BAN 502 Course Project

Winslow Goins

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library(tidyverse)  
library(tidymodels)  
library(mice)   
library(VIM)   
library(naniar)   
library(skimr)   
library(GGally)  
library(lmtest)  
library(MASS)  
library(car)  
library(ggcorrplot)  
library(glmnet)  
library(lubridate)  
library(splines)  
library(gridExtra)  
library(e1071)  
library(ROCR)  
library(ggcorrplot)  
library(lmtest)  
library(caret)  
library(rpart)  
library(rpart.plot)  
library(rattle)  
library(RColorBrewer)  
library(gridExtra)  
library(vip)  
library(ranger)  
library(skimr)  
library(e1071)  
library(xgboost)  
library(usemodels)  
library(nnet)  
library(stacks)  
library(leaps)   
library(splines)

ames\_student<- read\_csv("ames\_student.csv")

summary(ames\_student)

## MS\_SubClass MS\_Zoning Lot\_Frontage Lot\_Area   
## Length:2053 Length:2053 Min. : 0.00 Min. : 1300   
## Class :character Class :character 1st Qu.: 43.00 1st Qu.: 7500   
## Mode :character Mode :character Median : 62.00 Median : 9548   
## Mean : 57.38 Mean : 10258   
## 3rd Qu.: 78.00 3rd Qu.: 11600   
## Max. :313.00 Max. :215245   
## Street Alley Lot\_Shape Land\_Contour   
## Length:2053 Length:2053 Length:2053 Length:2053   
## Class :character Class :character Class :character Class :character   
## Mode :character Mode :character Mode :character Mode :character   
##   
##   
##   
## Utilities Lot\_Config Land\_Slope Neighborhood   
## Length:2053 Length:2053 Length:2053 Length:2053   
## Class :character Class :character Class :character Class :character   
## Mode :character Mode :character Mode :character Mode :character   
##   
##   
##   
## Condition\_1 Condition\_2 Bldg\_Type House\_Style   
## Length:2053 Length:2053 Length:2053 Length:2053   
## Class :character Class :character Class :character Class :character   
## Mode :character Mode :character Mode :character Mode :character   
##   
##   
##   
## Overall\_Qual Overall\_Cond Year\_Built Year\_Remod\_Add  
## Length:2053 Length:2053 Min. :1875 Min. :1950   
## Class :character Class :character 1st Qu.:1953 1st Qu.:1965   
## Mode :character Mode :character Median :1972 Median :1993   
## Mean :1971 Mean :1984   
## 3rd Qu.:2000 3rd Qu.:2004   
## Max. :2010 Max. :2010   
## Roof\_Style Roof\_Matl Exterior\_1st Exterior\_2nd   
## Length:2053 Length:2053 Length:2053 Length:2053   
## Class :character Class :character Class :character Class :character   
## Mode :character Mode :character Mode :character Mode :character   
##   
##   
##   
## Mas\_Vnr\_Type Mas\_Vnr\_Area Exter\_Qual Exter\_Cond   
## Length:2053 Min. : 0.0 Length:2053 Length:2053   
## Class :character 1st Qu.: 0.0 Class :character Class :character   
## Mode :character Median : 0.0 Mode :character Mode :character   
## Mean : 103.8   
## 3rd Qu.: 164.0   
## Max. :1600.0   
## Foundation Bsmt\_Qual Bsmt\_Cond Bsmt\_Exposure   
## Length:2053 Length:2053 Length:2053 Length:2053   
## Class :character Class :character Class :character Class :character   
## Mode :character Mode :character Mode :character Mode :character   
##   
##   
##   
## BsmtFin\_Type\_1 BsmtFin\_SF\_1 BsmtFin\_Type\_2 BsmtFin\_SF\_2   
## Length:2053 Min. :1.00 Length:2053 Min. : 0.00   
## Class :character 1st Qu.:3.00 Class :character 1st Qu.: 0.00   
## Mode :character Median :3.00 Mode :character Median : 0.00   
## Mean :4.21 Mean : 52.57   
## 3rd Qu.:7.00 3rd Qu.: 0.00   
## Max. :7.00 Max. :1526.00   
## Bsmt\_Unf\_SF Total\_Bsmt\_SF Heating Heating\_QC   
## Min. : 0.0 Min. : 0 Length:2053 Length:2053   
## 1st Qu.: 226.0 1st Qu.: 793 Class :character Class :character   
## Median : 460.0 Median : 988 Mode :character Mode :character   
## Mean : 561.2 Mean :1055   
## 3rd Qu.: 