              0.8214
```

The model achieved 71.4% accuracy after hyper parameter tuning

```r
rb <- train(`PAM50.mRNA`~., data = data_norm[samp,], method = "rf",
               trControl = trainControl(method = "repeatedcv", number=10, repeats=10))
rbps <- predict(rb, newdata=data_norm[-samp,])
#viewing confusion matrix
confusionMatrix(rbps, factor(data_norm$PAM50.mRNA[-samp]), mode = "everything")
```

```
## Confusion Matrix and Statistics
##
##                  Reference
## Prediction        Basal.like HER2.enriched Luminal.A Luminal.B
##   Basal.like               4             1         0         1
##   HER2.enriched            0             1         0         0
##   Luminal.A                1             0         5         2
##   Luminal.B                0             1         1         4
##
## Overall Statistics
##
##                  Accuracy : 0.6667
##                    95% CI : (0.4303, 0.8541)
##     No Information Rate : 0.3333
##     P-Value [Acc > NIR] : 0.001827
##
##                     Kappa : 0.5377
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Basal.like Class: HER2.enriched Class: Luminal.A
## Sensitivity                     0.8000              0.33333           0.8333
## Specificity                     0.8750              1.00000           0.8000
## Pos Pred Value                  0.6667              1.00000           0.6250
## Neg Pred Value                  0.9333              0.90000           0.9231
## Precision                       0.6667              1.00000           0.6250
## Recall                          0.8000              0.33333           0.8333
## F1                              0.7273              0.50000           0.7143
## Prevalence                      0.2381              0.14286           0.2857
## Detection Rate                  0.1905              0.04762           0.2381
## Detection Prevalence            0.2857              0.04762           0.3810
## Balanced Accuracy               0.8375              0.66667           0.8167
##                      Class: Luminal.B
## Sensitivity                    0.5714
## Specificity                    0.8571
## Pos Pred Value                 0.6667
## Neg Pred Value                 0.8000
## Precision                      0.6667
## Recall                         0.5714
## F1                             0.6154
```

```
## Prevalence                    0.3333
## Detection Rate                0.1905
## Detection Prevalence          0.2857
## Balanced Accuracy             0.7143
```

The model achieved 66.6% accuracy after hyper parameter tuning

The SVM model achieved a accuracy of 80% and the accuracy remained same after hyper-parameter tuning The neural networks model achieved accuracy of 80% and the accuracy remained the same after hyper-parameter tuning The naive bayes model achieved a accuracy of 76% and the accuracy decreased to 71.4% after hyper-parameter tuning The Random Forest model achieved a accuracy of 61% and the accuracy increased to 66.6% after hyper-parameter tuning

Comparison of models after tuning

- It is observed by comparing Accuracy that SVM and NNmodel performs the best amongst the others both before tuning and after tuning.

Compairing Model Accuracies:

SVM on original data set values : Accuracy : 0.809, Kappa : 0.7399 Neural Networks on original data set values : Accuracy : 0.809, Kappa : 0.7358 Naive bayes on original data set values : Accuracy : 0.7619, Kappa : 0.6729 Random Forest on original data set values : Accuracy : 0.619, Kappa : 0.4734

SVM with k-fold cross validation : Accuracy : 0.7723365, Kappa : 0.6914544 Neural Networks with k-fold cross validation : Accuracy : 0.7786581, Kappa : 0.6980310 Naive bayes with k-fold cross validation :Accuracy : 0.7535198, Kappa : 0.6617535 Random Forest with k-fold cross validation :Accuracy : 0.7795238, Kappa : 0.6920946

SVM on original data set values after hyper parameter tuning : Accuracy : 0.8095, Kappa : 0.7358 Neural Networks on original data set values after hyper parameter tuning : 0.8095 , Kappa : 0.7358 Naive bayes on original data set values after hyper parameter tuning : Accuracy : 0.7143, Kappa : 0.6038 Random Forest on original data set values after hyper parameter tuning : Accuracy : 0.6667, Kappa : 0.5377

-From the above, we can say that both SVM and Neural Network model has done a good job predicting the cancer subtype

Deployment

(i) bagging : use of bagging with homogeneous learners
(ii) Stacked ensemble using - SVM, Neural Networks, Naive Bayes - Majority voting
(iii) boosting : Extreme Gradient Boosting

Bagging

use of bagging with homogeneous learners

```
set.seed(1000)
#fit the bagged model
bag <- bagging(formula = PAM50.mRNA ~ .,data = train,nbagg = 150,   coob = TRUE,control = rpart.control
#display fitted bagged model
bag
```

