Package **CompSign**

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CompSign is a toolkit for differential abundance analysis of mutational signatures using a mixed effects Dirichlet-multinominal model (or simpler variations). The compositional nature of mutational signature exposures has often been overlooked but has important implications, as the analyses must be done in relative terms.

Contents

1 Installation

`CompSign` can be installed as usual from github:

```
rm(list = ls())
setwd("~/Documents/PhD/CompSign/vignette_knitr/")
```

```
# library(devtools)
# devtools::install_github("lm687/CompSign")
```

```
library(CompSign)
```

```
## Loading required package:  TMB
## Warning:  package 'TMB' was built under R version 4.0.5
## Loading required package:  RcppEigen
```

```
library(gridExtra)
library(TMB)
# setwd(dirname(rstudioapi::getSourceEditorContext()$path))
```

2 Datasets

```
## if the folder data/ is not in github
for(i in list.files("../inst/extdata/", pattern = "*RDA", full.names = TRUE)){load(i)}
```

The package contains the following datasets of exposures of mutational signatures and metadata of the corresponding samples. These datasets are:

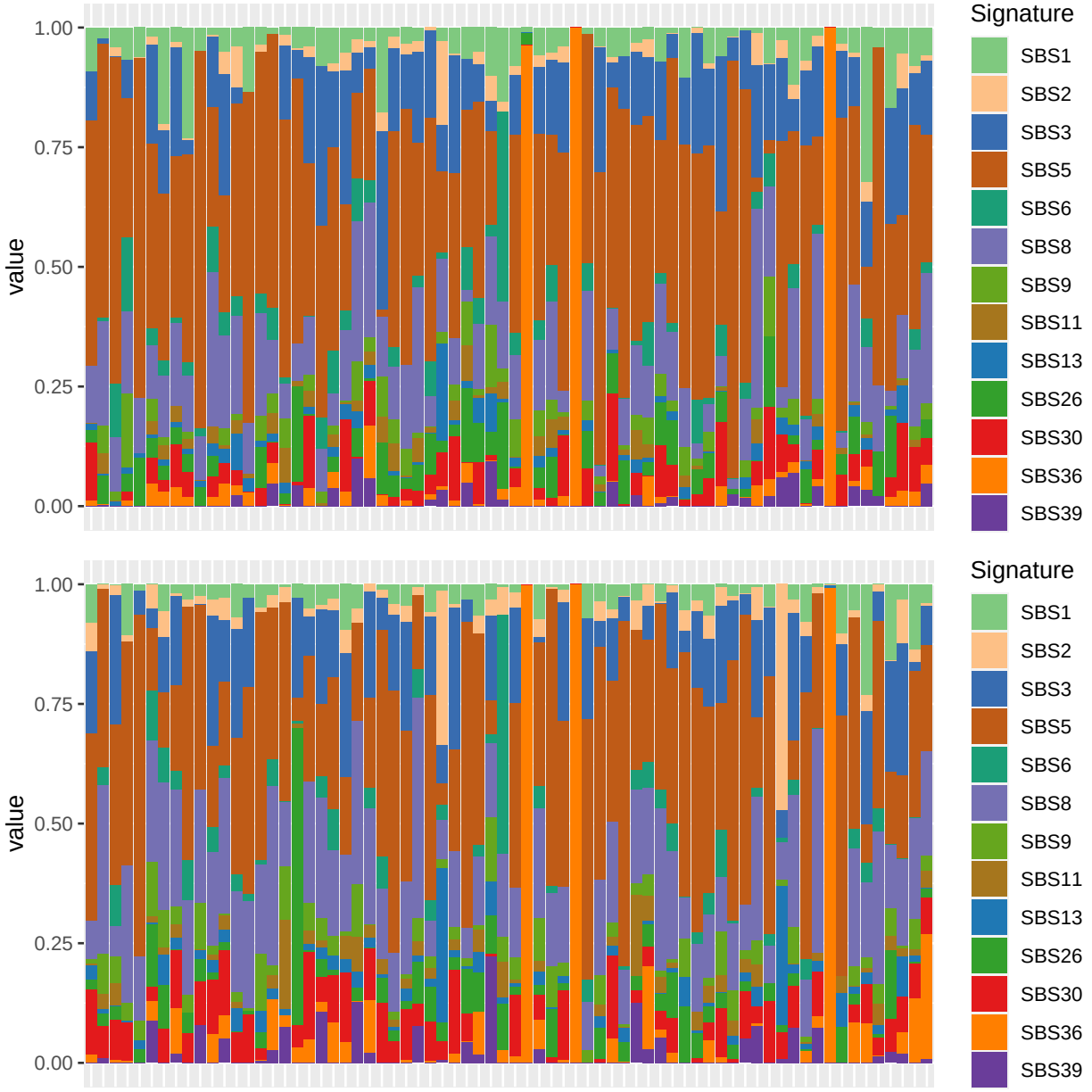
- `PancEndocrine_signaturesMSE`: Signature exposures for early and late mutations, in the PCAWG Panc-Endocrine cohort
- `ProstAdenoCA_chrom`: Signature exposures for each chromosome, in the PCAWG Prost-AdenoCA cohort

`PancEndocrine_signaturesMSE` is an object of class `sign`

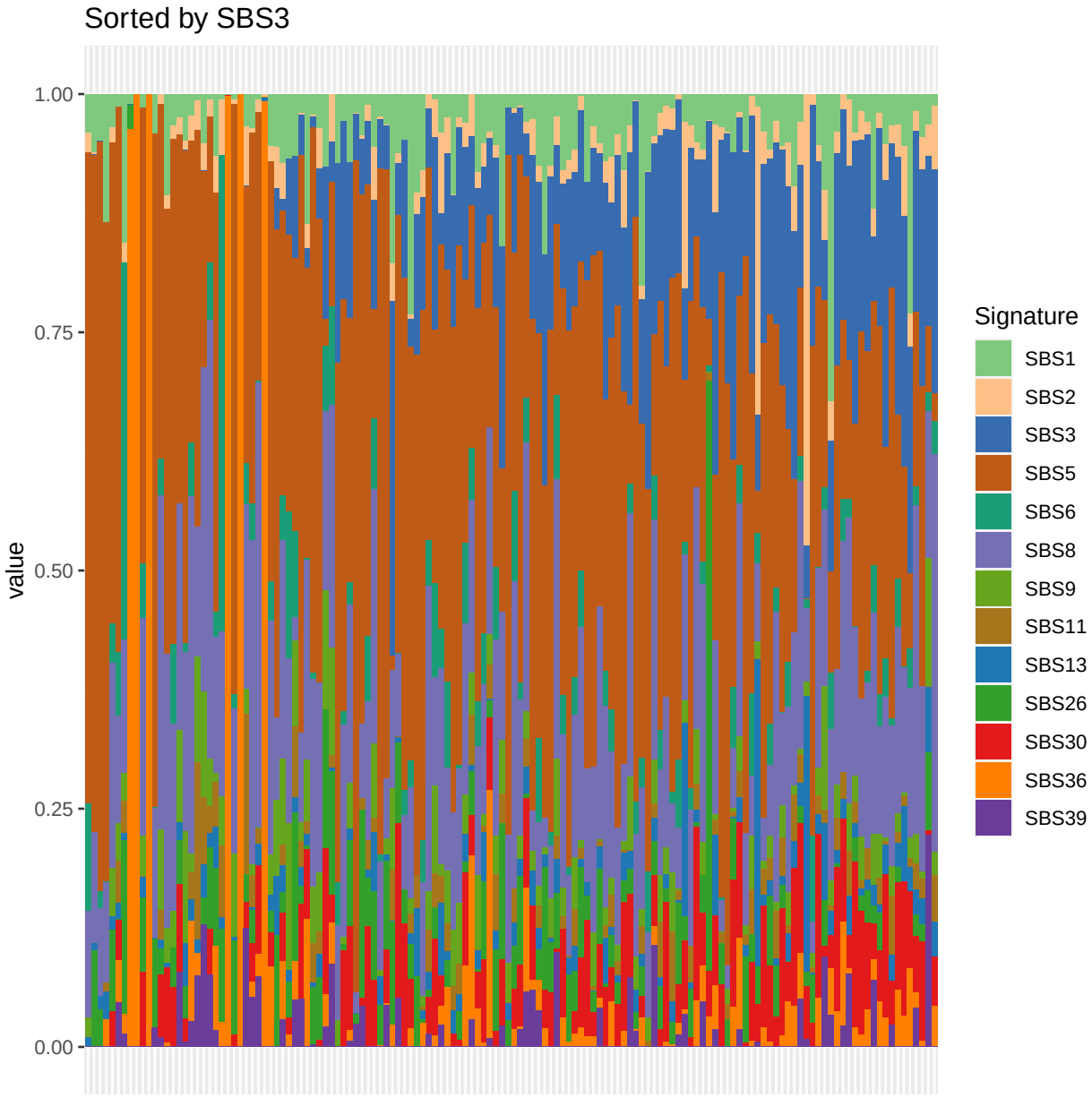
```
PancEndocrine_signaturesMSE = load_PCAWG("../inst/extdata/roo/Panc-Endocrine_signaturesMSE_ROO.RDS",
                                         read_directly = T,
                                         typedata = "signaturesMSE", override_warning_X_Z = T)

## [1] "../inst/extdata/roo/Panc-Endocrine_signaturesMSE_ROO.RDS"
## Reading file ../inst/extdata/roo/Panc-Endocrine_signaturesMSE_ROO.RDS

PancEndocrine_signaturesMSE_v2 = load_PCAWG(ct = "Panc-Endocrine", typedata = "signaturesMSE", path_to_da
```

```
# PancEndocrine_signaturesMSE
```

```
do.call('grid.arrange', lapply(split_matrix_in_half(PancEndocrine_signaturesMSE$Y), function(i) createBar

## Loading required package: reshape2
## Loading required package: ggplot2
## Warning: package 'RColorBrewer' was built under R version 4.0.5

## Creating plot... it might take some time if the data are large. Number of samples: 70
## Creating plot... it might take some time if the data are large. Number of samples: 70
```




```
createBarplot(normalise_rw(non_duplicated_rows(PancEndocrine_signaturesMSE$Y)),
              order_labels = names(sort(non_duplicated_rows(PancEndocrine_signaturesMSE$Y)[,'SBS3'],
                                        decreasing = F)), remove_labels=T)+ggtitle('Sorted by SBS3')

## Creating plot... it might take some time if the data are large. Number of samples: 140
```




```
# TMB::compile("../R/mm_multinomial/fullRE_ME_dirichletmultinomial.cpp",  "-std=gnu++17")
# dyn.load(dynlib("../R/mm_multinomial/fullRE_ME_dirichletmultinomial"))


# fullDM_no_small_sigs <- wrapper_run_TMB(object = give_subset_sigs_TMBobj(PancEndocrine_signaturesMSE,
#                           sigs_to_remove = c('SBS13', 'SBS17a', 'SBS17b', 'SBS30')),
#                                         model = "fullRE_DM", use_nlminb=T, smart_init_vals=F)
#
# diagDM_no_small_sigs <- wrapper_run_TMB(object = give_subset_sigs_TMBobj(PancEndocrine_signaturesMSE,
#                           sigs_to_remove = c('SBS13', 'SBS17a', 'SBS17b', 'SBS30')),
```

```r
#                                          model = "diagRE_DM", use_nlminb=T, smart_init_vals=F)

diagDM_no_small_sigs <- wrapper_run_TMB(object = give_subset_sigs_TMBobj(PancEndocrine_signaturesMSE,
                                                                         sigs_to_remove = c('SBS13', 'SBS
                                        model = "diagREDMsinglelambda", use_nlminb=T, smart_init_vals=F)
```

```
## Constructing atomic invpd
## Constructing atomic D_lgamma
## Constructing atomic invpd
## Constructing atomic D_lgamma
## Constructing atomic matmul
## Constructing atomic invpd
## Constructing atomic D_lgamma
## Constructing atomic matmul
## Optimizing tape... Done
## iter: 1  value: 290216.2 mgc: 6.015462 ustep: 0.1324035
## iter: 2  value: 290048.7 mgc: 12.14299 ustep: 0.2024439
## iter: 3  value: 289957.3 mgc: 4.553861 ustep: 0.4499927
## iter: 4  value: 289930.9 mgc: 1.030855 ustep: 0.6708478
## iter: 5  value: 289925.8 mgc: 0.3839529 ustep: 0.8190711
## iter: 6  value: 289925.4 mgc: 0.0928018 ustep: 0.905035
## iter: 7  value: 289925.4 mgc: 0.01208526 ustep: 0.9513381
## iter: 8  value: 289925.4 mgc: 0.001043225 ustep: 0.9753681
## iter: 9  value: 289925.4 mgc: 6.027499e-05 ustep: 0.9876085
## iter: 10  value: 289925.4 mgc: 1.787903e-06 ustep: 0.9937856
## iter: 11  value: 289925.4 mgc: 2.687416e-08 ustep: 0.9968882
## iter: 12  mgc: 2.032571e-10
## iter: 1  mgc: 2.032571e-10
## Matching hessian patterns... Done
## outer mgc:  382.7719
