LTMG - GCR track (LTMG->biclustering analysis)

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Analysis

We will have a data namely "Yan" for the example of LTMG - GCR (biclustering) pipeline.

Basically, we may need the following steps for this analysis

(i) a standard data loading function

```
data0 <- log(as.matrix(read.delim("Yan_expression_RPKM.txt", row.names = 1)))
```

(ii) running LTMG -> a standard output of LTMG parameters

Select genes

Genes with non-zero expression in more than 5 samples in `data0`

```
selected.genes <- which(rowSums(data0 > 0) > 5)
print(head(selected.genes, 30))
```

```
##     RPS11     ELMO2   CREB3L1     PNMA1   TMEM216 LOC653712
##         2         3         4         5         7         8
##  C10orf90      ZHX3     ERCC5     APBB2     PDCL3       AEN
##         9        10        11        14        17        18
##      FRG2     DECR1     SALL1     RPS18   SLC10A7     BRIX1
##        19        20        21        24        25        27
##     LMAN1      CHD8     SUMO1     GP1BA    UQCR11      DDB1
##        28        29        30        31        32        33
##     MYO9B    CRNKL1      XAB2      RTN1       UTY     CENPQ
##        34        35        37        38        42        43
```

Run LTMG for the selected genes

`LTMG -> output` list(`N`: number of peaks; a $3 \times$ `N` matrix: `A`, `U`, `S`; If `Zcut` (If 0 expression is more than 5, `Zcut`); Iteration number, upper limit 1000)

```
library(LTMGSCA)
for (gene in head(selected.genes, 3)) {
  for (k in 1:5) {
    print(SeparateKRpkmNew(x = data0[gene, ], n = 100, q = 0, k = k, err = 1e-10))
  }
}
```

```
##                           p    mean        sd
## Late_blastocyst.3_Cell.5 1 7.74797 0.5936434
##                                  p     mean        sd
## Late_blastocyst.2_Cell.7 0.5189909 7.632955 0.5688547
## X4.cell_embryo.1_Cell.4  0.4810091 7.872066 0.5948461
##                                  p     mean        sd
## X2.cell_embryo.1_Cell.2  0.1210234 7.083230 0.1913294
## Late_blastocyst.3_Cell.5 0.7937210 7.768004 0.5549263
## X4.cell_embryo.3_Cell.2  0.0852556 8.505077 0.1026225
##                                    p     mean         sd
## Late_blastocyst.2_Cell.4 0.006933978 7.788798 0.36486339
## Morulae.1_Cell.8         0.448993364 7.267528 0.35678557
## Morulae.2_Cell.3         0.480661380 8.095959 0.44529688
## X4.cell_embryo.3_Cell.1  0.063411278 8.507573 0.09591338
##                                   p     mean        sd
## Oocyte.1                 0.005328433 7.727174 0.3884293
## Late_blastocyst.2_Cell.7 0.356379577 7.199494 0.3289284
## Late_blastocyst.3_Cell.5 0.309216553 7.755904 0.3974516
## X4.cell_embryo.1_Cell.4  0.322192465 8.343583 0.3577630
## X8.cell_embryo.1_Cell.1  0.006882971 7.925339 0.4211202
##                          p     mean      sd
## X8.cell_embryo.3_Cell.1 1 1.558705 2.07965
##                                  p      mean       sd
## X8.cell_embryo.2_Cell.4 0.3138683 -2.385534 2.460532
## X8.cell_embryo.1_Cell.1 0.6861317  2.645441 1.280540
##                                   p      mean        sd
## Late_blastocyst.2_Cell.1 0.2726636 -2.943190 1.0155455
## X8.cell_embryo.3_Cell.1  0.4874510  1.851239 0.8095599
## X4.cell_embryo.1_Cell.2  0.2398854  4.123094 0.1710736
##                                  p      mean        sd
## X8.cell_embryo.2_Cell.6 0.2722165 -2.584755 0.8242646
## X8.cell_embryo.2_Cell.7 0.2930781  1.687644 0.7978886
## X8.cell_embryo.2_Cell.3 0.1945976  2.090904 0.7665579
## X2.cell_embryo.3_Cell.1 0.2401079  4.123058 0.1711315
##                                  p      mean        sd
## Morulae.1_Cell.2        0.27343650 -2.346844 0.7156853
## X8.cell_embryo.2_Cell.4 0.22096460  1.561465 0.7070268
## X8.cell_embryo.3_Cell.1 0.16654932  1.775654 0.7409112
## X8.cell_embryo.1_Cell.1 0.09679837  2.609410 0.5179847
## X4.cell_embryo.2_Cell.4 0.24225121  4.122422 0.1716394
##                           p       mean       sd
## Late_blastocyst.2_Cell.3 1 -0.9535114 1.562651
##                                  p       mean        sd
## Zygote.1                0.8524664 -1.4311960 1.4985531
## X8.cell_embryo.1_Cell.2 0.1475336  0.9262817 0.9096018
##                                    p       mean           sd
## X4.cell_embryo.2_Cell.3  0.70557942 -1.2865546 0.4785381776
## Late_blastocyst.2_Cell.3 0.27219997  0.7239671 0.5938110246
## X4.cell_embryo.3_Cell.3  0.02222061  2.7078834 0.0005667612
##                                  p       mean           sd
## Zygote.2                0.72496505 -1.2936882 0.4602185469
## X2.cell_embryo.2_Cell.1 0.11346035  0.4516975 0.2993225110
## X8.cell_embryo.1_Cell.4 0.13935362  1.0987104 0.4882202184
## X4.cell_embryo.1_Cell.2 0.02222099  2.7078834 0.0005667612
```

```
##                                    p       mean           sd
## Zygote.2                  0.69349422 -1.3076762 0.4388586900
## Zygote.1                  0.06286983  0.1033333 0.7265148824
## Late_blastocyst.2_Cell.3 0.08060027  0.4484580 0.3466538911
## X8.cell_embryo.1_Cell.2  0.14081500  1.0348833 0.5179808674
## X4.cell_embryo.3_Cell.4  0.02222069  2.7078834 0.0005667612
```