```
##
## Bagging classification trees with 150 bootstrap replications
##
## Call: bagging.data.frame(formula = PAM50.mRNA ~ ., data = train, nbagg = 150,
##     coob = TRUE, control = rpart.control(minsplit = 2, cp = 0))
##
## Out-of-bag estimate of misclassification error:  0.2542
```

```
bag_pred <- predict(bag, test)
confusionMatrix(test$`PAM50.mRNA`,bag_pred)
```

```
## Confusion Matrix and Statistics
##
##                 Reference
## Prediction       Basal.like HER2.enriched Luminal.A Luminal.B
##   Basal.like             4             0         0         1
##   HER2.enriched          1             1         0         1
##   Luminal.A              2             0         4         0
##   Luminal.B              1             0         2         4
##
## Overall Statistics
##
##                Accuracy : 0.619
##                  95% CI : (0.3844, 0.8189)
##     No Information Rate : 0.381
##     P-Value [Acc > NIR] : 0.02313
##
##                   Kappa : 0.475
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Basal.like Class: HER2.enriched Class: Luminal.A
## Sensitivity                     0.5000              1.00000           0.6667
## Specificity                     0.9231              0.90000           0.8667
## Pos Pred Value                  0.8000              0.33333           0.6667
## Neg Pred Value                  0.7500              1.00000           0.8667
## Prevalence                      0.3810              0.04762           0.2857
## Detection Rate                  0.1905              0.04762           0.1905
## Detection Prevalence            0.2381              0.14286           0.2857
## Balanced Accuracy               0.7115              0.95000           0.7667
##                      Class: Luminal.B
## Sensitivity                    0.6667
## Specificity                    0.8000
## Pos Pred Value                 0.5714
## Neg Pred Value                 0.8571
## Prevalence                     0.2857
## Detection Rate                 0.1905
## Detection Prevalence           0.3333
## Balanced Accuracy              0.7333
```

Accuracy achieved using bagging is 0.619

Stacking

The breast cancer sub-type classifier will be deployed as a model ensemble. A model ensemble is a prediction model that is an aggregate of a set of models. Specifically, a model ensemble aggregates predictions across all the individual models in the ensemble using a voting mechanism. In general, we expect that a collection of independent models would perform better than any individual model. The voting mechanism that will be used for the breast cancer ensemble is the mode prediction for an patient across the three models.

Define a function to calculate the mode across values.

```
Mode <- function(x) {
  ux <- unique(x)
  ux[which.max(tabulate(match(x, ux)))]
}
```

Next, define a function to loop through the observations in the test data and generate the modal prediction for each observation across the three classifiers.

```
vote <- function (p1, p2, p3) {

    m  <- length(p1) # number of predictions in the test data
    ds <- numeric(m) # creates numeric vector to hold final prediction

    # loops through predictions in the test data
    for (i in 1:m) {
        # calculate mode prediction for an obs across classifiers
        p     <- c(p1[i],p2[i],p3[i])
        # store modal prediction in return vector
        ds[i] <- Mode(p)
    }

    # return vector
    return(ds)
}
```

Use functions to generate the model ensemble.

```
ens_pred      <- vote(p1 = svm_pred, p2 = nnpred_model2, p3 = nbpred_model3)
ens_pred
```

```
##  [1] 1 1 1 1 1 2 2 4 3 3 3 3 3 3 4 1 4 4 4 3 4
```

```
# Factor
ens_pred[which(ens_pred == 1)] = "Basal.like"
ens_pred[which(ens_pred == 2)] =  "HER2.enriched"
ens_pred[which(ens_pred == 3)] = "Luminal.A"
ens_pred[which(ens_pred == 4)] = "Luminal.B"
```

```
label <- factor(test$PAM50.mRNA)
label
```

```
##  [1] Basal.like    Basal.like    Basal.like    Basal.like    Basal.like
```

```
##  [6] HER2.enriched HER2.enriched HER2.enriched Luminal.A     Luminal.A
## [11] Luminal.A     Luminal.A     Luminal.A     Luminal.A     Luminal.B
## [16] Luminal.B     Luminal.B     Luminal.B     Luminal.B     Luminal.B
## [21] Luminal.B
## Levels: Basal.like HER2.enriched Luminal.A Luminal.B
```