## iter: 1  value: 289618.3 mgc: 5.360763 ustep: 1
## iter: 2  value: 289582.1 mgc: 6.732816 ustep: 1
## iter: 3  value: 289581.7 mgc: 0.5344027 ustep: 1
## iter: 4  value: 289581.7 mgc: 0.02230462 ustep: 1
## iter: 5  value: 289581.7 mgc: 0.0001082869 ustep: 1
## iter: 6  mgc: 2.559375e-09
## iter: 1  mgc: 2.559375e-09
## outer mgc:  145.8589
## iter: 1  value: 289387 mgc: 4.997748 ustep: 1
## iter: 2  value: 289386.3 mgc: 1.074322 ustep: 1
## iter: 3  value: 289386.3 mgc: 0.06132626 ustep: 1
## iter: 4  value: 289386.3 mgc: 0.0003278063 ustep: 1
## iter: 5  value: 289386.3 mgc: 1.232964e-08 ustep: 1
## mgc: 1.487699e-14
## iter: 1  mgc: 1.487699e-14
## outer mgc:  48.17484
## iter: 1  value: 289448.6 mgc: 7.371968 ustep: 1
## iter: 2  value: 289430.9 mgc: 2.176067 ustep: 1
## iter: 3  value: 289430.8 mgc: 0.2122285 ustep: 1
## iter: 4  value: 289430.8 mgc: 0.0054237 ustep: 1
## iter: 5  value: 289430.8 mgc: 4.098206e-06 ustep: 1
```

```
## iter: 6  mgc: 2.325473e-12
## iter: 1  mgc: 2.325473e-12
## outer mgc:  209.9866
## iter: 1  value: 289434.4 mgc: 20.91279 ustep: 0.4414616
## iter: 2  value: 289257.5 mgc: 18.79818 ustep: 0.1331639
## iter: 3  value: 289184.7 mgc: 29.47962 ustep: 0.05022163
## iter: 4  value: 289171.4 mgc: 9.519155 ustep: 0.1191813
## iter: 5  value: 289167.3 mgc: 2.437683 ustep: 0.3452919
## iter: 6  value: 289165.2 mgc: 0.6391344 ustep: 0.5876567
## iter: 7  value: 289164.6 mgc: 0.2290889 ustep: 0.766611
## iter: 8  value: 289164.6 mgc: 0.06603244 ustep: 0.8755757
## iter: 9  value: 289164.6 mgc: 0.01404348 ustep: 0.9357285
## iter: 10  value: 289164.6 mgc: 0.002444937 ustep: 0.9673338
## iter: 11  value: 289164.6 mgc: 0.0002558516 ustep: 0.983533
## iter: 12  value: 289164.6 mgc: 1.37948e-05 ustep: 0.9917331
## iter: 13  value: 289164.6 mgc: 3.772917e-07 ustep: 0.9958584
## iter: 14  mgc: 5.193633e-09
## iter: 1  mgc: 5.193633e-09
## outer mgc:  312.2764
## iter: 1  value: 289961.7 mgc: 26.62633 ustep: 0.6827823
## iter: 2  value: 289326.1 mgc: 32.64421 ustep: 0.1157857
## iter: 3  value: 289315.8 mgc: 25.82002 ustep: 0.340339
## iter: 4  value: 289268 mgc: 12.58513 ustep: 0.2264387
## iter: 5  value: 289253.7 mgc: 14.96646 ustep: 0.4759081
## iter: 6  value: 289192.8 mgc: 22.00772 ustep: 0.07112462
## iter: 7  value: 289159.7 mgc: 10.5497 ustep: 0.1415293
## iter: 8  value: 289144.3 mgc: 9.727409 ustep: 0.3762662
## iter: 9  value: 289134.5 mgc: 13.44452 ustep: 0.2114524
## iter: 10  value: 289121.4 mgc: 10.96556 ustep: 0.2650541
## iter: 11  value: 289103.4 mgc: 9.174821 ustep: 0.5148826
## iter: 12  value: 289094.6 mgc: 3.821551 ustep: 0.428715
## iter: 13  value: 289085.8 mgc: 14.19838 ustep: 0.6547979
## iter: 14  value: 289085.5 mgc: 1.414224 ustep: 0.8092149
## iter: 15  value: 289085.5 mgc: 0.0642921 ustep: 0.8995738
## iter: 16  value: 289085.5 mgc: 0.003111111 ustep: 0.9484638
## iter: 17  value: 289085.5 mgc: 0.000189303 ustep: 0.9738937
## iter: 18  value: 289085.5 mgc: 1.144722e-05 ustep: 0.9868618
## iter: 19  value: 289085.5 mgc: 5.219508e-07 ustep: 0.9934099
## iter: 20  value: 289085.5 mgc: 1.21379e-08 ustep: 0.9966998
## iter: 21  mgc: 1.425434e-10
## iter: 1  mgc: 1.425434e-10
## outer mgc:  164.1466
## iter: 1  value: 289916.9 mgc: 11.57202 ustep: 1
## iter: 2  value: 289880 mgc: 8.149587 ustep: 1
## iter: 3  value: 289876.2 mgc: 3.536326 ustep: 0.6827823
## iter: 4  value: 289873.1 mgc: 4.446995 ustep: 0.8263238
## iter: 5  value: 289873.1 mgc: 0.1540159 ustep: 0.9090326
## iter: 6  value: 289873.1 mgc: 0.01135657 ustep: 0.9534367
## iter: 7  value: 289873.1 mgc: 0.0008654795 ustep: 0.9764432
## iter: 8  value: 289873.1 mgc: 3.355404e-05 ustep: 0.9881526
## iter: 9  value: 289873.1 mgc: 6.665875e-07 ustep: 0.9940592
```

```
## iter: 10  mgc: 8.850067e-09
## iter: 1  value: 289070.9 mgc: 4.850847 ustep: 1
## iter: 2  value: 289065.1 mgc: 4.116268 ustep: 1
## iter: 3  value: 289064.8 mgc: 1.029607 ustep: 1
## iter: 4  value: 289064.8 mgc: 0.1532742 ustep: 1
## iter: 5  value: 289064.8 mgc: 0.005173916 ustep: 1
## iter: 6  value: 289064.8 mgc: 6.447625e-06 ustep: 1
## iter: 7  mgc: 1.004252e-11
## iter: 1  mgc: 1.004252e-11
## outer mgc:  197.166
## iter: 1  value: 288867.2 mgc: 5.032842 ustep: 1
## iter: 2  value: 288865.5 mgc: 3.486836 ustep: 1
## iter: 3  value: 288865.5 mgc: 0.3441658 ustep: 1
## iter: 4  value: 288865.5 mgc: 0.00545161 ustep: 1
## iter: 5  value: 288865.5 mgc: 1.509327e-06 ustep: 1
## iter: 6  mgc: 1.154632e-13
## iter: 1  mgc: 1.154632e-13
## outer mgc:  40.57349
## iter: 1  value: 288850 mgc: 4.516196 ustep: 1
## iter: 2  value: 288848 mgc: 1.07789 ustep: 1
## iter: 3  value: 288848 mgc: 0.05401946 ustep: 1
## iter: 4  value: 288848 mgc: 0.0001637878 ustep: 1
## iter: 5  mgc: 1.514219e-09
## iter: 1  mgc: 1.514219e-09
## outer mgc:  33.77688
## iter: 1  value: 288808.4 mgc: 5.919606 ustep: 1
## iter: 2  value: 288806.5 mgc: 1.038756 ustep: 1
## iter: 3  value: 288806.5 mgc: 0.08693136 ustep: 1
## iter: 4  value: 288806.5 mgc: 0.0008137611 ustep: 1
## iter: 5  value: 288806.5 mgc: 7.366848e-08 ustep: 1
## iter: 