801.0 3rd Qu.:1304   
## Max. :2336.0 Max. :5095   
## Central\_Air Electrical First\_Flr\_SF Second\_Flr\_SF   
## Length:2053 Length:2053 Min. : 432 Min. : 0.0   
## Class :character Class :character 1st Qu.: 882 1st Qu.: 0.0   
## Mode :character Mode :character Median :1088 Median : 0.0   
## Mean :1168 Mean : 326.1   
## 3rd Qu.:1402 3rd Qu.: 701.0   
## Max. :5095 Max. :1862.0   
## Low\_Qual\_Fin\_SF Gr\_Liv\_Area Bsmt\_Full\_Bath Bsmt\_Half\_Bath   
## Min. : 0.000 Min. : 480 Min. :0.0000 Min. :0.00000   
## 1st Qu.: 0.000 1st Qu.:1137 1st Qu.:0.0000 1st Qu.:0.00000   
## Median : 0.000 Median :1447 Median :0.0000 Median :0.00000   
## Mean : 4.973 Mean :1499 Mean :0.4301 Mean :0.05796   
## 3rd Qu.: 0.000 3rd Qu.:1737 3rd Qu.:1.0000 3rd Qu.:0.00000   
## Max. :1064.000 Max. :5095 Max. :3.0000 Max. :2.00000   
## Full\_Bath Half\_Bath Bedroom\_AbvGr Kitchen\_AbvGr   
## Min. :0.000 Min. :0.0000 Min. :0.000 Min. :1.000   
## 1st Qu.:1.000 1st Qu.:0.0000 1st Qu.:2.000 1st Qu.:1.000   
## Median :2.000 Median :0.0000 Median :3.000 Median :1.000   
## Mean :1.564 Mean :0.3751 Mean :2.855 Mean :1.047   
## 3rd Qu.:2.000 3rd Qu.:1.0000 3rd Qu.:3.000 3rd Qu.:1.000   
## Max. :4.000 Max. :2.0000 Max. :6.000 Max. :3.000   
## Kitchen\_Qual TotRms\_AbvGrd Functional Fireplaces   
## Length:2053 Min. : 3.000 Length:2053 Min. :0.000   
## Class :character 1st Qu.: 5.000 Class :character 1st Qu.:0.000   
## Mode :character Median : 6.000 Mode :character Median :1.000   
## Mean : 6.442 Mean :0.603   
## 3rd Qu.: 7.000 3rd Qu.:1.000   
## Max. :15.000 Max. :4.000   
## Fireplace\_Qu Garage\_Type Garage\_Finish Garage\_Cars   
## Length:2053 Length:2053 Length:2053 Min. :0.000   
## Class :character Class :character Class :character 1st Qu.:1.000   
## Mode :character Mode :character Mode :character Median :2.000   
## Mean :1.774   
## 3rd Qu.:2.000   
## Max. :5.000   
## Garage\_Area Garage\_Qual Garage\_Cond Paved\_Drive   
## Min. : 0 Length:2053 Length:2053 Length:2053   
## 1st Qu.: 320 Class :character Class :character Class :character   
## Median : 478 Mode :character Mode :character Mode :character   
## Mean : 472   
## 3rd Qu.: 576   
## Max. :1488   
## Wood\_Deck\_SF Open\_Porch\_SF Enclosed\_Porch Three\_season\_porch  
## Min. : 0.00 Min. : 0.00 Min. : 0.00 Min. : 0.000   
## 1st Qu.: 0.00 1st Qu.: 0.00 1st Qu.: 0.00 1st Qu.: 0.000   
## Median : 0.00 Median : 27.00 Median : 0.00 Median : 0.000   
## Mean : 93.52 Mean : 48.17 Mean : 23.02 Mean : 2.799   
## 3rd Qu.: 168.00 3rd Qu.: 72.00 3rd Qu.: 0.00 3rd Qu.: 0.000   
## Max. :1424.00 Max. :742.00 Max. :584.00 Max. :407.000   
## Screen\_Porch Pool\_Area Pool\_QC Fence   
## Min. : 0.00 Min. : 0.000 Length:2053 Length:2053   
## 1st Qu.: 0.00 1st Qu.: 0.000 Class :character Class :character   
## Median : 0.00 Median : 0.000 Mode :character Mode :character   
## Mean : 16.68 Mean : 1.339   
## 3rd Qu.: 0.00 3rd Qu.: 0.000   
## Max. :576.00 Max. :800.000   
## Misc\_Feature Misc\_Val Mo\_Sold Year\_Sold   
## Length:2053 Min. : 0.00 Min. : 1.000 Min. :2006   
## Class :character 1st Qu.: 0.00 1st Qu.: 4.000 1st Qu.:2007   
## Mode :character Median : 0.00 Median : 6.000 Median :2008   
## Mean : 60.12 Mean : 6.189 Mean :2008   
## 3rd Qu.: 0.00 3rd Qu.: 8.000 3rd Qu.:2009   
## Max. :17000.00 Max. :12.000 Max. :2010   
## Sale\_Type Sale\_Condition Longitude Latitude   
## Length:2053 Length:2053 Min. :-93.69 Min. :41.99   
## Class :character Class :character 1st Qu.:-93.66 1st Qu.:42.02   
## Mode :character Mode :character Median :-93.64 Median :42.03   
## Mean :-93.64 Mean :42.03   
## 3rd Qu.:-93.62 3rd Qu.:42.05   
## Max. :-93.58 Max. :42.06   
## Above\_Median   
## Length:2053   
## Class :character   
## Mode :character   
##   
##   
##