Here we have the BIC functions:

```
BIC_f_zcut <- function(y, rrr, Zcut) {
  n <- length(y)
  nparams <- nrow(rrr) * 3
  w <- rrr[, 1]
  u <- rrr[, 2]
  sig <- rrr[, 3]
  cc <- c()
  y0 <- y[which(y >= Zcut)]
  y1 <- y[which(y < Zcut)]
  y1 <- y1 * 0 + Zcut
  for (i in 1:nrow(rrr)) {
    c0 <- dnorm(y0, u[i], sig[i]) * w[i]
    c1 <- (1 - pnorm(y1, u[i], sig[i])) * w[i]
    c <- c(c0, c1)
    cc <- rbind(cc, c)
  }
  d <- apply(cc, 2, sum)
  e <- sum(log(d))
  f <- e * 2 - nparams * log(n)
  return (f)
}

BIC_f_zcut2 <- function(y, rrr, Zcut) {
  n <- length(y)
  nparams <- nrow(rrr) * 3
  w <- rrr[, 1]
  u <- rrr[, 2]
  sig <- rrr[, 3]
  y0 <- y[which(y >= Zcut)]
  cc <- c()
  for (i in 1:nrow(rrr)) {
    c <- dnorm(y0, u[i], sig[i]) * w[i]
    cc <- rbind(cc, c)
  }
  d <- apply(cc, 2, sum)
  e <- sum(log(d))
  f <- e * 2 - nparams * log(n)
  return (f)
}
```

We can now get `f` value using `BIC_f_zcut2()`.

```
for (k in 1:5) {
  rrr <- SeparateKRpkmNew(x = data0[selected.genes[1], ], n = 100, q = 0, k = k, err = 1e-10)
  print(BIC_f_zcut2(y = data0[selected.genes[1], ], rrr, 0))
}
```

```
## [1] -175.0426
## [1] -188.4811
## [1] -195.0944
## [1] -208.8539
## [1] -223.8346
```

We are only print while `k > 1`.

```
GetBestK <- function(x, n, q, err = 1e-10){
  best.bic <- -Inf
  best.k <- 0
  best.result <- c(0, 0, 0)
  for (k in 1:7) {
    rrr <- SeparateKRpkmNew(x = x, n = n, q = q, k = k, err = err)
    bic <- BIC_f_zcut2(y = x, rrr, q)
    if(is.nan(bic)) {
      bic <- -Inf
    }
    if (bic >= best.bic) {
      best.bic <- bic
      best.k <- k
      best.result <- rrr
    } else {
      return(list(k = best.k, bic = best.bic, result = best.result))
    }
  }
  return(list(k = 0, bic = 0, result = c(0, 0, 0)))
}
```

```
for (gene in head(selected.genes, 30)) {
  best <- GetBestK(x = data0[gene, ], n = 100, q = 0, err = 1e-10)
  if (best[1] > 1) {
    print(gene)
  }
}
```

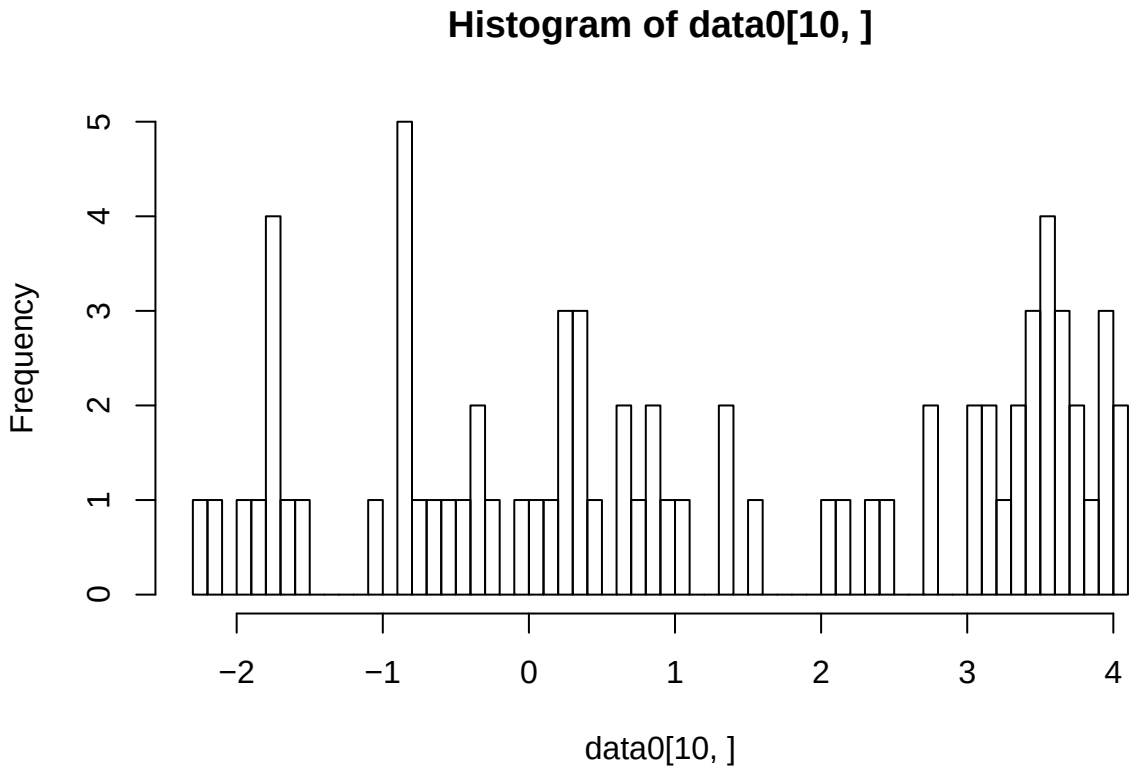
```
## [1] 10
## [1] 11
## [1] 14
## [1] 17
## [1] 29
## [1] 35
```