6  mgc: 1.904032e-14
## iter: 1  mgc: 1.904032e-14
## outer mgc:  45.78203
## iter: 1  value: 288786.2 mgc: 8.132768 ustep: 1
## iter: 2  value: 288780.1 mgc: 3.432827 ustep: 1
## iter: 3  value: 288780.1 mgc: 0.1893315 ustep: 1
## iter: 4  value: 288780.1 mgc: 0.0009027429 ustep: 1
## iter: 5  value: 288780.1 mgc: 3.242912e-08 ustep: 1
## mgc: 1.759703e-14
## iter: 1  value: 288772.8 mgc: 4.490524 ustep: 1
## iter: 2  value: 288772.6 mgc: 0.5672354 ustep: 1
## iter: 3  value: 288772.6 mgc: 0.006833447 ustep: 1
## iter: 4  value: 288772.6 mgc: 1.305383e-06 ustep: 1
## iter: 5  mgc: 6.283862e-14
## iter: 1  mgc: 6.283862e-14
## outer mgc:  33.37919
## iter: 1  value: 288798.7 mgc: 3.900641 ustep: 1
## iter: 2  value: 288798.7 mgc: 0.2468406 ustep: 1
## iter: 3  value: 288798.7 mgc: 0.004904173 ustep: 1
## iter: 4  value: 288798.7 mgc: 2.042386e-06 ustep: 1
## iter: 5  mgc: 3.539391e-13
```

```
## iter: 1  value: 288783.1 mgc: 1.973948 ustep: 1
## iter: 2  value: 288783.1 mgc: 0.05267718 ustep: 1
## iter: 3  value: 288783.1 mgc: 0.0002105413 ustep: 1
## iter: 4  mgc: 3.889966e-09
## iter: 1  mgc: 3.889966e-09
## outer mgc:  20.13044
## iter: 1  value: 288765.8 mgc: 1.521343 ustep: 1
## iter: 2  value: 288765.8 mgc: 0.03160043 ustep: 1
## iter: 3  value: 288765.8 mgc: 3.710231e-05 ustep: 1
## iter: 4  mgc: 9.207302e-11
## iter: 1  mgc: 9.207302e-11
## outer mgc:  23.51402
## iter: 1  value: 288767.9 mgc: 1.08075 ustep: 1
## iter: 2  value: 288767.9 mgc: 0.03732692 ustep: 1
## iter: 3  value: 288767.9 mgc: 0.0001083482 ustep: 1
## iter: 4  mgc: 9.371783e-10
## iter: 1  mgc: 9.371783e-10
## outer mgc:  11.05018
## iter: 1  value: 288745.4 mgc: 1.09277 ustep: 1
## iter: 2  value: 288745.4 mgc: 0.02127332 ustep: 1
## iter: 3  value: 288745.4 mgc: 2.750436e-05 ustep: 1
## iter: 4  mgc: 1.677051e-10
## iter: 1  mgc: 1.677051e-10
## outer mgc:  13.73099
## iter: 1  value: 288740 mgc: 2.32309 ustep: 1
## iter: 2  value: 288740 mgc: 0.05035307 ustep: 1
## iter: 3  value: 288740 mgc: 4.96187e-05 ustep: 1
## iter: 4  mgc: 3.186198e-10
## iter: 1  mgc: 3.186198e-10
## outer mgc:  15.93512
## iter: 1  value: 288730.5 mgc: 1.229492 ustep: 1
## iter: 2  value: 288730.5 mgc: 0.02965242 ustep: 1
## iter: 3  value: 288730.5 mgc: 5.750273e-05 ustep: 1
## iter: 4  mgc: 3.333218e-10
## iter: 1  mgc: 3.333218e-10
## outer mgc:  8.810975
## iter: 1  value: 288728.2 mgc: 1.834708 ustep: 1
## iter: 2  value: 288728.2 mgc: 0.08135906 ustep: 1
## iter: 3  value: 288728.2 mgc: 0.000750968 ustep: 1
## iter: 4  value: 288728.2 mgc: 6.4175e-08 ustep: 1
## iter: 5  mgc: 1.609823e-14
## iter: 1  mgc: 1.609823e-14
## outer mgc:  9.650541
## iter: 1  value: 288714.1 mgc: 1.496351 ustep: 1
## iter: 2  value: 288714.1 mgc: 0.1134891 ustep: 1
## iter: 3  value: 288714.1 mgc: 0.0008578552 ustep: 1
## iter: 4  value: 288714.1 mgc: 5.074528e-08 ustep: 1
## iter: 5  mgc: 1.998401e-14
## iter: 1  value: 288719.1 mgc: 0.6688759 ustep: 1
## iter: 2  value: 288719.1 mgc: 0.01345298 ustep: 1
## iter: 3  value: 288719.1 mgc: 1.153822e-05 ustep: 1
```

```
## iter: 4  mgc: 9.423268e-12
## iter: 1  mgc: 9.423268e-12
## outer mgc:  16.74783
## iter: 1  value: 288724.5 mgc: 1.222705 ustep: 1
## iter: 2  value: 288724.5 mgc: 0.01370095 ustep: 1
## iter: 3  value: 288724.5 mgc: 7.086828e-06 ustep: 1
## iter: 4  mgc: 3.468337e-12
## iter: 1  mgc: 3.468337e-12
## outer mgc:  12.47621
## iter: 1  value: 288718.2 mgc: 0.6438052 ustep: 1
## iter: 2  value: 288718.2 mgc: 0.01161722 ustep: 1
## iter: 3  value: 288718.2 mgc: 1.030234e-05 ustep: 1
## iter: 4  mgc: 1.401435e-11
## iter: 1  mgc: 1.401435e-11
## outer mgc:  2.993846
## iter: 1  value: 288716.4 mgc: 0.6561235 ustep: 1
## iter: 2  value: 288716.4 mgc: 0.01960927 ustep: 1
## iter: 3  value: 288716.4 mgc: 2.836722e-05 ustep: 1
## iter: 4  mgc: 6.064349e-11
## iter: 1  mgc: 6.064349e-11
## outer mgc:  6.227307
## iter: 1  value: 288710.8 mgc: 0.7362887 ustep: 1
## iter: 2  value: 288710.8 mgc: 0.00912599 ustep: 1
## iter: 3  value: 288710.8 mgc: 6.456061e-06 ustep: 1
## iter: 4  mgc: 3.160583e-12
## iter: 1  mgc: 3.160583e-12
## outer mgc:  10.30561
## iter: 1  value: 288710.9 mgc: 0.9202383 ustep: 1
## iter: 2  value: 288710.9 mgc: 0.009704019 ustep: 1
## iter: 3  value: 288710.9 mgc: 1.254852e-06 ustep: 1
## iter: 4  mgc: 3.68594e-14
## iter: 1  mgc: 3.68594e-14
## outer mgc:  3.427546
## iter: 1  value: 288706 mgc: 0.3861816 ustep: 1
## iter: 2  value: 288706 mgc: 0.004672568 ustep: 1
## iter: 3  value: 288706 mgc: 1.334783e-06 ustep: 1
## iter: 4  mgc: 1.132427e-13
## iter: 1  mgc: 1.132427e-13
## outer mgc:  4.24239
## iter: 1  value: 288704.1 mgc: 0.3546992 ustep: 1
## iter: 2  value: 288704.1 mgc: 0.006033714 ustep: 1
## iter: 3  value: 288704.1 mgc: 2.189424e-06 ustep: 1
## iter: 4  mgc: 2.944311e-13
## iter: 1  mgc: 2.944311e-13
## outer mgc:  2.350959
## iter: 1  value: 288700.5 mgc: 0.3530215 ustep: 1
## iter: 2  value: 288700.5 mgc: 0.004154084 ustep: 1
## iter: 3  value: 288700.5 mgc: 9.201116e-07 ustep: 1
## iter: 4  mgc: 1.421085e-13
## iter: 1  mgc: 1.421085e-13
## outer mgc:  3.55996
```