ames = ames\_student %>% mutate(MS\_SubClass = as\_factor(MS\_SubClass)) %>%  
 mutate(MS\_Zoning = as\_factor(MS\_Zoning)) %>%  
 mutate(Street = as\_factor(Street)) %>%  
 mutate(Alley = as\_factor(Alley)) %>%  
 mutate(Lot\_Shape = as\_factor(Lot\_Shape)) %>%  
 mutate(Land\_Contour = as\_factor(Land\_Contour)) %>%  
 mutate(Utilities = as\_factor(Utilities)) %>%  
 mutate(Lot\_Config = as\_factor(Lot\_Config)) %>%  
 mutate(Land\_Slope = as\_factor(Land\_Slope)) %>%  
 mutate(Neighborhood = as\_factor(Neighborhood)) %>%  
 mutate(Condition\_1 = as\_factor(Condition\_1)) %>%  
 mutate(Condition\_2 = as\_factor(Condition\_2)) %>%  
 mutate(Bldg\_Type = as\_factor(Bldg\_Type)) %>%  
 mutate(House\_Style = as\_factor(House\_Style)) %>%  
 mutate(Overall\_Qual = as\_factor(Overall\_Qual)) %>%  
 mutate(Exter\_Cond = as\_factor(Exter\_Cond)) %>%  
 mutate(Year\_Built = as\_factor(Year\_Built)) %>%  
 mutate(Year\_Remod\_Add = as\_factor(Year\_Remod\_Add)) %>%  
 mutate(Roof\_Style = as\_factor(Roof\_Style)) %>%  
 mutate(Roof\_Matl = as\_factor(Roof\_Matl)) %>%  
 mutate(Exterior\_1st = as\_factor(Exterior\_1st)) %>%  
 mutate(Exterior\_2nd = as\_factor(Exterior\_2nd)) %>%  
 mutate(Mas\_Vnr\_Type = as\_factor(Mas\_Vnr\_Type)) %>%  
 mutate(Exter\_Qual = as\_factor(Exter\_Qual)) %>%  
 mutate(Exter\_Cond = as\_factor(Exter\_Cond)) %>%  
 mutate(Foundation = as\_factor(Foundation)) %>%  
 mutate(Bsmt\_Qual = as\_factor(Bsmt\_Qual)) %>%  
 mutate(Bsmt\_Cond = as\_factor(Bsmt\_Cond)) %>%  
 mutate(Bsmt\_Exposure = as\_factor(Bsmt\_Exposure)) %>%  
 mutate(BsmtFin\_Type\_1 = as\_factor(BsmtFin\_Type\_1)) %>%  
 mutate(MS\_SubClass = as\_factor(MS\_SubClass)) %>%  
 mutate(BsmtFin\_Type\_2 = as\_factor(BsmtFin\_Type\_2)) %>%  
 mutate(Heating = as\_factor(Heating)) %>%  
 mutate(Heating\_QC = as\_factor(Heating\_QC)) %>%  
 mutate(Central\_Air = as\_factor(Central\_Air)) %>%  
 mutate(Electrical = as\_factor(Electrical)) %>%  
 mutate(Bsmt\_Full\_Bath = as\_factor(Bsmt\_Full\_Bath)) %>%  
 mutate(Bsmt\_Half\_Bath = as\_factor(Bsmt\_Half\_Bath)) %>%  
 mutate(Full\_Bath = as\_factor(Full\_Bath)) %>%  
 mutate(Half\_Bath = as\_factor(Half\_Bath)) %>%  
 mutate(Bedroom\_AbvGr = as\_factor(Bedroom\_AbvGr)) %>%  
 mutate(Kitchen\_AbvGr = as\_factor(Kitchen\_AbvGr)) %>%  
 mutate(Kitchen\_Qual = as\_factor(Kitchen\_Qual)) %>%  
 mutate(Functional = as\_factor(Functional)) %>%  
 mutate(Fireplaces = as\_factor(Fireplaces)) %>%  
 mutate(Fireplace\_Qu = as\_factor(Fireplace\_Qu)) %>%  
 mutate(Garage\_Type = as\_factor(Garage\_Type)) %>%  
 mutate(Garage\_Finish = as\_factor(Garage\_Finish)) %>%  
 mutate(Garage\_Cars = as\_factor(Garage\_Cars)) %>%  
 mutate(Garage\_Qual = as\_factor(Garage\_Qual)) %>%  
 mutate(Garage\_Cond = as\_factor(Garage\_Cond)) %>%  
 mutate(Paved\_Drive = as\_factor(Paved\_Drive)) %>%  
 mutate(Pool\_QC = as\_factor(Pool\_QC)) %>%  
 mutate(Fence = as\_factor(Fence)) %>%  
 mutate(Misc\_Feature = as\_factor(Misc\_Feature)) %>%  
 mutate(Mo\_Sold = as\_factor(Mo\_Sold)) %>%  
 mutate(Year\_Sold = as\_factor(Year\_Sold)) %>%  
 mutate(Sale\_Type = as\_factor(Sale\_Type)) %>%  
 mutate(Sale\_Condition = as\_factor(Sale\_Condition)) %>%  
 mutate(Above\_Median = as\_factor(Above\_Median)) %>%  
 mutate(Overall\_Cond = as\_factor(Overall\_Cond))