This is the 10th one:

```
best <- GetBestK(x = data0[10, ], n = 100, q = 0, err = 1e-10)
print(best)
```

```
## $k
## [1] 2
##
## $bic
## [1] -213.088
##
## $result
##                                   p       mean       sd
## X8.cell_embryo.3_Cell.5 0.7180743 -0.4877287 1.572815
## Zygote.1                0.2819257  3.5271235 0.333060
```

```
hist(data0[10,], breaks = 60)
```



(iii) LTMG -> discretization

We have the following functions ready for this step:

1. `calculate_prob_sep_Zcut`,
2. `discretization_method_1_LLR_mean`, and
3. `Build_R_matrix`.

```r
calculate_prob_sep_Zcut <- function(data1, Zcut, a, u, sig) {
  cc <- matrix(0, length(a), length(data1))
  colnames(cc) <- names(data1)
  for (i in 1:length(a)) {
    c <- a[i] / sig[i] * exp(-(data1 - u[i]) ^ 2 / (2 * sig[i] ^ 2))
    cc[i, ] <- c
  }
  cut_p <- rep(0, length(a))
  for (i in 1:length(a)) {
    cut_p[i] <- a[i] * pnorm(Zcut, u[i], sig[i])
  }
  for (i in 1:ncol(cc)) {
    if (data1[i] < Zcut) {
      cc[, i] <- cut_p
    }
  }
  cc[which(is.na(cc) == 1)] <- 0
  return(cc)
}
```

```r
discretization_method_1_LLR_mean <- function(y, aaa, ccc, LLR_cut = 2) {
  K <- 1 / LLR_cut + 1
  if (nrow(aaa) == 1) {
    print("Only one class")
    return(y)
  } else {
    discretized_y <- rep(0, length(y))
    for (i in 1:ncol(ccc)) {
      ll <- which(ccc[, i] == max(ccc[, i]))[1]
      if ((max(ccc[, i])/sum(ccc[, i])) > (1/K)) {
        discretized_y[i] <- ll
      }
    }
    blocks <- c()
    st_c <- 1
    end_c <- 1
    st_c_v <- y[order(y)[1]]
    end_c_v <- y[order(y)[1]]
    label_c <- discretized_y[order(y)[1]]
    for (i in 2:length(order(y))) {
      if (discretized_y[order(y)[i]] == discretized_y[order(y)[i - 1]]) {
        end_c <- i
        end_c_v <- y[order(y)[i]]
        if (i == length(order(y))) {
          end_c <- i
          end_c_v <- y[order(y)[i]]
          blocks <- rbind(blocks, c(st_c, end_c, st_c_v, end_c_v, label_c))
        }
      } else {
        blocks <- rbind(blocks, c(st_c, end_c, st_c_v, end_c_v,
          label_c))
        label_c <- discretized_y[order(y)[i]]
        st_c <- i
```

```
        end_c <- i
        st_c_v <- y[order(y)[i]]
        end_c_v <- y[order(y)[i]]
        if (i == length(order(y))) {
          end_c <- i
          end_c_v <- y[order(y)[i]]
          blocks <- rbind(blocks, c(st_c, end_c, st_c_v, end_c_v, label_c))
        }
      }
    }
    if (nrow(blocks) > 1) {
      for (i in 1:nrow(blocks)) {
        if (blocks[i, 5] != 0) {
          tg_i <- blocks[i, 5]
          if (!((blocks[i, 3] <= aaa[tg_i, 2]) & (blocks[i, 4] >= aaa[tg_i, 2]))) {
          blocks[i, 5] <- 0
          }
        }
      }
      for (i in 1:nrow(blocks)) {
        discretized_y[order(y)[blocks[i, 1]:blocks[i, 2]]] <- blocks[i, 5]
      }
    }
    return(discretized_y)
  }
}
```

```
Build_R_matrix <- function(cc, Zcut0, U, Gname) {
  tg_s <- intersect(which(U > Zcut0), unique(cc))
  dd <- c()
  nc <- c()
  if (length(tg_s) > 0) {
    for (i in 1:length(tg_s)) {
      nc <- c(nc, paste(Gname, tg_s[i], sep = "__"))
      ccc <- (cc == tg_s[i]) * 1
      dd <- rbind(dd, ccc)
    }
  }
  rownames(dd) <- nc
  return(dd)
}
```