```
## iter: 1  value: 288698.1 mgc: 0.430426 ustep: 1
## iter: 2  value: 288698.1 mgc: 0.004655697 ustep: 1
## iter: 3  value: 288698.1 mgc: 2.155191e-06 ustep: 1
## iter: 4  mgc: 7.560619e-13
## iter: 1  mgc: 7.560619e-13
## outer mgc:  2.198704
## iter: 1  value: 288693.4 mgc: 0.4619701 ustep: 1
## iter: 2  value: 288693.4 mgc: 0.01315749 ustep: 1
## iter: 3  value: 288693.4 mgc: 1.285179e-05 ustep: 1
## iter: 4  mgc: 1.797729e-11
## iter: 1  mgc: 1.797729e-11
## outer mgc:  4.562502
## iter: 1  value: 288692.7 mgc: 0.6225979 ustep: 1
## iter: 2  value: 288692.7 mgc: 0.005927129 ustep: 1
## iter: 3  value: 288692.7 mgc: 1.856451e-06 ustep: 1
## iter: 4  mgc: 2.552403e-13
## iter: 1  mgc: 2.552403e-13
## outer mgc:  4.125239
## iter: 1  value: 288686.8 mgc: 0.6505156 ustep: 1
## iter: 2  value: 288686.8 mgc: 0.00895908 ustep: 1
## iter: 3  value: 288686.8 mgc: 3.877485e-06 ustep: 1
## iter: 4  mgc: 8.695267e-13
## iter: 1  mgc: 8.695267e-13
## outer mgc:  8.879846
## iter: 1  value: 288688.2 mgc: 0.7235614 ustep: 1
## iter: 2  value: 288688.2 mgc: 0.01008148 ustep: 1
## iter: 3  value: 288688.2 mgc: 3.091398e-06 ustep: 1
## iter: 4  mgc: 1.121825e-12
## iter: 1  mgc: 1.121825e-12
## outer mgc:  7.817
## iter: 1  value: 288682.4 mgc: 0.3940903 ustep: 1
## iter: 2  value: 288682.4 mgc: 0.001485006 ustep: 1
## iter: 3  value: 288682.4 mgc: 2.290624e-07 ustep: 1
## iter: 4  mgc: 1.44329e-14
## iter: 1  mgc: 1.44329e-14
## outer mgc:  3.607363
## iter: 1  value: 288680.8 mgc: 0.4969665 ustep: 1
## iter: 2  value: 288680.8 mgc: 0.009256689 ustep: 1
## iter: 3  value: 288680.8 mgc: 2.790863e-06 ustep: 1
## iter: 4  mgc: 8.919532e-13
## iter: 1  mgc: 8.919532e-13
## outer mgc:  4.545495
## iter: 1  value: 288676.6 mgc: 0.4228731 ustep: 1
## iter: 2  value: 288676.6 mgc: 0.002217737 ustep: 1
## iter: 3  value: 288676.6 mgc: 3.157768e-07 ustep: 1
## iter: 4  mgc: 1.154632e-14
## iter: 1  mgc: 1.154632e-14
## outer mgc:  2.652565
## iter: 1  value: 288674.5 mgc: 0.4238797 ustep: 1
## iter: 2  value: 288674.5 mgc: 0.004432043 ustep: 1
## iter: 3  value: 288674.5 mgc: 1.889827e-06 ustep: 1
```

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## iter: 4  mgc: 4.907186e-13
## iter: 1  mgc: 4.907186e-13
## outer mgc:  2.656259
## iter: 1  value: 288670.9 mgc: 0.4501135 ustep: 1
## iter: 2  value: 288670.9 mgc: 0.003943893 ustep: 1
## iter: 3  value: 288670.9 mgc: 1.347168e-06 ustep: 1
## iter: 4  mgc: 3.064216e-13
## iter: 1  mgc: 3.064216e-13
## outer mgc:  1.595993
## iter: 1  value: 288667.7 mgc: 0.3871122 ustep: 1
## iter: 2  value: 288667.7 mgc: 0.003279969 ustep: 1
## iter: 3  value: 288667.7 mgc: 2.385524e-06 ustep: 1
## iter: 4  mgc: 1.265058e-12
## iter: 1  mgc: 1.265058e-12
## outer mgc:  1.95488
## iter: 1  value: 288663.4 mgc: 0.2971828 ustep: 1
## iter: 2  value: 288663.4 mgc: 0.001983309 ustep: 1
## iter: 3  value: 288663.4 mgc: 4.542598e-07 ustep: 1
## iter: 4  mgc: 2.58682e-14
## iter: 1  mgc: 2.58682e-14
## outer mgc:  2.09374
## iter: 1  value: 288661.4 mgc: 0.5801794 ustep: 1
## iter: 2  value: 288661.4 mgc: 0.001858104 ustep: 1
## iter: 3  value: 288661.4 mgc: 7.670011e-07 ustep: 1
## iter: 4  mgc: 1.316447e-13
## iter: 1  mgc: 1.316447e-13
## outer mgc:  5.265721
## iter: 1  value: 288655.7 mgc: 0.4199575 ustep: 1
## iter: 2  value: 288655.7 mgc: 0.002750385 ustep: 1
## iter: 3  value: 288655.7 mgc: 2.582169e-07 ustep: 1
## iter: 4  mgc: 1.326717e-14
## iter: 1  mgc: 1.326717e-14
## outer mgc:  3.2143
## iter: 1  value: 288652 mgc: 0.4709439 ustep: 1
## iter: 2  value: 288652 mgc: 0.002834257 ustep: 1
## iter: 3  value: 288652 mgc: 5.987204e-07 ustep: 1
## iter: 4  mgc: 6.175616e-14
## iter: 1  mgc: 6.175616e-14
## outer mgc:  1.265723
## iter: 1  value: 288653.4 mgc: 0.5844584 ustep: 1
## iter: 2  value: 288653.4 mgc: 0.01080039 ustep: 1
## iter: 3  value: 288653.4 mgc: 5.527042e-06 ustep: 1
## iter: 4  mgc: 2.015277e-12
## iter: 1  value: 288652.5 mgc: 0.1313757 ustep: 1
## iter: 2  value: 288652.5 mgc: 0.0006047095 ustep: 1
## iter: 3  value: 288652.5 mgc: 2.118369e-08 ustep: 1
## mgc: 1.570966e-14
## iter: 1  mgc: 1.570966e-14
## outer mgc:  2.903383
## iter: 1  value: 288650.6 mgc: 0.08394814 ustep: 1
## iter: 2  value: 288650.6 mgc: 0.0002740753 ustep: 1
```

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## iter: 3  mgc: 5.387829e-09