summary(ames)

## MS\_SubClass MS\_Zoning   
## One\_Story\_1946\_and\_Newer\_All\_Styles :772 Residential\_Low\_Density :1600   
## Two\_Story\_1946\_and\_Newer :383 Residential\_High\_Density : 20   
## One\_and\_Half\_Story\_Finished\_All\_Ages:204 Floating\_Village\_Residential: 87   
## One\_Story\_PUD\_1946\_and\_Newer :129 Residential\_Medium\_Density : 326   
## One\_Story\_1945\_and\_Older : 98 C\_all : 17   
## Two\_Story\_1945\_and\_Older : 95 A\_agr : 2   
## (Other) :372 I\_all : 1   
## Lot\_Frontage Lot\_Area Street Alley   
## Min. : 0.00 Min. : 1300 Pave:2046 No\_Alley\_Access:1914   
## 1st Qu.: 43.00 1st Qu.: 7500 Grvl: 7 Paved : 45   
## Median : 62.00 Median : 9548 Gravel : 94   
## Mean : 57.38 Mean : 10258   
## 3rd Qu.: 78.00 3rd Qu.: 11600   
## Max. :313.00 Max. :215245   
##   
## Lot\_Shape Land\_Contour Utilities Lot\_Config   
## Slightly\_Irregular : 714 Lvl:1833 AllPub:2052 Corner : 359   
## Regular :1275 HLS: 94 NoSewr: 1 Inside :1495   
## Moderately\_Irregular: 53 Bnk: 81 CulDSac: 135   
## Irregular : 11 Low: 45 FR2 : 56   
## FR3 : 8   
##   
##   
## Land\_Slope Neighborhood Condition\_1 Condition\_2 Bldg\_Type   
## Gtl:1951 North\_Ames : 327 Norm :1771 Norm :2027 OneFam :1706   
## Mod: 89 College\_Creek: 183 Feedr : 113 Feedr : 12 TwnhsE : 157   
## Sev: 13 Old\_Town : 181 Artery : 67 PosA : 4 Twnhs : 67   
## Edwards : 129 RRAn : 35 Artery : 4 Duplex : 76   
## Somerset : 119 PosN : 24 PosN : 3 TwoFmCon: 47   
## Gilbert : 109 RRAe : 19 RRNn : 1   
## (Other) :1005 (Other): 24 (Other): 2   
## House\_Style Overall\_Qual Overall\_Cond   
## One\_Story :1052 Average :587 Average :1143   
## Two\_Story : 590 Above\_Average:518 Above\_Average: 376   
## One\_and\_Half\_Fin: 225 Good :411 Good : 286   
## SLvl : 90 Very\_Good :237 Very\_Good : 98   
## SFoyer : 56 Below\_Average:169 Below\_Average: 73   
## Two\_and\_Half\_Unf: 19 Excellent : 70 Fair : 35   
## (Other) : 21 (Other) : 61 (Other) : 42   
## Year\_Built Year\_Remod\_Add Roof\_Style Roof\_Matl Exterior\_1st  
## 2005 : 104 1950 : 256 Hip : 404 CompShg:2023 VinylSd:705   
## 2006 : 93 2006 : 147 Gable :1607 WdShake: 8 MetalSd:319   
## 2007 : 76 2007 : 116 Mansard: 9 Tar&Grv: 17 Wd Sdng:313   
## 2003 : 62 2005 : 94 Gambrel: 14 WdShngl: 3 HdBoard:303   
## 2004 : 60 2004 : 80 Shed : 5 Roll : 1 Plywood:151   
## 1977 : 40 2003 : 70 Flat : 14 Metal : 1 CemntBd: 90   
## (Other):1618 (Other):1290 (Other):172   
## Exterior\_2nd Mas\_Vnr\_Type Mas\_Vnr\_Area Exter\_Qual   
## VinylSd:699 Stone : 166 Min. : 0.0 Typical :1272   
## MetalSd:317 None :1231 1st Qu.: 0.0 Good : 682   
## Wd Sdng:302 BrkFace: 638 Median : 0.0 Excellent: 78   
## HdBoard:277 BrkCmn : 17 Mean : 103.8 Fair : 21   
## Plywood:190 CBlock : 1 3rd Qu.: 164.0   
## CmentBd: 90 Max. :1600.0   
## (Other):178   
## Exter\_Cond Foundation Bsmt\_Qual Bsmt\_Cond   
## Typical :1787 CBlock:880 Typical :911 Good : 80   
## Good : 213 PConc :911 Good :849 Typical :1833   
## Fair : 43 Wood : 4 Excellent :178 Poor : 4   
## Excellent: 9 BrkTil:216 No\_Basement: 57 No\_Basement: 57   
## Poor : 1 Slab : 36 Fair : 57 Fair : 76   
## Stone : 6 Poor : 1 Excellent : 3   
##   
## Bsmt\_Exposure BsmtFin\_Type\_1 BsmtFin\_SF\_1 BsmtFin\_Type\_2  
## Gd : 199 BLQ :196 Min. :1.00 Unf :1740   
## No :1331 Rec :216 1st Qu.:3.00 LwQ : 64   
## Av : 284 ALQ :298 Median :3.00 BLQ : 47   
## Mn : 179 GLQ :578 Mean :4.21 Rec : 79   
## No\_Basement: 60 Unf :602 3rd Qu.:7.00 GLQ : 23   
## LwQ :106 Max. :7.00 No\_Basement: 58   
## No\_Basement: 57 ALQ : 42   
## BsmtFin\_SF\_2 Bsmt\_Unf\_SF Total\_Bsmt\_SF Heating   
## Min. : 0.00 Min. : 0.0 Min. : 0 GasA :2019   
## 1st Qu.: 0.00 1st Qu.: 226.0 1st Qu.: 793 GasW : 21   
## Median : 0.00 Median : 460.0 Median : 988 