`best$result` is a $K \times 3$ matrix with 1st, 2nd and 3rd columns are the `A`, `U`, `S` of the gene `x` is the normalized expression level

```
i <- 4
x <- data0[i, ]
Zcut0 <- 0
best <- GetBestK(x = x, n = 1000, q = Zcut0, err = 1e-10)

pp <- calculate_prob_sep_Zcut(x, Zcut0, best$result[, 1], best$result[, 2], best$result[, 3])
cc <- discretization_method_1_LLR_mean(x, best$result, pp, LLR_cut = 0.1)
```

```
## [1] "Only one class"
```

```r
dd <- Build_R_matrix(cc, Zcut0, best$result[, 2], rownames(data0)[i])

print(x)
```

```
##                  Oocyte.1                  Oocyte.2
##                 0.0000000                 0.3534698
##                  Oocyte.3                  Zygote.1
##                 0.6657760                 0.5905606
##                  Zygote.2                  Zygote.3
##                 0.3611648                -0.3133418
##   X2.cell_embryo.1_Cell.1   X2.cell_embryo.1_Cell.2
##                 0.4643627                 0.2342813
##   X2.cell_embryo.2_Cell.1   X2.cell_embryo.2_Cell.2
##                 0.6339278                 0.3708737
##   X2.cell_embryo.3_Cell.1   X2.cell_embryo.3_Cell.2
##                -0.3523984                -0.7052198
##   X4.cell_embryo.1_Cell.1   X4.cell_embryo.1_Cell.2
##                      -Inf                 1.5526559
##   X4.cell_embryo.1_Cell.3   X4.cell_embryo.1_Cell.4
##                      -Inf                      -Inf
##   X4.cell_embryo.2_Cell.1   X4.cell_embryo.2_Cell.2
##                -1.3586792                -0.2943711
##   X4.cell_embryo.2_Cell.3   X4.cell_embryo.2_Cell.4
##                 0.4491630                 1.0217312
##   X4.cell_embryo.3_Cell.1   X4.cell_embryo.3_Cell.2
##                 1.1177611                 0.9250522
##   X4.cell_embryo.3_Cell.3   X4.cell_embryo.3_Cell.4
##                 1.4548872                 1.6122340
##   X8.cell_embryo.1_Cell.1   X8.cell_embryo.1_Cell.2
##                -0.7635696                 1.0328285
##   X8.cell_embryo.1_Cell.3   X8.cell_embryo.1_Cell.4
##                 0.6559644                 0.9266370
##   X8.cell_embryo.2_Cell.1   X8.cell_embryo.2_Cell.2
##                      -Inf                      -Inf
##   X8.cell_embryo.2_Cell.3   X8.cell_embryo.2_Cell.4
##                      -Inf                      -Inf
##   X8.cell_embryo.2_Cell.5   X8.cell_embryo.2_Cell.6
##                      -Inf                      -Inf
##   X8.cell_embryo.2_Cell.7   X8.cell_embryo.2_Cell.8
##                      -Inf                      -Inf
##   X8.cell_embryo.3_Cell.1   X8.cell_embryo.3_Cell.2
##                      -Inf                      -Inf
##   X8.cell_embryo.3_Cell.3   X8.cell_embryo.3_Cell.4
##                      -Inf                      -Inf
##   X8.cell_embryo.3_Cell.5   X8.cell_embryo.3_Cell.6
##                      -Inf                      -Inf
##   X8.cell_embryo.3_Cell.7   X8.cell_embryo.3_Cell.8
##                      -Inf                 1.7516317
##          Morulae.1_Cell.1          Morulae.1_Cell.2
##                      -Inf                      -Inf
##          Morulae.1_Cell.3          Morulae.1_Cell.4
##                      -Inf                -0.2930297
##          Morulae.1_Cell.5          Morulae.1_Cell.6
```

```
##                       -Inf                       -Inf
##          Morulae.1_Cell.7          Morulae.1_Cell.8
##                       -Inf                       -Inf
##          Morulae.2_Cell.1          Morulae.2_Cell.2
##                       -Inf                       -Inf
##          Morulae.2_Cell.3          Morulae.2_Cell.4
##                       -Inf                       -Inf
##          Morulae.2_Cell.5          Morulae.2_Cell.6
##                       -Inf                -0.9702191
##          Morulae.2_Cell.7          Morulae.2_Cell.8
##                -0.9597203                       -Inf
##  Late_blastocyst.1_Cell.1  Late_blastocyst.1_Cell.2
##                       -Inf                       -Inf
##  Late_blastocyst.1_Cell.3  Late_blastocyst.1_Cell.4
##                       -Inf                       -Inf
##  Late_blastocyst.1_Cell.5  Late_blastocyst.1_Cell.6
##                       -Inf                       -Inf
##  Late_blastocyst.1_Cell.7  Late_blastocyst.1_Cell.8
##                       -Inf                       -Inf
##  Late_blastocyst.1_Cell.9 Late_blastocyst.1_Cell.10
##                       -Inf                       -Inf
## Late_blastocyst.1_Cell.11 Late_blastocyst.1_Cell.12
##                       -Inf                       -Inf
##  Late_blastocyst.2_Cell.1  Late_blastocyst.2_Cell.2
##                -0.3495575                 1.6981811
##  Late_blastocyst.2_Cell.3  Late_blastocyst.2_Cell.4
##                 0.6714127                       -Inf
##  Late_blastocyst.2_Cell.5  Late_blastocyst.2_Cell.6
##                       -Inf                       -Inf
##  Late_blastocyst.2_Cell.7  Late_blastocyst.2_Cell.8
##                       -Inf                       -Inf
##  Late_blastocyst.2_Cell.9 Late_blastocyst.2_Cell.10
##                       -Inf                       -Inf
##  Late_blastocyst.3_Cell.1  Late_blastocyst.3_Cell.2
##                       -Inf                       -Inf
##  Late_blastocyst.3_Cell.3  Late_blastocyst.3_Cell.4
##                       -Inf                       -Inf
##  Late_blastocyst.3_Cell.5  Late_blastocyst.3_Cell.6
##                 2.7084501                       -Inf
##  Late_blastocyst.3_Cell.7  Late_blastocyst.3_Cell.8
##                       -Inf                 2.7073166
```