## iter: 1  mgc: 5.387829e-09
## outer mgc:  1.838836
## iter: 1  value: 288650.2 mgc: 0.1678143 ustep: 1
## iter: 2  value: 288650.2 mgc: 0.0001168162 ustep: 1
## iter: 3  mgc: 3.871769e-10
## iter: 1  mgc: 3.871769e-10
## outer mgc:  0.5530602
## iter: 1  value: 288648.9 mgc: 0.1102363 ustep: 1
## iter: 2  value: 288648.9 mgc: 1.942e-05 ustep: 1
## iter: 3  mgc: 1.314926e-11
## iter: 1  value: 288646.7 mgc: 0.2374196 ustep: 1
## iter: 2  value: 288646.7 mgc: 0.0001346449 ustep: 1
## iter: 3  mgc: 5.351298e-10
## iter: 1  value: 288640.6 mgc: 0.6084601 ustep: 1
## iter: 2  value: 288640.6 mgc: 0.0006537256 ustep: 1
## iter: 3  value: 288640.6 mgc: 1.682794e-08 ustep: 1
## iter: 4  mgc: 1.409983e-14
## iter: 1  mgc: 1.409983e-14
## outer mgc:  1.393693
## iter: 1  value: 288629.7 mgc: 0.9191753 ustep: 1
## iter: 2  value: 288629.7 mgc: 0.001158097 ustep: 1
## iter: 3  value: 288629.7 mgc: 2.956356e-07 ustep: 1
## iter: 4  mgc: 1.804112e-14
## iter: 1  mgc: 1.804112e-14
## outer mgc:  1.764136
## iter: 1  value: 288618.7 mgc: 0.8965077 ustep: 1
## iter: 2  value: 288618.7 mgc: 0.003589481 ustep: 1
## iter: 3  value: 288618.7 mgc: 1.430634e-06 ustep: 1
## iter: 4  mgc: 4.652945e-13
## iter: 1  mgc: 4.652945e-13
## outer mgc:  2.636119
## iter: 1  value: 288608.2 mgc: 1.019029 ustep: 1
## iter: 2  value: 288608.2 mgc: 0.006368144 ustep: 1
## iter: 3  value: 288608.2 mgc: 4.699401e-06 ustep: 1
## iter: 4  mgc: 4.532374e-12
## iter: 1  value: 288614.6 mgc: 0.5597425 ustep: 1
## iter: 2  value: 288614.6 mgc: 0.002859302 ustep: 1
## iter: 3  value: 288614.6 mgc: 8.607276e-07 ustep: 1
## iter: 4  mgc: 1.156852e-13
## iter: 1  mgc: 1.156852e-13
## outer mgc:  2.659467
## iter: 1  value: 288610.1 mgc: 0.4188484 ustep: 1
## iter: 2  value: 288610.1 mgc: 0.002602152 ustep: 1
## iter: 3  value: 288610.1 mgc: 9.718793e-07 ustep: 1
## iter: 4  mgc: 1.351697e-13
## iter: 1  mgc: 1.351697e-13
## outer mgc:  2.328991
## iter: 1  value: 288603.7 mgc: 0.4608757 ustep: 1
## iter: 2  value: 288603.7 mgc: 0.001436184 ustep: 1
## iter: 3  value: 288603.7 mgc: 1.084367e-07 ustep: 1
```

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## iter: 4  mgc: 1.620926e-14
## iter: 1  value: 288606.6 mgc: 0.2264483 ustep: 1
## iter: 2  value: 288606.6 mgc: 0.0006166238 ustep: 1
## iter: 3  value: 288606.6 mgc: 2.553062e-08 ustep: 1
## iter: 4  mgc: 1.820766e-14
## iter: 1  value: 288608.7 mgc: 0.19206 ustep: 1
## iter: 2  value: 288608.7 mgc: 0.000218728 ustep: 1
## iter: 3  mgc: 3.4122e-09
## iter: 1  value: 288609.5 mgc: 0.07954065 ustep: 1
## iter: 2  value: 288609.5 mgc: 3.730126e-05 ustep: 1
## iter: 3  mgc: 1.003775e-10
## iter: 1  mgc: 1.003775e-10
## outer mgc:  0.4561961
## iter: 1  value: 288609.6 mgc: 0.03885573 ustep: 1
## iter: 2  value: 288609.6 mgc: 1.627649e-05 ustep: 1
## iter: 3  mgc: 1.660072e-11
## iter: 1  mgc: 1.660072e-11
## outer mgc:  0.6977403
## iter: 1  value: 288609.2 mgc: 0.04357049 ustep: 1
## iter: 2  value: 288609.2 mgc: 1.006272e-05 ustep: 1
## iter: 3  mgc: 5.942802e-12
## iter: 1  mgc: 5.942802e-12
## outer mgc:  0.3396297
## iter: 1  value: 288608.7 mgc: 0.08929321 ustep: 1
## iter: 2  value: 288608.7 mgc: 9.79845e-06 ustep: 1
## iter: 3  mgc: 9.343221e-12
## iter: 1  mgc: 9.343221e-12
## outer mgc:  0.497232
## iter: 1  value: 288607.9 mgc: 0.06301072 ustep: 1
## iter: 2  value: 288607.9 mgc: 2.259842e-05 ustep: 1
## iter: 3  mgc: 7.218776e-11
## iter: 1  value: 288607.1 mgc: 0.07232041 ustep: 1
## iter: 2  value: 288607.1 mgc: 2.398098e-05 ustep: 1
## iter: 3  mgc: 8.241496e-11
## iter: 1  value: 288604.1 mgc: 0.2941864 ustep: 1
## iter: 2  value: 288604.1 mgc: 0.0003861794 ustep: 1
## iter: 3  value: 288604.1 mgc: 2.137367e-08 ustep: 1
## iter: 4  mgc: 1.176836e-14
## iter: 1  value: 288597.2 mgc: 0.6622246 ustep: 1
## iter: 2  value: 288597.2 mgc: 0.002048267 ustep: 1
## iter: 3  value: 288597.2 mgc: 6.004365e-07 ustep: 1
## iter: 4  mgc: 5.218048e-14
## iter: 1  mgc: 5.218048e-14
## outer mgc:  0.6587366
## iter: 1  value: 288585.2 mgc: 1.093801 ustep: 1
## iter: 2  value: 288585.2 mgc: 0.0004414404 ustep: 1
## iter: 3  value: 288585.2 mgc: 2.337073e-08 ustep: 1
## iter: 4  mgc: 1.176836e-14
## iter: 1  mgc: 1.176836e-14
## outer mgc:  1.057806
## iter: 1  value: 288573.5 mgc: 1.123152 ustep: 1
```

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## iter: 2  value: 288573.5 mgc: 0.00163709 ustep: 1
## iter: 3  value: 288573.5 mgc: 3.834675e-07 ustep: 1
## iter: 4  mgc: 2.170486e-14
## iter: 1  mgc: 2.170486e-14
## outer mgc:  1.052022
## iter: 1  value: 288561.7 mgc: 1.142899 ustep: 1
## iter: 2  value: 288561.7 mgc: 0.0008847097 ustep: 1
## iter: 3  value: 288561.7 mgc: 2.089069e-07 ustep: 1
## iter: 4  mgc: 1.236511e-14
## iter: 1  value: 288567.9 mgc: 0.4775138 ustep: 1
## iter: 2  value: 288567.9 mgc: 0.0001494467 ustep: 1
## iter: 3  mgc: 6.052763e-09
## iter: 1  mgc: 6.052763e-09
## outer mgc:  0.543937
## iter: 1  value: 288562.2 mgc: 0.4544831 ustep: 1
## iter: 2  value: 288562.2 mgc: 0.0001147797 ustep: 1
## iter: 3  mgc: 1.63659e-09
## iter: 1  mgc: 1.63659e-09
## outer mgc:  0.547259
## iter: 1  value: 288556.6 mgc: 0.4825621 ustep: 1
## iter: 2  value: 288556.6 mgc: 0.0001564361 ustep: 1
## iter: 3  mgc: 3.020954e-09
## iter: 1  mgc: 3.020954e-09
## outer mgc:  0.6100886
## iter: 1  value: 288551.2 mgc: 0.5408622 ustep: 1
## iter: 2  value: 288551.2 mgc: 0.0002040156 ustep: 1
## iter: 3  mgc: 2.19223e-09
## iter: 1  mgc: 2.19223e-09
## outer mgc:  0.4647097
## iter: 1  value: 288545.7 mgc: 0.4910778 ustep: 1
## iter: 2  value: 288545.7 mgc: 0.0002718928 ustep: 1
## iter: 3  value: 288545.7 mgc: 1.058898e-08 ustep: 1
## mgc: 9.825474e-15
## iter: 1  mgc: 9.825474e-15
## outer mgc:  0.3388953
## iter: 1  value: 288539.9 mgc: 0.473581 ustep: 1
## iter: 2  value: 288539.9 mgc: 2.404295e-05 ustep: 1
## iter: 3  mgc: 1.928058e-11
## iter: 1  mgc: 1.928058e-11
## outer mgc:  0.562116
## iter: 1  value: 288534.4 mgc: 0.524099 ustep: 1
## iter: 2  value: 288534.4 mgc: 0.0001867211 ustep: 1
## iter: 3  mgc: 5.01661e-09
## iter: 1  mgc: 5.01661e-09
## outer mgc:  0.1587898
## iter: 1  value: 288528.8 mgc: 0.5314875 ustep: 1
## iter: 2  value: 288528.8 mgc: 5.266786e-05 ustep: 1
## iter: 3  mgc: 2.008387e-10
## iter: 1  mgc: 2.008387e-10
## outer mgc:  0.4942487
## iter: 1  value: 288522.9 mgc: 0.5079985 ustep: 1
```