Grav : 6   
## Mean : 52.57 Mean : 561.2 Mean :1055 Wall : 5   
## 3rd Qu.: 0.00 3rd Qu.: 801.0 3rd Qu.:1304 Floor: 1   
## Max. :1526.00 Max. :2336.0 Max. :5095 OthW : 1   
##   
## Heating\_QC Central\_Air Electrical First\_Flr\_SF Second\_Flr\_SF   
## Fair : 61 Y:1916 SBrkr :1887 Min. : 432 Min. : 0.0   
## Typical : 618 N: 137 FuseA : 126 1st Qu.: 882 1st Qu.: 0.0   
## Excellent:1040 FuseF : 33 Median :1088 Median : 0.0   
## Good : 333 FuseP : 6 Mean :1168 Mean : 326.1   
## Poor : 1 Unknown: 1 3rd Qu.:1402 3rd Qu.: 701.0   
## Max. :5095 Max. :1862.0   
##   
## Low\_Qual\_Fin\_SF Gr\_Liv\_Area Bsmt\_Full\_Bath Bsmt\_Half\_Bath Full\_Bath  
## Min. : 0.000 Min. : 480 0:1201 0:1936 0: 10   
## 1st Qu.: 0.000 1st Qu.:1137 1: 823 1: 115 1: 920   
## Median : 0.000 Median :1447 2: 27 2: 2 2:1080   
## Mean : 4.973 Mean :1499 3: 2 3: 41   
## 3rd Qu.: 0.000 3rd Qu.:1737 4: 2   
## Max. :1064.000 Max. :5095   
##   
## Half\_Bath Bedroom\_AbvGr Kitchen\_AbvGr Kitchen\_Qual TotRms\_AbvGrd   
## 0:1300 0: 7 1:1959 Typical :1070 Min. : 3.000   
## 1: 736 1: 73 2: 92 Good : 790 1st Qu.: 5.000   
## 2: 17 2: 527 3: 2 Excellent: 142 Median : 6.000   
## 3:1105 Fair : 50 Mean : 6.442   
## 4: 297 Poor : 1 3rd Qu.: 7.000   
## 5: 32 Max. :15.000   
## 6: 12   
## Functional Fireplaces Fireplace\_Qu Garage\_Type   
## Typ :1896 0:993 Good :538 Attchd :1204   
## Min2 : 54 1:891 No\_Fireplace:993 BuiltIn : 127   
## Min1 : 51 2:161 Typical :409 Basment : 29   
## Mod : 27 3: 7 Poor : 36 Detchd : 549   
## Maj1 : 15 4: 1 Excellent : 21 No\_Garage : 108   
## Maj2 : 6 Fair : 56 CarPort : 15   
## (Other): 4 More\_Than\_Two\_Types: 21   
## Garage\_Finish Garage\_Cars Garage\_Area Garage\_Qual Garage\_Cond   
## Fin :509 0: 108 Min. : 0 Typical :1839 Typical :1872   
## Unf :872 1: 539 1st Qu.: 320 No\_Garage: 109 No\_Garage: 109   
## RFn :563 2:1131 Median : 478 Fair : 85 Fair : 53   
## No\_Garage:109 3: 261 Mean : 472 Good : 16 Excellent: 1   
## 4: 13 3rd Qu.: 576 Excellent: 2 Poor : 8   
## 5: 1 Max. :1488 Poor : 2 Good : 10   
##   
## Paved\_Drive Wood\_Deck\_SF Open\_Porch\_SF Enclosed\_Porch   
## Partial\_Pavement: 42 Min. : 0.00 Min. : 0.00 Min. : 0.00   
## Paved :1848 1st Qu.: 0.00 1st Qu.: 0.00 1st Qu.: 0.00   
## Dirt\_Gravel : 163 Median : 0.00 Median : 27.00 Median : 0.00   
## Mean : 93.52 Mean : 48.17 Mean : 23.02   
## 3rd Qu.: 168.00 3rd Qu.: 72.00 3rd Qu.: 0.00   
## Max. :1424.00 Max. :742.00 Max. :584.00   
##   
## Three\_season\_porch Screen\_Porch Pool\_Area Pool\_QC   
## Min. : 0.000 Min. : 0.00 Min. : 0.000 No\_Pool :2047   
## 1st Qu.: 0.000 1st Qu.: 0.00 1st Qu.: 0.000 Excellent: 2   
## Median : 0.000 Median : 0.00 Median : 0.000 Typical : 2   
## Mean : 2.799 Mean : 16.68 Mean : 1.339 Fair : 1   
## 3rd Qu.: 0.000 3rd Qu.: 0.00 3rd Qu.: 0.000 Good : 1   
## Max. :407.000 Max. :576.00 Max. :800.000   
##   
## Fence Misc\_Feature Misc\_Val Mo\_Sold   
## No\_Fence :1661 None:1978 Min. : 0.00 6 :352   
## Minimum\_Privacy : 225 Gar2: 5 1st Qu.: 0.00 7 :320   
## Good\_Privacy : 81 Shed: 66 Median : 0.00 5 :275   
## Good\_Wood : 77 Othr: 3 Mean : 60.12 4 :187   
## Minimum\_Wood\_Wire: 9 Elev: 1 3rd Qu.: 0.00 8 :169   
## Max. :17000.00 3 :164   
## (Other):586   
## Year\_Sold Sale\_Type Sale\_Condition Longitude Latitude   
## 2006:442 WD :1789 Normal :1712 Min. :-93.69 Min. :41.99   
## 2007:499 New : 163 Partial: 169 1st Qu.:-93.66 1st Qu.:42.02   
## 2008:445 COD : 54 Family : 30 Median :-93.64 Median :42.03   
## 2009:456 ConLD : 16 Abnorml: 121 Mean :-93.64 Mean :42.03   
## 2010:211 ConLI : 8 Alloca : 16 3rd Qu.:-93.62 3rd Qu.:42.05   
## CWD : 8 AdjLand: 5 Max. :-93.58 Max. :42.06   
## (Other): 15   
## Above\_Median  
## Yes:1043   
## No :1010   
##   
##   
##   
##   
##