```
confusionMatrix(factor(ens_pred),  label , mode = "everything")
```

```
## Confusion Matrix and Statistics
##
##                Reference
## Prediction      Basal.like HER2.enriched Luminal.A Luminal.B
##   Basal.like             5             0         0         1
##   HER2.enriched          0             2         0         0
##   Luminal.A              0             0         6         1
##   Luminal.B              0             1         0         5
##
## Overall Statistics
##
##                Accuracy : 0.8571
##                  95% CI : (0.6366, 0.9695)
##     No Information Rate : 0.3333
##     P-Value [Acc > NIR] : 1.102e-06
##
##                   Kappa : 0.8037
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Basal.like Class: HER2.enriched Class: Luminal.A
## Sensitivity                     1.0000              0.66667           1.0000
## Specificity                     0.9375              1.00000           0.9333
## Pos Pred Value                  0.8333              1.00000           0.8571
## Neg Pred Value                  1.0000              0.94737           1.0000
## Precision                       0.8333              1.00000           0.8571
## Recall                          1.0000              0.66667           1.0000
## F1                              0.9091              0.80000           0.9231
## Prevalence                      0.2381              0.14286           0.2857
## Detection Rate                  0.2381              0.09524           0.2857
## Detection Prevalence            0.2857              0.09524           0.3333
## Balanced Accuracy               0.9688              0.83333           0.9667
##                      Class: Luminal.B
## Sensitivity                    0.7143
## Specificity                    0.9286
## Pos Pred Value                 0.8333
## Neg Pred Value                 0.8667
## Precision                      0.8333
## Recall                         0.7143
## F1                             0.7692
## Prevalence                     0.3333
## Detection Rate                 0.2381
## Detection Prevalence           0.2857
## Balanced Accuracy              0.8214
```

```
mv_auc <- multiclass.roc(label, as.ordered(ens_pred))
auc(mv_auc)
```

```
## Multi-class area under the curve: 0.8452
```

Macro-averaged Metrics : The per-class metrics can be averaged over all the classes resulting in macro-averaged precision, recall and F-1.

```
# macro-averaged precision
precision_stack<- c(0.8333,1.00000,0.8571,0.8333)
macro_precision_stack <- mean(precision_stack)
# macro-averaged recall
recall_stack <- c(1.0000,0.66667,1.0000,0.7143)
macro_recall_stack<- mean(recall_stack)
# macro-averaged F-1
F1_stack<- c(0.9091,0.80000,0.9231,0.7692)
macroF1_stack <- mean(F1_stack)
macro_average_stack <-data.frame(macro_precision_stack, macro_recall_stack, macroF1_stack)
macro_average_stack
```

```
##   macro_precision_stack macro_recall_stack macroF1_stack
## 1              0.880925          0.8452425       0.85035
```

```
Name_metrics <- c("Accuracy", "Precision", "Recall", "F-1", "AUC", "Kappa")
values_stack <- c(0.8571, 0.880925, 0.8452425, 0.85035, 0.8452, 0.8037)
metrics_stack <- data.frame(Name_metrics, values_stack)
print (metrics_stack)
```

```
##   Name_metrics values_stack
## 1     Accuracy    0.8571000
## 2    Precision    0.8809250
## 3       Recall    0.8452425
## 4          F-1    0.8503500
## 5          AUC    0.8452000
## 6        Kappa    0.8037000
```

comparison of ensemble to individual models

Of the four models (SVM, NN, NB, RF)- The SVM and NN works better and both the models have similar Accuracy, Precision, Recall, F-1, AUC and Kappa Values

Now, comparing Accuracy, Precision, Recall, F-1, AUC and Kappa values with that of stacked ensemble model (SVM, NN, NB)

I have saved the Accuracy, Precision, Recall, F-1, AUC and Kappa values under metric_model

```
metrics_svm
```

```
##   Name_metrics values_svm
## 1     Accuracy  0.8095000
```

```
## 2    Precision  0.8428500
## 3       Recall  0.8095175
## 4          F-1  0.8057750
## 5          AUC  0.7897000
## 6        Kappa  0.7399000
```

```
metrics_nn
```

```
##   Name_metrics values_nn
## 1     Accuracy 0.8095000
## 2    Precision 0.8541500
## 3       Recall 0.7619075
## 4          F-1 0.7588500
## 5          AUC 0.8571000
## 6        Kappa 0.7358000
```