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## iter: 2  value: 288522.9 mgc: 1.584426e-05 ustep: 1
## iter: 3  mgc: 9.5568e-12
## iter: 1  mgc: 9.5568e-12
## outer mgc:  0.2636366
## iter: 1  value: 288517.1 mgc: 0.5003954 ustep: 1
## iter: 2  value: 288517.1 mgc: 2.17603e-05 ustep: 1
## iter: 3  mgc: 2.404921e-11
## iter: 1  mgc: 2.404921e-11
## outer mgc:  0.3635693
## iter: 1  value: 288511.5 mgc: 0.5165382 ustep: 1
## iter: 2  value: 288511.5 mgc: 2.055806e-05 ustep: 1
## iter: 3  mgc: 3.223555e-11
## iter: 1  value: 288504 mgc: 0.6714493 ustep: 1
## iter: 2  value: 288504 mgc: 3.843966e-05 ustep: 1
## iter: 3  mgc: 1.107905e-10
## iter: 1  mgc: 1.107905e-10
## outer mgc:  0.2951963
## iter: 1  value: 288490.9 mgc: 1.266564 ustep: 1
## iter: 2  value: 288490.9 mgc: 8.127978e-05 ustep: 1
## iter: 3  mgc: 2.622427e-10
## iter: 1  mgc: 2.622427e-10
## outer mgc:  0.1463083
## iter: 1  value: 288477.7 mgc: 1.259177 ustep: 1
## iter: 2  value: 288477.7 mgc: 0.0001824536 ustep: 1
## iter: 3  mgc: 2.210443e-09
## iter: 1  mgc: 2.210443e-09
## outer mgc:  0.1244155
## iter: 1  value: 288464.2 mgc: 1.270653 ustep: 1
## iter: 2  value: 288464.2 mgc: 4.231219e-05 ustep: 1
## iter: 3  mgc: 9.770784e-11
## iter: 1  mgc: 9.770784e-11
## outer mgc:  0.2973672
## iter: 1  value: 288451 mgc: 1.254252 ustep: 1
## iter: 2  value: 288451 mgc: 7.965064e-05 ustep: 1
## iter: 3  mgc: 3.806733e-10
## iter: 1  mgc: 3.806733e-10
## outer mgc:  0.1269032
## iter: 1  value: 288437.7 mgc: 1.261014 ustep: 1
## iter: 2  value: 288437.7 mgc: 1.662646e-05 ustep: 1
## iter: 3  mgc: 3.380629e-11
## iter: 1  mgc: 3.380629e-11
## outer mgc:  0.1430407
## iter: 1  value: 288424.2 mgc: 1.267155 ustep: 1
## iter: 2  value: 288424.2 mgc: 6.104528e-05 ustep: 1
## iter: 3  mgc: 1.875113e-10
## iter: 1  mgc: 1.875113e-10
## outer mgc:  0.1139739
## iter: 1  value: 288410.9 mgc: 1.258094 ustep: 1
## iter: 2  value: 288410.9 mgc: 1.640707e-05 ustep: 1
## iter: 3  mgc: 8.77648e-12
## iter: 1  mgc: 8.77648e-12
```

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## outer mgc:  0.1643159
## iter: 1  value: 288397.6 mgc: 1.268887 ustep: 1
## iter: 2  value: 288397.6 mgc: 1.859447e-05 ustep: 1
## iter: 3  mgc: 3.553136e-11
## iter: 1  mgc: 3.553136e-11
## outer mgc:  0.07468359
## iter: 1  value: 288384.2 mgc: 1.272674 ustep: 1
## iter: 2  value: 288384.2 mgc: 7.336456e-06 ustep: 1
## iter: 3  mgc: 3.93019e-12
## iter: 1  mgc: 3.93019e-12
## outer mgc:  0.05404475
## iter: 1  value: 288370.8 mgc: 1.273172 ustep: 1
## iter: 2  value: 288370.8 mgc: 1.541004e-06 ustep: 1
## iter: 3  mgc: 7.371881e-14
## iter: 1  value: 288351.6 mgc: 1.917863 ustep: 1
## iter: 2  value: 288351.6 mgc: 2.47e-06 ustep: 1
## iter: 3  mgc: 3.530509e-13
## iter: 1  mgc: 3.530509e-13
## outer mgc:  0.1395675
## iter: 1  value: 288318.8 mgc: 3.574589 ustep: 1
## iter: 2  value: 288318.8 mgc: 3.146658e-05 ustep: 1
## iter: 3  mgc: 5.120437e-11
## iter: 1  mgc: 5.120437e-11
## outer mgc:  0.1428326
## iter: 1  value: 288285.8 mgc: 3.567198 ustep: 1
## iter: 2  value: 288285.8 mgc: 1.471199e-05 ustep: 1
## iter: 3  mgc: 3.772774e-11
## iter: 1  mgc: 3.772774e-11
## outer mgc:  0.08875903
## iter: 1  value: 288253.2 mgc: 3.582681 ustep: 1
## iter: 2  value: 288253.2 mgc: 1.233027e-05 ustep: 1
## iter: 3  mgc: 9.769074e-12
## iter: 1  mgc: 9.769074e-12
## outer mgc:  0.06399396
## iter: 1  value: 288232.1 mgc: 2.121031 ustep: 1
## iter: 2  value: 288232.1 mgc: 1.824631e-05 ustep: 1
## iter: 3  mgc: 2.094458e-11
## iter: 1  mgc: 2.094458e-11
## outer mgc:  0.04751151
## iter: 1  value: 288210.9 mgc: 2.119781 ustep: 1
## iter: 2  value: 288210.9 mgc: 1.176631e-05 ustep: 1
## iter: 3  mgc: 8.549605e-12
## iter: 1  mgc: 8.549605e-12
## outer mgc:  0.04456715
## iter: 1  value: 288190.2 mgc: 2.089178 ustep: 1
## iter: 2  value: 288190.2 mgc: 2.389143e-06 ustep: 1
## iter: 3  mgc: 4.28102e-13
## iter: 1  mgc: 4.28102e-13
## outer mgc:  0.02414511
## iter: 1  value: 288169.3 mgc: 2.081118 ustep: 1
## iter: 2  value: 288169.3 mgc: 6.309083e-07 ustep: 1
```

```