skim(ames)

Data summary

|  |  |
| --- | --- |
| Name | ames |
| Number of rows | 2053 |
| Number of columns | 81 |
| \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |  |
| Column type frequency: |  |
| factor | 59 |
| numeric | 22 |
| \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |  |
| Group variables | None |

**Variable type: factor**

| skim\_variable | n\_missing | complete\_rate | ordered | n\_unique | top\_counts |
| --- | --- | --- | --- | --- | --- |
| MS\_SubClass | 0 | 1 | FALSE | 16 | One: 772, Two: 383, One: 204, One: 129 |
| MS\_Zoning | 0 | 1 | FALSE | 7 | Res: 1600, Res: 326, Flo: 87, Res: 20 |
| Street | 0 | 1 | FALSE | 2 | Pav: 2046, Grv: 7 |
| Alley | 0 | 1 | FALSE | 3 | No\_: 1914, Gra: 94, Pav: 45 |
| Lot\_Shape | 0 | 1 | FALSE | 4 | Reg: 1275, Sli: 714, Mod: 53, Irr: 11 |
| Land\_Contour | 0 | 1 | FALSE | 4 | Lvl: 1833, HLS: 94, Bnk: 81, Low: 45 |
| Utilities | 0 | 1 | FALSE | 2 | All: 2052, NoS: 1 |
| Lot\_Config | 0 | 1 | FALSE | 5 | Ins: 1495, Cor: 359, Cul: 135, FR2: 56 |
| Land\_Slope | 0 | 1 | FALSE | 3 | Gtl: 1951, Mod: 89, Sev: 13 |
| Neighborhood | 0 | 1 | FALSE | 28 | Nor: 327, Col: 183, Old: 181, Edw: 129 |
| Condition\_1 | 0 | 1 | FALSE | 9 | Nor: 1771, Fee: 113, Art: 67, RRA: 35 |
| Condition\_2 | 0 | 1 | FALSE | 8 | Nor: 2027, Fee: 12, Pos: 4, Art: 4 |
| Bldg\_Type | 0 | 1 | FALSE | 5 | One: 1706, Twn: 157, Dup: 76, Twn: 67 |
| House\_Style | 0 | 1 | FALSE | 8 | One: 1052, Two: 590, One: 225, SLv: 90 |
| Overall\_Qual | 0 | 1 | FALSE | 10 | Ave: 587, Abo: 518, Goo: 411, Ver: 237 |
| Overall\_Cond | 0 | 1 | FALSE | 9 | Ave: 1143, Abo: 376, Goo: 286, Ver: 98 |
| Year\_Built | 0 | 1 | FALSE | 114 | 200: 104, 200: 93, 200: 76, 200: 62 |
| Year\_Remod\_Add | 0 | 1 | FALSE | 61 | 195: 256, 200: 147, 200: 116, 200: 94 |
| Roof\_Style | 0 | 1 | FALSE | 6 | Gab: 1607, Hip: 404, Gam: 14, Fla: 14 |
| Roof\_Matl | 0 | 1 | FALSE | 6 | Com: 2023, Tar: 17, WdS: 8, WdS: 3 |
| Exterior\_1st | 0 | 1 | FALSE | 16 | Vin: 705, Met: 319, Wd : 313, HdB: 303 |
| Exterior\_2nd | 0 | 1 | FALSE | 17 | Vin: 699, Met: 317, Wd : 302, HdB: 277 |
| Mas\_Vnr\_Type | 0 | 1 | FALSE | 5 | Non: 1231, Brk: 638, Sto: 166, Brk: 17 |
| Exter\_Qual | 0 | 1 | FALSE | 4 | Typ: 1272, Goo: 682, Exc: 78, Fai: 21 |
| Exter\_Cond | 0 | 1 | FALSE | 5 | Typ: 1787, Goo: 213, Fai: 43, Exc: 9 |
| Foundation | 0 | 1 | FALSE | 6 | PCo: 911, CBl: 880, Brk: 216, Sla: 36 |
| Bsmt\_Qual | 0 | 1 | FALSE | 6 | Typ: 911, Goo: 849, Exc: 178, No\_: 57 |
| Bsmt\_Cond | 0 | 1 | FALSE | 6 | Typ: 1833, Goo: 80, Fai: 76, No\_: 57 |
| Bsmt\_Exposure | 0 | 1 | FALSE | 5 | No: 1331, Av: 284, Gd: 199, Mn: 179 |
| BsmtFin\_Type\_1 | 0 | 1 | FALSE | 7 | Unf: 602, GLQ: 578, ALQ: 298, Rec: 216 |
| BsmtFin\_Type\_2 | 0 | 1 | FALSE | 7 | Unf: 1740, Rec: 79, LwQ: 64, No\_: 58 |
| Heating | 0 | 1 | FALSE | 6 | Gas: 2019, Gas: 21, Gra: 6, Wal: 5 |
| Heating\_QC | 0 | 1 | FALSE | 5 | Exc: 1040, Typ: 618, Goo: 333, Fai: 61 |
| Central\_Air | 0 | 1 | FALSE | 2 | Y: 1916, N: 137 |
| Electrical | 0 | 1 | FALSE | 5 | SBr: 1887, Fus: 126, Fus: 33, Fus: 6 |
| Bsmt\_Full\_Bath | 0 | 1 | FALSE | 4 | 0: 1201, 1: 823, 2: 27, 3: 2 |
| Bsmt\_Half\_Bath | 0 | 1 | FALSE | 3 | 0: 1936, 1: 115, 2: 2 |
| Full\_Bath | 0 | 1 | FALSE | 5 | 2: 1080, 1: 920, 3: 41, 0: 10 |
| Half\_Bath | 0 | 1 | FALSE | 3 | 0: 1300, 1: 736, 2: 17 |
| Bedroom\_AbvGr | 0 | 1 | FALSE | 7 | 3: 1105, 2: 527, 4: 297, 1: 73 |
| Kitchen\_AbvGr | 0 | 1 | FALSE | 3 | 1: 1959, 2: 92, 3: 2 |
| Kitchen\_Qual | 0 | 1 | FALSE | 5 | Typ: 1070, Goo: 790, Exc: 142, Fai: 50 |
| Functional | 0 | 1 | FALSE | 8 | Typ: 1896, Min: 54, Min: 51, Mod: 27 |
| Fireplaces | 0 | 1 | FALSE | 5 | 0: 993, 1: 891, 2: 161, 3: 7 |
| Fireplace\_Qu | 0 | 1 | FALSE | 6 | No\_: 993, Goo: 538, Typ: 409, Fai: 56 |
| Garage\_Type | 0 | 1 | FALSE | 7 | Att: 1204, Det: 549, Bui: 127, No\_: 108 |
| Garage\_Finish | 0 | 1 | FALSE | 4 | Unf: 872, RFn: 563, Fin: 509, No\_: 109 |
| Garage\_Cars | 0 | 1 | FALSE | 6 | 2: 1131, 1: 539, 3: 261, 0: 108 |
| Garage\_Qual | 0 | 1 | FALSE | 6 | Typ: 1839, No\_: 109, Fai: 85, Goo: 16 |
| Garage\_Cond | 0 | 1 | FALSE | 6 | Typ: 1872, No\_: 109, Fai: 53, Goo: 10 |
| Paved\_Drive | 0 | 1 | FALSE | 3 | Pav: 1848, Dir: 163, Par: 42 |
| Pool\_QC | 0 | 1 | FALSE | 5 | No\_: 2047, Exc: 2, Typ: 2, Fai: 1 |
| Fence | 0 | 1 | FALSE | 5 | No\_: 1661, Min: 225, Goo: 81, Goo: 77 |
| Misc\_Feature | 0 | 1 | FALSE | 5 | Non: 1978, She: 66, Gar: 5, Oth: 3 |
| Mo\_Sold | 0 | 1 | FALSE | 12 | 6: 352, 7: 320, 5: 275, 4: 187 |
| Year\_Sold | 0 | 1 | FALSE | 5 | 200: 499, 200: 456, 200: 445, 200: 442 |
| Sale\_Type | 0 | 1 | FALSE | 10 | WD: 1789, New: 163, COD: 54, Con: 16 |
| Sale\_Condition | 0 | 1 | FALSE | 6 | Nor: 1712, Par: 169, Abn: 121, Fam: 30 |
| Above\_Median | 0 | 1 | FALSE | 2 | Yes: 1043, No: 1010 |