```
print(pp)
```

```
##       Oocyte.1  Oocyte.2  Oocyte.3  Zygote.1  Zygote.2
## [1,] 0.5312359 0.4510596 0.3740803 0.3927565 0.4492002
##       Zygote.3 X2.cell_embryo.1_Cell.1
## [1,] 0.7291316               0.4239975
##      X2.cell_embryo.1_Cell.2 X2.cell_embryo.2_Cell.1
## [1,]               0.4793757               0.3819854
##      X2.cell_embryo.2_Cell.2 X2.cell_embryo.3_Cell.1
## [1,]               0.4468497               0.7291316
##      X2.cell_embryo.3_Cell.2 X4.cell_embryo.1_Cell.1
## [1,]               0.7291316               0.7291316
```

```
##      X4.cell_embryo.1_Cell.2 X4.cell_embryo.1_Cell.3
## [1,]                0.176849               0.7291316
##      X4.cell_embryo.1_Cell.4 X4.cell_embryo.2_Cell.1
## [1,]               0.7291316               0.7291316
##      X4.cell_embryo.2_Cell.2 X4.cell_embryo.2_Cell.3
## [1,]               0.7291316               0.4277359
##      X4.cell_embryo.2_Cell.4 X4.cell_embryo.3_Cell.1
## [1,]                0.287862               0.2658452
##      X4.cell_embryo.3_Cell.2 X4.cell_embryo.3_Cell.3
## [1,]               0.3106824               0.1951331
##      X4.cell_embryo.3_Cell.4 X8.cell_embryo.1_Cell.1
## [1,]               0.1662384               0.7291316
##      X8.cell_embryo.1_Cell.2 X8.cell_embryo.1_Cell.3
## [1,]               0.2852823               0.3765147
##      X8.cell_embryo.1_Cell.4 X8.cell_embryo.2_Cell.1
## [1,]               0.3103037               0.7291316
##      X8.cell_embryo.2_Cell.2 X8.cell_embryo.2_Cell.3
## [1,]               0.7291316               0.7291316
##      X8.cell_embryo.2_Cell.4 X8.cell_embryo.2_Cell.5
## [1,]               0.7291316               0.7291316
##      X8.cell_embryo.2_Cell.6 X8.cell_embryo.2_Cell.7
## [1,]               0.7291316               0.7291316
##      X8.cell_embryo.2_Cell.8 X8.cell_embryo.3_Cell.1
## [1,]               0.7291316               0.7291316
##      X8.cell_embryo.3_Cell.2 X8.cell_embryo.3_Cell.3
## [1,]               0.7291316               0.7291316
##      X8.cell_embryo.3_Cell.4 X8.cell_embryo.3_Cell.5
## [1,]               0.7291316               0.7291316
##      X8.cell_embryo.3_Cell.6 X8.cell_embryo.3_Cell.7
## [1,]               0.7291316               0.7291316
##      X8.cell_embryo.3_Cell.8 Morulae.1_Cell.1
## [1,]               0.1430187        0.7291316
##      Morulae.1_Cell.2 Morulae.1_Cell.3 Morulae.1_Cell.4
## [1,]        0.7291316        0.7291316        0.7291316
##      Morulae.1_Cell.5 Morulae.1_Cell.6 Morulae.1_Cell.7
## [1,]        0.7291316        0.7291316        0.7291316
##      Morulae.1_Cell.8 Morulae.2_Cell.1 Morulae.2_Cell.2
## [1,]        0.7291316        0.7291316        0.7291316
##      Morulae.2_Cell.3 Morulae.2_Cell.4 Morulae.2_Cell.5
## [1,]        0.7291316        0.7291316        0.7291316
##      Morulae.2_Cell.6 Morulae.2_Cell.7 Morulae.2_Cell.8
## [1,]        0.7291316        0.7291316        0.7291316
##      Late_blastocyst.1_Cell.1 Late_blastocyst.1_Cell.2
## [1,]                0.7291316                0.7291316
##      Late_blastocyst.1_Cell.3 Late_blastocyst.1_Cell.4
## [1,]                0.7291316                0.7291316
##      Late_blastocyst.1_Cell.5 Late_blastocyst.1_Cell.6
## [1,]                0.7291316                0.7291316
##      Late_blastocyst.1_Cell.7 Late_blastocyst.1_Cell.8
## [1,]                0.7291316                0.7291316
##      Late_blastocyst.1_Cell.9 Late_blastocyst.1_Cell.10
## [1,]                0.7291316                 0.7291316
##      Late_blastocyst.1_Cell.11 Late_blastocyst.1_Cell.12
## [1,]                 0.7291316                 0.7291316
```

```
##      Late_blastocyst.2_Cell.1 Late_blastocyst.2_Cell.2
## [1,]                0.7291316                0.1516543
##      Late_blastocyst.2_Cell.3 Late_blastocyst.2_Cell.4
## [1,]                0.3726822                0.7291316
##      Late_blastocyst.2_Cell.5 Late_blastocyst.2_Cell.6
## [1,]                0.7291316                0.7291316
##      Late_blastocyst.2_Cell.7 Late_blastocyst.2_Cell.8
## [1,]                0.7291316                0.7291316
##      Late_blastocyst.2_Cell.9 Late_blastocyst.2_Cell.10
## [1,]                0.7291316                 0.7291316
##      Late_blastocyst.3_Cell.1 Late_blastocyst.3_Cell.2
## [1,]                0.7291316                0.7291316
##      Late_blastocyst.3_Cell.3 Late_blastocyst.3_Cell.4
## [1,]                0.7291316                0.7291316
##      Late_blastocyst.3_Cell.5 Late_blastocyst.3_Cell.6
## [1,]               0.04108083                0.7291316
##      Late_blastocyst.3_Cell.7 Late_blastocyst.3_Cell.8
## [1,]                0.7291316               0.04115071
```

```
print(cc)
```

```