## iter: 3  mgc: 2.975398e-14
## iter: 1  mgc: 2.975398e-14
## outer mgc:  0.01919178
## iter: 1  value: 288148.5 mgc: 2.08235 ustep: 1
## iter: 2  value: 288148.5 mgc: 1.678123e-07 ustep: 1
## iter: 3  mgc: 1.071365e-14
## iter: 1  mgc: 1.071365e-14
## outer mgc:  0.01209689
## iter: 1  mgc: 1.071365e-14
## iter: 1  mgc: 1.071365e-14
## outer mgc:  0.01209689
## iter: 1  value: 288148.5 mgc: 0.004765068 ustep: 1
## iter: 2  value: 288148.5 mgc: 7.897695e-07 ustep: 1
## iter: 3  mgc: 2.4869e-14
## outer mgc:  0.110458
## iter: 1  value: 288148.5 mgc: 0.004759821 ustep: 1
## iter: 2  value: 288148.5 mgc: 7.887839e-07 ustep: 1
## iter: 3  mgc: 2.842171e-14
## outer mgc:  0.1014145
## iter: 1  value: 288148.5 mgc: 0.002583837 ustep: 1
## iter: 2  value: 288148.5 mgc: 2.986759e-07 ustep: 1
## iter: 3  mgc: 8.65974e-15
## outer mgc:  0.07397941
## iter: 1  value: 288148.5 mgc: 0.002581065 ustep: 1
## iter: 2  value: 288148.5 mgc: 2.982484e-07 ustep: 1
## iter: 3  mgc: 1.154632e-14
## outer mgc:  0.06156397
## iter: 1  value: 288148.5 mgc: 0.006842536 ustep: 1
## iter: 2  value: 288148.5 mgc: 2.458872e-06 ustep: 1
## iter: 3  mgc: 3.241851e-13
## outer mgc:  0.07107595
## iter: 1  value: 288148.5 mgc: 0.006833633 ustep: 1
## iter: 2  value: 288148.5 mgc: 2.46272e-06 ustep: 1
## iter: 3  mgc: 3.268497e-13
## outer mgc:  0.07408518
## iter: 1  value: 288148.5 mgc: 0.002563627 ustep: 1
## iter: 2  value: 288148.5 mgc: 4.765182e-07 ustep: 1
## iter: 3  mgc: 2.220446e-14
## outer mgc:  0.05873716
## iter: 1  value: 288148.5 mgc: 0.002559263 ustep: 1
## iter: 2  value: 288148.5 mgc: 4.75984e-07 ustep: 1
## iter: 3  mgc: 1.465494e-14
## outer mgc:  0.06712368
## iter: 1  value: 288148.5 mgc: 0.007840182 ustep: 1
## iter: 2  value: 288148.5 mgc: 3.094892e-06 ustep: 1
## iter: 3  mgc: 6.787904e-13
## outer mgc:  0.04370847
## iter: 1  value: 288148.5 mgc: 0.007832847 ustep: 1
## iter: 2  value: 288148.5 mgc: 3.100591e-06 ustep: 1
## iter: 3  mgc: 6.784573e-13
## outer mgc:  0.04414195
```

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## iter: 1  value: 288148.5 mgc: 0.003962623 ustep: 1
## iter: 2  value: 288148.5 mgc: 1.191384e-06 ustep: 1
## iter: 3  mgc: 1.569855e-13
## outer mgc:  0.0669081
## iter: 1  value: 288148.5 mgc: 0.003958668 ustep: 1
## iter: 2  value: 288148.5 mgc: 1.191728e-06 ustep: 1
## iter: 3  mgc: 1.516565e-13
## outer mgc:  0.06527365
## iter: 1  value: 288148.5 mgc: 0.01185928 ustep: 1
## iter: 2  value: 288148.5 mgc: 2.711885e-06 ustep: 1
## iter: 3  mgc: 3.326228e-13
## outer mgc:  0.09231717
## iter: 1  value: 288148.5 mgc: 0.01186095 ustep: 1
## iter: 2  value: 288148.5 mgc: 2.716687e-06 ustep: 1
## iter: 3  mgc: 3.330669e-13
## outer mgc:  0.0869696
## iter: 1  value: 288148.5 mgc: 0.006009431 ustep: 1
## iter: 2  value: 288148.5 mgc: 2.56148e-06 ustep: 1
## iter: 3  mgc: 4.636291e-13
## outer mgc:  0.1629531
## iter: 1  value: 288148.5 mgc: 0.006007677 ustep: 1
## iter: 2  value: 288148.5 mgc: 2.565157e-06 ustep: 1
## iter: 3  mgc: 4.694023e-13
## outer mgc:  0.1527581
## iter: 1  value: 288148.5 mgc: 0.008730455 ustep: 1
## iter: 2  value: 288148.5 mgc: 2.634547e-06 ustep: 1
## iter: 3  mgc: 2.544631e-13
## outer mgc:  0.05018708
## iter: 1  value: 288148.5 mgc: 0.008723591 ustep: 1
## iter: 2  value: 288148.5 mgc: 2.641748e-06 ustep: 1
## iter: 3  mgc: 2.571277e-13
## outer mgc:  0.0407576
## iter: 1  value: 288148.5 mgc: 0.003574875 ustep: 1
## iter: 2  value: 288148.5 mgc: 4.405115e-07 ustep: 1
## iter: 3  mgc: 1.554312e-14
## outer mgc:  0.04708979
## iter: 1  value: 288148.5 mgc: 0.00357061 ustep: 1
## iter: 2  value: 288148.5 mgc: 4.403693e-07 ustep: 1
## iter: 3  mgc: 1.865175e-14
## outer mgc:  0.03669915
## iter: 1  value: 288148.5 mgc: 0.009548363 ustep: 1
## iter: 2  value: 288148.5 mgc: 4.657758e-07 ustep: 1
## iter: 3  mgc: 1.354472e-14
## outer mgc:  0.2838243
## iter: 1  value: 288148.5 mgc: 0.009541565 ustep: 1
## iter: 2  value: 288148.5 mgc: 4.657113e-07 ustep: 1
## iter: 3  mgc: 1.64313e-14
## outer mgc:  0.2977679
## iter: 1  value: 288148.5 mgc: 0.005178131 ustep: 1
## iter: 2  value: 288148.5 mgc: 1.780079e-07 ustep: 1
## iter: 3  mgc: 1.210143e-14
```

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## outer mgc:  0.174306
## iter: 1  value: 288148.5 mgc: 0.005175205 ustep: 1
## iter: 2  value: 288148.5 mgc: 1.779015e-07 ustep: 1
## iter: 3  mgc: 1.11855e-14
## outer mgc:  0.1983603
## iter: 1  value: 288148.5 mgc: 0.00557281 ustep: 1
## iter: 2  value: 288148.5 mgc: 9.610585e-08 ustep: 1
## iter: 3  mgc: 1.226796e-14
## outer mgc:  0.142494
## iter: 1  value: 288148.5 mgc: 0.005567713 ustep: 1
## iter: 2  value: 288148.5 mgc: 9.606676e-08 ustep: 1
## iter: 3  mgc: 1.199041e-14
## outer mgc:  0.1385387
## iter: 1  value: 288148.5 mgc: 0.00382367 ustep: 1
## iter: 2  value: 288148.5 mgc: 5.162087e-08 ustep: 1
## iter: 3  mgc: 1.619538e-14
## outer mgc:  0.08472751
## iter: 1  value: 288148.5 mgc: 0.003820588 ustep: 1
## iter: 2  value: 288148.5 mgc: 5.158212e-08 ustep: 1
## iter: 3  mgc: 1.554312e-14
## outer mgc:  0.07541563
## iter: 1  value: 288148.5 mgc: 0.003449678 ustep: 1
## iter: 2  value: 288148.5 mgc: 4.402191e-07 ustep: 1
## iter: 3  mgc: 1.598721e-14
## outer mgc:  0.06989172
## iter: 1  value: 288148.5 mgc: 0.003446329 ustep: 1
## iter: 2  value: 288148.5 mgc: 4.395793e-07 ustep: 1
## iter: 3  mgc: 1.521006e-14
## outer mgc:  0.07310196
## iter: 1  value: 288148.5 mgc: 0.002193836 ustep: 1
## iter: 2  value: 288148.5 mgc: 1.792815e-07 