**Variable type: numeric**

| skim\_variable | n\_missing | complete\_rate | mean | sd | p0 | p25 | p50 | p75 | p100 | hist |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Lot\_Frontage | 0 | 1 | 57.38 | 33.20 | 0.00 | 43.00 | 62.00 | 78.00 | 313.00 | ▇▇▁▁▁ |
| Lot\_Area | 0 | 1 | 10258.40 | 8427.38 | 1300.00 | 7500.00 | 9548.00 | 11600.00 | 215245.00 | ▇▁▁▁▁ |
| Mas\_Vnr\_Area | 0 | 1 | 103.75 | 183.59 | 0.00 | 0.00 | 0.00 | 164.00 | 1600.00 | ▇▁▁▁▁ |
| BsmtFin\_SF\_1 | 0 | 1 | 4.21 | 2.24 | 1.00 | 3.00 | 3.00 | 7.00 | 7.00 | ▅▆▁▁▇ |
| BsmtFin\_SF\_2 | 0 | 1 | 52.57 | 175.99 | 0.00 | 0.00 | 0.00 | 0.00 | 1526.00 | ▇▁▁▁▁ |
| Bsmt\_Unf\_SF | 0 | 1 | 561.19 | 441.72 | 0.00 | 226.00 | 460.00 | 801.00 | 2336.00 | ▇▅▂▁▁ |
| Total\_Bsmt\_SF | 0 | 1 | 1054.57 | 435.33 | 0.00 | 793.00 | 988.00 | 1304.00 | 5095.00 | ▇▇▁▁▁ |
| First\_Flr\_SF | 0 | 1 | 1167.52 | 391.79 | 432.00 | 882.00 | 1088.00 | 1402.00 | 5095.00 | ▇▃▁▁▁ |
| Second\_Flr\_SF | 0 | 1 | 326.07 | 422.44 | 0.00 | 0.00 | 0.00 | 701.00 | 1862.00 | ▇▂▂▁▁ |
| Low\_Qual\_Fin\_SF | 0 | 1 | 4.97 | 49.09 | 0.00 | 0.00 | 0.00 | 0.00 | 1064.00 | ▇▁▁▁▁ |
| Gr\_Liv\_Area | 0 | 1 | 1498.56 | 487.84 | 480.00 | 1137.00 | 1447.00 | 1737.00 | 5095.00 | ▇▇▁▁▁ |
| TotRms\_AbvGrd | 0 | 1 | 6.44 | 1.54 | 3.00 | 5.00 | 6.00 | 7.00 | 15.00 | ▅▇▃▁▁ |
| Garage\_Area | 0 | 1 | 471.96 | 213.43 | 0.00 | 320.00 | 478.00 | 576.00 | 1488.00 | ▃▇▂▁▁ |
| Wood\_Deck\_SF | 0 | 1 | 93.52 | 127.71 | 0.00 | 0.00 | 0.00 | 168.00 | 1424.00 | ▇▁▁▁▁ |
| Open\_Porch\_SF | 0 | 1 | 48.17 | 69.51 | 0.00 | 0.00 | 27.00 | 72.00 | 742.00 | ▇▁▁▁▁ |
| Enclosed\_Porch | 0 | 1 | 23.02 | 60.59 | 0.00 | 0.00 | 0.00 | 0.00 | 584.00 | ▇▁▁▁▁ |
| Three\_season\_porch | 0 | 1 | 2.80 | 25.65 | 0.00 | 0.00 | 0.00 | 0.00 | 407.00 | ▇▁▁▁▁ |
| Screen\_Porch | 0 | 1 | 16.68 | 57.94 | 0.00 | 0.00 | 0.00 | 0.00 | 576.00 | ▇▁▁▁▁ |
| Pool\_Area | 0 | 1 | 1.34 | 27.74 | 0.00 | 0.00 | 0.00 | 0.00 | 800.00 | ▇▁▁▁▁ |
| Misc\_Val | 0 | 1 | 60.12 | 662.76 | 0.00 | 0.00 | 0.00 | 0.00 | 17000.00 | ▇▁▁▁▁ |
| Longitude | 0 | 1 | -93.64 | 0.03 | -93.69 | -93.66 | -93.64 | -93.62 | -93.58 | ▅▅▇▇▁ |
| Latitude | 0 | 1 | 42.03 | 0.02 | 41.99 | 42.02 | 42.03 | 42.05 | 42.06 | ▂▂▇▇▇ |

## Data Clean, Data Split, Recip

amesclean = ames %>% dplyr::select(-Alley, -Street, -Utilities, -Heating, -Bsmt\_Half\_Bath, -Pool\_QC, -Mo\_Sold, -Year\_Sold, -Pool\_Area, -Longitude, -Latitude)

set.seed(12345)  
ames\_split = initial\_split(amesclean, prop = 0.65, strata = Above\_Median)  
train = training(ames\_split)  
test = testing(ames\_split)

amesABMV\_recipe = recipe(Above\_Median ~., train) #recipe 1  
  
amesABMV\_recipe2 = recipe(Above\_Median ~ MS\_SubClass + Lot\_Shape + Neighborhood + Bldg\_Type + House\_Style + Overall\_Qual + Overall\_Cond + Year\_Built + Year\_Remod\_Add + Foundation + Bsmt\_Qual + Bsmt\_Cond + Bsmt\_Full\_Bath + Full\_Bath + Half\_Bath + Kitchen\_Qual + Fireplaces + Garage\_Cars + Garage\_Type + Sale\_Type + Sale\_Condition + Lot\_Area + Total\_Bsmt\_SF + First\_Flr\_SF + Second\_Flr\_SF + Gr\_Liv\_Area+ TotRms\_AbvGrd + Garage\_Area, train) #recipe2  
  
amesABMV\_recipe3 = recipe(Above\_Median ~ Neighborhood + House\_Style + Overall\_Qual + Overall\_Cond + Full\_Bath + Half\_Bath + Kitchen\_Qual + Fireplaces + Garage\_Cars + Sale\_Type + Lot\_Area + Total\_Bsmt\_SF + Gr\_Liv\_Area+ Garage\_Area, train) #recipe3  
  
ctrl\_grid = control\_stack\_grid() #necessary for working with the stacks package  
ctrl\_res = control\_stack\_resamples() #necessary for working with the stacks package