##                  Oocyte.1                  Oocyte.2
##                 0.0000000                 0.3534698
##                  Oocyte.3                  Zygote.1
##                 0.6657760                 0.5905606
##                  Zygote.2                  Zygote.3
##                 0.3611648                -0.3133418
##   X2.cell_embryo.1_Cell.1   X2.cell_embryo.1_Cell.2
##                 0.4643627                 0.2342813
##   X2.cell_embryo.2_Cell.1   X2.cell_embryo.2_Cell.2
##                 0.6339278                 0.3708737
##   X2.cell_embryo.3_Cell.1   X2.cell_embryo.3_Cell.2
##                -0.3523984                -0.7052198
##   X4.cell_embryo.1_Cell.1   X4.cell_embryo.1_Cell.2
##                      -Inf                 1.5526559
##   X4.cell_embryo.1_Cell.3   X4.cell_embryo.1_Cell.4
##                      -Inf                      -Inf
##   X4.cell_embryo.2_Cell.1   X4.cell_embryo.2_Cell.2
##                -1.3586792                -0.2943711
##   X4.cell_embryo.2_Cell.3   X4.cell_embryo.2_Cell.4
##                 0.4491630                 1.0217312
##   X4.cell_embryo.3_Cell.1   X4.cell_embryo.3_Cell.2
##                 1.1177611                 0.9250522
##   X4.cell_embryo.3_Cell.3   X4.cell_embryo.3_Cell.4
##                 1.4548872                 1.6122340
##   X8.cell_embryo.1_Cell.1   X8.cell_embryo.1_Cell.2
##                -0.7635696                 1.0328285
##   X8.cell_embryo.1_Cell.3   X8.cell_embryo.1_Cell.4
##                 0.6559644                 0.9266370
##   X8.cell_embryo.2_Cell.1   X8.cell_embryo.2_Cell.2
##                      -Inf                      -Inf
##   X8.cell_embryo.2_Cell.3   X8.cell_embryo.2_Cell.4
##                      -Inf                      -Inf
##   X8.cell_embryo.2_Cell.5   X8.cell_embryo.2_Cell.6
```

```
##                       -Inf                       -Inf
##   X8.cell_embryo.2_Cell.7   X8.cell_embryo.2_Cell.8
##                       -Inf                       -Inf
##   X8.cell_embryo.3_Cell.1   X8.cell_embryo.3_Cell.2
##                       -Inf                       -Inf
##   X8.cell_embryo.3_Cell.3   X8.cell_embryo.3_Cell.4
##                       -Inf                       -Inf
##   X8.cell_embryo.3_Cell.5   X8.cell_embryo.3_Cell.6
##                       -Inf                       -Inf
##   X8.cell_embryo.3_Cell.7   X8.cell_embryo.3_Cell.8
##                       -Inf                  1.7516317
##          Morulae.1_Cell.1          Morulae.1_Cell.2
##                       -Inf                       -Inf
##          Morulae.1_Cell.3          Morulae.1_Cell.4
##                       -Inf                 -0.2930297
##          Morulae.1_Cell.5          Morulae.1_Cell.6
##                       -Inf                       -Inf
##          Morulae.1_Cell.7          Morulae.1_Cell.8
##                       -Inf                       -Inf
##          Morulae.2_Cell.1          Morulae.2_Cell.2
##                       -Inf                       -Inf
##          Morulae.2_Cell.3          Morulae.2_Cell.4
##                       -Inf                       -Inf
##          Morulae.2_Cell.5          Morulae.2_Cell.6
##                       -Inf                 -0.9702191
##          Morulae.2_Cell.7          Morulae.2_Cell.8
##                -0.9597203                       -Inf
##  Late_blastocyst.1_Cell.1  Late_blastocyst.1_Cell.2
##                       -Inf                       -Inf
##  Late_blastocyst.1_Cell.3  Late_blastocyst.1_Cell.4
##                       -Inf                       -Inf
##  Late_blastocyst.1_Cell.5  Late_blastocyst.1_Cell.6
##                       -Inf                       -Inf
##  Late_blastocyst.1_Cell.7  Late_blastocyst.1_Cell.8
##                       -Inf                       -Inf
##  Late_blastocyst.1_Cell.9 Late_blastocyst.1_Cell.10
##                       -Inf                       -Inf
## Late_blastocyst.1_Cell.11 Late_blastocyst.1_Cell.12
##                       -Inf                       -Inf
##  Late_blastocyst.2_Cell.1  Late_blastocyst.2_Cell.2
##                -0.3495575                  1.6981811
##  Late_blastocyst.2_Cell.3  Late_blastocyst.2_Cell.4
##                 0.6714127                       -Inf
##  Late_blastocyst.2_Cell.5  Late_blastocyst.2_Cell.6
##                       -Inf                       -Inf
##  Late_blastocyst.2_Cell.7  Late_blastocyst.2_Cell.8
##                       -Inf                       -Inf
##  Late_blastocyst.2_Cell.9 Late_blastocyst.2_Cell.10
##                       -Inf                       -Inf
##  Late_blastocyst.3_Cell.1  Late_blastocyst.3_Cell.2
##                       -Inf                       -Inf
##  Late_blastocyst.3_Cell.3  Late_blastocyst.3_Cell.4
##                       -Inf                       -Inf
##  Late_blastocyst.3_Cell.5  Late_blastocyst.3_Cell.6
```

```
##                 2.7084501                      -Inf
##  Late_blastocyst.3_Cell.7  Late_blastocyst.3_Cell.8
##                      -Inf                 2.7073166
```

```
print(dd)
```

```
## NULL
```

```
i <- 5
x <- data0[i, ]
Zcut0 <- 0
best <- GetBestK(x = x, n = 1000, q = Zcut0, err = 1e-10)

pp <- calculate_prob_sep_Zcut(x, Zcut0, best$result[, 1], best$result[, 2], best$result[, 3])