ustep: 1
## iter: 3  mgc: 1.44329e-14
## outer mgc:  0.04568114
## iter: 1  value: 288148.5 mgc: 0.00219183 ustep: 1
## iter: 2  value: 288148.5 mgc: 1.790176e-07 ustep: 1
## iter: 3  mgc: 1.332268e-14
## outer mgc:  0.04879044
## iter: 1  value: 288148.5 mgc: 0.009336683 ustep: 1
## iter: 2  value: 288148.5 mgc: 2.375309e-06 ustep: 1
## iter: 3  mgc: 5.015988e-13
## outer mgc:  0.04031337
## iter: 1  value: 288148.5 mgc: 0.00933094 ustep: 1
## iter: 2  value: 288148.5 mgc: 2.383415e-06 ustep: 1
## iter: 3  mgc: 5.087042e-13
## outer mgc:  0.0459859
## iter: 1  value: 288148.5 mgc: 0.003780708 ustep: 1
## iter: 2  value: 288148.5 mgc: 7.442019e-07 ustep: 1
## iter: 3  mgc: 7.571721e-14
## outer mgc:  0.04759889
## iter: 1  value: 288148.5 mgc: 0.003775898 ustep: 1
## iter: 2  value: 288148.5 mgc: 7.441949e-07 ustep: 1
```

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## iter: 3  mgc: 7.571721e-14
## outer mgc:  0.05383001
## iter: 1  value: 288148.5 mgc: 0.005039306 ustep: 1
## iter: 2  value: 288148.5 mgc: 3.128221e-06 ustep: 1
## iter: 3  mgc: 1.215472e-12
## outer mgc:  0.01419448
## iter: 1  value: 288148.5 mgc: 0.005032619 ustep: 1
## iter: 2  value: 288148.5 mgc: 3.133515e-06 ustep: 1
## iter: 3  mgc: 1.214917e-12
## outer mgc:  0.01064047
## iter: 1  value: 288148.5 mgc: 0.00238208 ustep: 1
## iter: 2  value: 288148.5 mgc: 8.762843e-07 ustep: 1
## iter: 3  mgc: 1.70787e-13
## outer mgc:  0.02968329
## iter: 1  value: 288148.5 mgc: 0.00237881 ustep: 1
## iter: 2  value: 288148.5 mgc: 8.765526e-07 ustep: 1
## iter: 3  mgc: 1.696629e-13
## outer mgc:  0.03203832
## iter: 1  value: 288148.5 mgc: 0.003701933 ustep: 1
## iter: 2  value: 288148.5 mgc: 6.956126e-07 ustep: 1
## iter: 3  mgc: 3.019807e-14
## outer mgc:  0.01482241
## iter: 1  value: 288148.5 mgc: 0.003705637 ustep: 1
## iter: 2  value: 288148.5 mgc: 6.952009e-07 ustep: 1
## iter: 3  mgc: 3.108624e-14
## outer mgc:  0.01201867
## iter: 1  value: 288148.5 mgc: 0.004937838 ustep: 1
## iter: 2  value: 288148.5 mgc: 1.170993e-06 ustep: 1
## iter: 3  mgc: 1.003642e-13
## outer mgc:  0.01392189
## iter: 1  value: 288148.5 mgc: 0.004942779 ustep: 1
## iter: 2  value: 288148.5 mgc: 1.171993e-06 ustep: 1
## iter: 3  mgc: 1.065814e-13
## outer mgc:  0.01142134
## iter: 1  value: 288148.5 mgc: 0.001927059 ustep: 1
## iter: 2  value: 288148.5 mgc: 4.349529e-07 ustep: 1
## iter: 3  mgc: 2.331468e-14
## outer mgc:  0.01859769
## iter: 1  value: 288148.5 mgc: 0.001928987 ustep: 1
## iter: 2  value: 288148.5 mgc: 4.354494e-07 ustep: 1
## iter: 3  mgc: 2.375877e-14
## outer mgc:  0.01491023
## iter: 1  value: 288148.5 mgc: 0.004597516 ustep: 1
## iter: 2  value: 288148.5 mgc: 1.066316e-06 ustep: 1
## iter: 3  mgc: 6.483702e-14
## outer mgc:  0.02211066
## iter: 1  value: 288148.5 mgc: 0.004602116 ustep: 1
## iter: 2  value: 288148.5 mgc: 1.067592e-06 ustep: 1
## iter: 3  mgc: 6.57252e-14
## outer mgc:  0.0161729
## iter: 1  value: 288148.5 mgc: 0.003104468 ustep: 1
```

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## iter: 2  value: 288148.5 mgc: 4.011987e-07 ustep: 1
## iter: 3  mgc: 2.930989e-14
## outer mgc:  0.01331185
## iter: 1  value: 288148.5 mgc: 0.003107574 ustep: 1
## iter: 2  value: 288148.5 mgc: 4.013055e-07 ustep: 1
## iter: 3  mgc: 2.620126e-14
## outer mgc:  0.01189505
## iter: 1  value: 288148.6 mgc: 0.006318504 ustep: 1
## iter: 2  mgc: 8.082424e-14
## outer mgc:  0.01209608
## iter: 1  value: 288148.5 mgc: 0.006324826 ustep: 1
## iter: 2  mgc: 7.993606e-14
## outer mgc:  0.0120977
## iter: 1  value: 288148.6 mgc: 0.003982816 ustep: 1
## iter: 2  mgc: 1.262879e-14
## outer mgc:  0.01209691
## iter: 1  value: 288148.5 mgc: 0.003986801 ustep: 1
## iter: 2  mgc: 1.421085e-14
## outer mgc:  0.01209686
## iter: 1  value: 288148.5 mgc: 0.002671406 ustep: 1
## iter: 2  value: 288148.5 mgc: 4.371271e-07 ustep: 1
## iter: 3  mgc: 1.332268e-14
## outer mgc:  0.01272816
## iter: 1  value: 288148.5 mgc: 0.002674079 ustep: 1
## iter: 2  value: 288148.5 mgc: 4.36222e-07 ustep: 1
## iter: 3  mgc: 1.332268e-14
## outer mgc:  0.01146609
## iter: 1  value: 288148.5 mgc: 0.003059917 ustep: 1
## iter: 2  value: 288148.5 mgc: 3.450096e-07 ustep: 1
## iter: 3  mgc: 1.465494e-14
## outer mgc:  0.01713159
## iter: 1  value: 288148.5 mgc: 0.003062979 ustep: 1
## iter: 2  value: 288148.5 mgc: 3.453289e-07 ustep: 1
## iter: 3  mgc: 1.354472e-14
## outer mgc:  0.01370748
## iter: 1  value: 288148.5 mgc: 0.001447892 ustep: 1
## iter: 2  value: 288148.5 mgc: 5.643781e-07 ustep: 1
## iter: 3  mgc: 8.526513e-14
## outer mgc:  0.01869547
## iter: 1  value: 288148.5 mgc: 0.001449341 ustep: 1
## iter: 2  value: 288148.5 mgc: 5.655721e-07 ustep: 1
## iter: 3  mgc: 8.837375e-14
## outer mgc:  0.02193738
## iter: 1  value: 288148.4 mgc: 0.008224373 ustep: 1
## iter: 2  value: 288148.4 mgc: 2.063162e-06 ustep: 1
## iter: 3  mgc: 3.277378e-13
## outer mgc:  0.377087
## iter: 1  value: 288148.6 mgc: 0.008217846 ustep: 1
## iter: 2  value: 288148.6 mgc: 2.058941e-06 ustep: 1
## iter: 3  mgc: 3.224088e-13
## outer mgc:  0.3890021
```