## Model 5 Neural Network

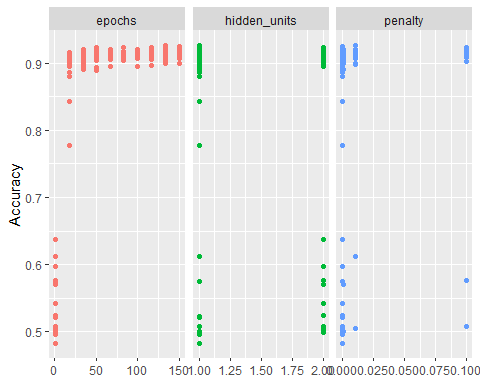
set.seed(123)  
folds9 = vfold\_cv(train, v = 3)

Neural network with parameter tuning

start\_time = Sys.time() #for timing  
  
neural\_grid = grid\_regular(  
 hidden\_units(range = c(1,2)),  
 penalty(range = c(-10,-1)),   
 #penalty is a weird one, you are not setting the actual penalty itself, you are setting the range of x in 10^x  
 epochs(range = c(1,150)),  
 levels = 10  
)  
   
ames9\_recipe = recipe(Above\_Median ~., train) %>%  
 step\_normalize(all\_predictors(), -all\_nominal()) #normalize the numeric predictors, not needed for categorical  
  
ames9\_model =   
 mlp(hidden\_units = tune(), penalty = tune(),   
 epochs = tune()) %>%  
 set\_mode("classification") %>%   
 set\_engine("nnet", verbose = 0) #verbose = 0 reduces output from the model  
   
ames9\_workflow <-   
 workflow() %>%   
 add\_recipe(ames9\_recipe) %>%   
 add\_model(ames9\_model)   
  
set.seed(1234)  
neural\_tune2 <-  
 tune\_grid(ames9\_workflow, resamples = folds9, grid = neural\_grid)  
  
end\_time = Sys.time()  
end\_time-start\_time

## Time difference of 7.496982 mins

neural\_tune2 %>%  
 collect\_metrics() %>%  
 filter(.metric == "accuracy") %>%  
 dplyr::select(mean, hidden\_units, penalty, epochs) %>%  
 pivot\_longer(hidden\_units:epochs,  
 values\_to = "value",  
 names\_to = "parameter"  
 ) %>%  
 ggplot(aes(value, mean, color = parameter)) +  
 geom\_point(show.legend = FALSE) +  
 facet\_wrap(~parameter, scales = "free\_x") +  
 labs(x = NULL, y = "Accuracy")



best\_nn2 = select\_best(neural\_tune2, "accuracy")  
  
final\_nn2 = finalize\_workflow(  
 ames9\_workflow,  
 best\_nn2  
)  
  
final\_nn2

## == Workflow ====================================================================  
## Preprocessor: Recipe  
## Model: mlp()  
##   
## -- Preprocessor ----------------------------------------------------------------  
## 1 Recipe Step  
##   
## \* step\_normalize()  
##   
## -- Model -----------------------------------------------------------------------  
## Single Layer Neural Network Specification (classification)  
##   
## Main Arguments:  
## hidden\_units = 1  
## penalty = 0.01  
## epochs = 133  
##   
## Engine-Specific Arguments:  
## verbose = 0  
##   
## Computational engine: nnet

#fit the finalized workflow to our training data  
final\_nn\_fit2 = fit(final\_nn2, train)

trainprednn2 = predict(final\_nn\_fit2, train)  
head(trainprednn2)

## # A tibble: 6 x 1  
## .pred\_class  
## <fct>   
## 1 No   
## 2 No   
## 3 No   
## 4 No   
## 5 No   
## 6 No

confusionMatrix(trainprednn2$.pred\_class, train$Above\_Median,   
 positive = "Yes")

## Confusion Matrix and Statistics  
##   
## Reference  
## Prediction Yes No  
## Yes 671 7  
## No 6 649  
##   
## Accuracy : 0.9902   
## 95% CI : (0.9834, 0.9948)  
## No Information Rate : 0.5079   
## P-Value [Acc > NIR] : <2e-16   
##   
## Kappa : 0.9805   
##   
## Mcnemar's Test P-Value : 1   
##   
## Sensitivity : 0.9911   
## Specificity : 0.9893   
## Pos Pred Value : 0.9897   
## Neg Pred Value : 0.9908   
## Prevalence : 0.5079   
## Detection Rate : 0.5034   
## Detection Prevalence : 0.5086   
## Balanced Accuracy : 0.9902   
##   
## 'Positive' Class : Yes   
##

testprednn2 = predict(final\_nn\_fit2, test)  
head(testprednn2)

## # A tibble: 6 x 1  
## .pred\_class  
## <fct>   
## 1 Yes   
## 2 Yes   
## 3 Yes   
## 4 No   
## 5 Yes   
## 6 No

Confusion matrix

confusionMatrix(testprednn2$.pred\_class, test$Above\_Median,   
 positive = "Yes")

## Confusion Matrix and Statistics  
##   
## Reference  
## Prediction Yes No  
## Yes 339 38  
## No 27 316  
##   
## Accuracy : 0.9097   
## 95% CI : (0.8864, 0.9296)  
## No Information Rate : 0.5083   
## P-Value [Acc > NIR] : <2e-16   
##   
## Kappa : 0.8193   
##   
## Mcnemar's Test P-Value : 0.2148   
##   
## Sensitivity : 0.9262   
## Specificity : 0.8927   
## Pos Pred Value : 0.8992   
## Neg Pred Value : 0.9213   
## Prevalence : 0.5083   
## Detection Rate : 0.4708   
## Detection Prevalence : 0.5236   
## Balanced Accuracy : 0.9094   
##   
## 'Positive' Class : Yes   
##

The result for the neural network is ok. Its a little overfitted.