```
metrics_stack
```

```
##   Name_metrics values_stack
## 1     Accuracy    0.8571000
## 2    Precision    0.8809250
## 3       Recall    0.8452425
## 4          F-1    0.8503500
## 5          AUC    0.8452000
## 6        Kappa    0.8037000
```

By comparing above values, we can say that stacked ensemble model worked better than other individual models with the highest accuracy of 85.7% and Precision-0.8809250, Recall-0.8452425, F-1-0.8503500, AUC - 0.8452000, Kappa - 0.8037000
Therefore, These values are higher than individual models.

Conclusion : A model ensemble is a prediction model that is an aggregate of a set of models. Specifically, a model ensemble aggregates predictions across all the individual models (SVM, NN, NB) in the ensemble using a voting mechanism.And this model has high accuracy of predicting the subtype of cancer than individual models.

Boosting

Extreme gradient boosting

The term "gradient boosting" comes from the idea of "boosting" or improving a single weak model by combining it with a number of other weak models in order to generate a collectively strong model. Gradient boosting is an extension of boosting where the process of additively generating weak models is formalized as a gradient descent algorithm over an objective function. Gradient boosting sets targeted outcomes for the next model in an effort to minimize errors. Targeted outcomes for each case are based on the gradient of the error (hence the name gradient boosting) with respect to the prediction.

XGBoost (eXtreme Gradient Boosting) is a machine learning classifier/predictor, which produces a model in a form of an ensemble of weak prediction models. XGBoost helps to reduce overfitting.

```r
## Extreme gradient boosting

xgbGrid <- expand.grid(nrounds = c(1, 10),
                       max_depth = c(1, 4),
                       eta = c(.1, .4),
                       gamma = 0,
                       colsample_bytree = .7,
                       min_child_weight = 1,
                       subsample = c(.8, 1))


cctrl1 <- trainControl(method = "cv", number = 3, returnResamp = "all",
                       classProbs = TRUE)


train_en<- createDataPartition(data_norm$`PAM50.mRNA`, p = .70, list = FALSE)
trainDF<-data_norm[train_en,]
testDF<-data_norm[-train_en,]
trainDF$`PAM50.mRNA`<- as.factor(trainDF$`PAM50.mRNA`)

xgb <- train(`PAM50.mRNA` ~., data=trainDF,
                              method = "xgbTree",
                              trControl = cctrl1,
                              preProc = c("center", "scale"),
                              tuneGrid = xgbGrid)
```

```
## [14:15:14] WARNING: amalgamation/../src/c_api/c_api.cc:785: ‘ntree_limit‘ is deprecated, use ‘iterat
## [14:15:14] WARNING: amalgamation/../src/c_api/c_api.cc:785: ‘ntree_limit‘ is deprecated, use ‘iterat
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```

```
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## [14:15:14] WARNING: amalgamation/../src/c_api/c_api.cc:785: `ntree_limit` is deprecated, use `iterati
```

```r
bpred_xgb <- predict(xgb, newdata=testDF)

confusionMatrix(testDF$`PAM50.mRNA`,bpred_xgb)
```

```
## Confusion Matrix and Statistics
##
##                  Reference
## Prediction        Basal.like HER2.enriched Luminal.A Luminal.B
##   Basal.like               3             0         2         0
##   HER2.enriched            1             2         0         0
##   Luminal.A                0             0         5         1
##   Luminal.B                0             0         1         6
##
## Overall Statistics
##
##                Accuracy : 0.7619
##                  95% CI : (0.5283, 0.9178)
##     No Information Rate : 0.381
##     P-Value [Acc > NIR] : 0.0004398
##
##                   Kappa : 0.6698
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Basal.like Class: HER2.enriched Class: Luminal.A
## Sensitivity                     0.7500              1.00000           0.6250
## Specificity                     0.8824              0.94737           0.9231
## Pos Pred Value                  0.6000              0.66667           0.8333
## Neg Pred Value                  0.9375              1.00000           0.8000
## Prevalence                      0.1905              0.09524           0.3810
```

```
## Detection Rate                    0.1429             0.09524           0.2381
## Detection Prevalence              0.2381             0.14286           0.2857
## Balanced Accuracy                 0.8162             0.97368           0.7740
##                       Class: Luminal.B
## Sensitivity                     0.8571
## Specificity                     0.9286
## Pos Pred Value                  0.8571
## Neg Pred Value                  0.9286
## Prevalence                      0.3333
## Detection Rate                  0.2857
## Detection Prevalence            0.3333
## Balanced Accuracy               0.8929
```

I have also built extreme gradient boosting model. This model has an accuracy of 61.9%

Therefore, Stacked ensemble stacked ensemble (SVM, NN, NB) model works better than extereme gradient boosting model

Conclusion

It's really intriguing to me that ML techniques may be used to identify a group of predictor proteins that outperform proteins known to be linked to the genetic test that determines the classification in terms of identifying cancer subtypes.

The lasso-selected variables consistently outperformed the PAM50 ones, but no other methods produced classification results that were more accurate than the SVM NN and stacked ensemble (SVM, NN, NB).