cc <- discretization_method_1_LLR_mean(x, best$result, pp, LLR_cut = 0.1)
```

```
## [1] "Only one class"
```

```
dd <- Build_R_matrix(cc, Zcut0, best$result[, 2], rownames(data0)[i])

print(x)
```

```
##                   Oocyte.1                   Oocyte.2
##                 -0.3871342                  0.2949059
##                   Oocyte.3                   Zygote.1
##                  0.7537718                  1.7446679
##                   Zygote.2                   Zygote.3
##                  1.5871923                  1.7313015
##   X2.cell_embryo.1_Cell.1   X2.cell_embryo.1_Cell.2
##                  1.4611699                  1.4011830
##   X2.cell_embryo.2_Cell.1   X2.cell_embryo.2_Cell.2
##                  1.4731599                  1.5475625
##   X2.cell_embryo.3_Cell.1   X2.cell_embryo.3_Cell.2
##                  1.0501221                  0.8742180
##   X4.cell_embryo.1_Cell.1   X4.cell_embryo.1_Cell.2
##                  1.4060970                 -1.8325815
##   X4.cell_embryo.1_Cell.3   X4.cell_embryo.1_Cell.4
##                  0.1856493                      -Inf
##   X4.cell_embryo.2_Cell.1   X4.cell_embryo.2_Cell.2
##                  1.1413524                      -Inf
##   X4.cell_embryo.2_Cell.3   X4.cell_embryo.2_Cell.4
##                  2.3799164                 -0.9288695
##   X4.cell_embryo.3_Cell.1   X4.cell_embryo.3_Cell.2
##                  1.5411591                  1.7523254
##   X4.cell_embryo.3_Cell.3   X4.cell_embryo.3_Cell.4
##                  1.5091755                  1.7288197
##   X8.cell_embryo.1_Cell.1   X8.cell_embryo.1_Cell.2
##                  3.5036336                  3.6047095
##   X8.cell_embryo.1_Cell.3   X8.cell_embryo.1_Cell.4
##                  2.8523237                  3.7815954
##   X8.cell_embryo.2_Cell.1   X8.cell_embryo.2_Cell.2
##                  2.7822296                  1.7838953
```

```
##   X8.cell_embryo.2_Cell.3   X8.cell_embryo.2_Cell.4
##                 2.0550208                 3.6057967
##   X8.cell_embryo.2_Cell.5   X8.cell_embryo.2_Cell.6
##                 2.8845213                 2.2490788
##   X8.cell_embryo.2_Cell.7   X8.cell_embryo.2_Cell.8
##                 2.2758304                 2.9764475
##   X8.cell_embryo.3_Cell.1   X8.cell_embryo.3_Cell.2
##                 3.2518463                 3.4940196
##   X8.cell_embryo.3_Cell.3   X8.cell_embryo.3_Cell.4
##                 4.0421210                 3.8096580
##   X8.cell_embryo.3_Cell.5   X8.cell_embryo.3_Cell.6
##                 3.6084554                 2.3880286
##   X8.cell_embryo.3_Cell.7   X8.cell_embryo.3_Cell.8
##                 2.9516759                 4.0716217
##          Morulae.1_Cell.1          Morulae.1_Cell.2
##                 3.9599366                 3.4106195
##          Morulae.1_Cell.3          Morulae.1_Cell.4
##                -0.1086994                 3.2040464
##          Morulae.1_Cell.5          Morulae.1_Cell.6
##                 3.0037004                 4.1114475
##          Morulae.1_Cell.7          Morulae.1_Cell.8
##                 3.7993021                -0.8141855
##          Morulae.2_Cell.1          Morulae.2_Cell.2
##                 3.0061775                 4.1204670
##          Morulae.2_Cell.3          Morulae.2_Cell.4
##                 3.9427656                 3.4452781
##          Morulae.2_Cell.5          Morulae.2_Cell.6
##                 3.0906333                 3.1098642
##          Morulae.2_Cell.7          Morulae.2_Cell.8
##                 3.8282935                 4.1413236
##  Late_blastocyst.1_Cell.1  Late_blastocyst.1_Cell.2
##                 0.3133498                 2.3487050
##  Late_blastocyst.1_Cell.3  Late_blastocyst.1_Cell.4
##                 3.4520489                 2.5867861
##  Late_blastocyst.1_Cell.5  Late_blastocyst.1_Cell.6
##                 4.2983325                 3.2938349
##  Late_blastocyst.1_Cell.7  Late_blastocyst.1_Cell.8
##                 2.2683042                 1.4092782
##  Late_blastocyst.1_Cell.9 Late_blastocyst.1_Cell.10
##                      -Inf                 3.0728322
## Late_blastocyst.1_Cell.11 Late_blastocyst.1_Cell.12
##                 1.8878269                 2.3270826
##  Late_blastocyst.2_Cell.1  Late_blastocyst.2_Cell.2
##                 2.2086040                 2.9670756
##  Late_blastocyst.2_Cell.3  Late_blastocyst.2_Cell.4
##                 3.2008340                -0.3768777
##  Late_blastocyst.2_Cell.5  Late_blastocyst.2_Cell.6
##                -0.2256467                 2.8136107
##  Late_blastocyst.2_Cell.7  Late_blastocyst.2_Cell.8
##                -0.8462984                 2.6758713
##  Late_blastocyst.2_Cell.9 Late_blastocyst.2_Cell.10
##                 1.4768204                 2.1813210
##  Late_blastocyst.3_Cell.1  Late_blastocyst.3_Cell.2
##                 2.0725428                 1.3790180
```

```
##  Late_blastocyst.3_Cell.3  Late_blastocyst.3_Cell.4
##                 2.3051817                 2.4216118
##  Late_blastocyst.3_Cell.5  Late_blastocyst.3_Cell.6
##                 3.4375293                -1.9661129
##  Late_blastocyst.3_Cell.7  Late_blastocyst.3_Cell.8
##                -0.9314044                 1.9226415
```

```
print(pp)
```

```
##        Oocyte.1  Oocyte.2  Oocyte.3 Zygote.1  Zygote.2
## [1,] 0.08272947 0.3284781 0.4512065 0.650595 0.6320212
##       Zygote.3 X2.cell_embryo.1_Cell.1
## [1,] 0.6492757               0.6126515
##      X2.cell_embryo.1_Cell.2 X2.cell_embryo.2_Cell.1
## [1,]               0.6021446               0.6146554
##      X2.cell_embryo.2_Cell.2 X2.cell_embryo.3_Cell.1
## [1,]               0.6263418               0.5269793
##      X2.cell_embryo.3_Cell.2 X4.cell_embryo.1_Cell.1
## [1,]               0.4828621               0.6030348
##      X4.cell_embryo.1_Cell.2 X4.cell_embryo.1_Cell.3
## [1,]              0.08272947               0.3003883
##      X4.cell_embryo.1_Cell.4 X4.cell_embryo.2_Cell.1
## [1,]              0.08272947               0.5484437
##      X4.cell_embryo.2_Cell.2 X4.cell_embryo.2_Cell.3
## [1,]              0.08272947               0.6537385
##      X4.cell_embryo.2_Cell.4 X4.cell_embryo.3_Cell.1
## [1,]              0.08272947               0.6253879
##      X4.cell_embryo.3_Cell.2 X4.cell_embryo.3_Cell.3
## [1,]               0.6513288               0.6204757
##      X4.cell_embryo.3_Cell.4 X8.cell_embryo.1_Cell.1
## [1,]               0.6490253               0.4247675
##      X8.cell_embryo.1_Cell.2 X8.cell_embryo.1_Cell.3
## [1,]               0.3975103               0.5839943
##      X8.cell_embryo.1_Cell.4 X8.cell_embryo.2_Cell.1
## [1,]               0.3501002               0.5975892
##      X8.cell_embryo.2_Cell.2 X8.cell_embryo.2_Cell.3
## [1,]               0.6541823               0.6669216
##      X8.cell_embryo.2_Cell.4 X8.cell_embryo.2_Cell.5
## [1,]                0.397217               0.5774304
##      X8.cell_embryo.2_Cell.6 X8.cell_embryo.2_Cell.7
## [1,]               0.6627484               0.6613057
##      X8.cell_embryo.2_Cell.8 X8.cell_embryo.3_Cell.1
## [1,]               0.5576759               0.4912675
##      X8.cell_embryo.3_Cell.2 X8.cell_embryo.3_Cell.3
## [1,]               0.4273543               0.2831046
##      X8.cell_embryo.3_Cell.4 X8.cell_embryo.3_Cell.5
## [1,]               0.3426781               0.3964998
##      X8.cell_embryo.3_Cell.6 X8.cell_embryo.3_Cell.7
## [1,]               0.6530201                 0.56314
##      X8.cell_embryo.3_Cell.8 Morulae.1_Cell.1
## [1,]               0.2758512       0.3037122
##      Morulae.1_Cell.2 Morulae.1_Cell.3 Morulae.1_Cell.4
## [1,]        0.4496895       0.08272947        0.5034151
##      Morulae.1_Cell.5 Morulae.1_Cell.6 Morulae.1_Cell.7
```

```
## [1,]        0.5515517        0.2661895        0.3454127
##      Morulae.1_Cell.8 Morulae.2_Cell.1 Morulae.2_Cell.2
## [1,]       0.08272947        0.5509893        0.2640229
##      Morulae.2_Cell.3 Morulae.2_Cell.4 Morulae.2_Cell.5
## [1,]        0.3080868        0.4404348        0.5312876
##      Morulae.2_Cell.6 Morulae.2_Cell.7 Morulae.2_Cell.8
## [1,]        0.5266672        0.3377711        0.2590444
##      Late_blastocyst.1_Cell.1 Late_blastocyst.1_Cell.2
## [1,]                 0.333298                0.6563305
##      Late_blastocyst.1_Cell.3 Late_blastocyst.1_Cell.4
## [1,]                0.4386218                0.6298768
##      Late_blastocyst.1_Cell.5 Late_blastocyst.1_Cell.6
## [1,]                0.2230686                0.4804357
##      Late_blastocyst.1_Cell.7 Late_blastocyst.1_Cell.8
## [1,]                0.6617326                0.6036083
##      Late_blastocyst.1_Cell.9 Late_blastocyst.1_Cell.10
## [1,]               0.08272947                 0.5355221
##      Late_blastocyst.1_Cell.11 Late_blastocyst.1_Cell.12
## [1,]                 0.6615891                 0.6579649
##      Late_blastocyst.2_Cell.1 Late_blastocyst.2_Cell.2
## [1,]                 0.664535                0.5597549
##      Late_blastocyst.2_Cell.3 Late_blastocyst.2_Cell.4
## [1,]                0.5042238               0.08272947
##      Late_blastocyst.2_Cell.5 Late_blastocyst.2_Cell.6
## [1,]               0.08272947                0.5916239
##      Late_blastocyst.2_Cell.7 Late_blastocyst.2_Cell.8
## [1,]               0.08272947                0.6162464
##      Late_blastocyst.2_Cell.9 Late_blastocyst.2_Cell.10
## [1,]                0.6152607                 0.6654682
##      Late_blastocyst.3_Cell.1 Late_blastocyst.3_Cell.2
## [1,]                0.6670025                0.5980658
##      Late_blastocyst.3_Cell.3 Late_blastocyst.3_Cell.4
## [1,]                0.6594847                0.6498522
##      Late_blastocyst.3_Cell.5 Late_blastocyst.3_Cell.6
## [1,]                0.4425078               0.08272947
##      Late_blastocyst.3_Cell.7 Late_blastocyst.3_Cell.8
## [1,]               0.08272947                0.6633757
```

```
print(cc)
```

```
##                  Oocyte.1                  Oocyte.2
##                -0.3871342                 0.2949059
##                  Oocyte.3                  Zygote.1
##                 0.7537718                 1.7446679
##                  Zygote.2                  Zygote.3
##                 1.5871923                 1.7313015
##   X2.cell_embryo.1_Cell.1   X2.cell_embryo.1_Cell.2
##                 1.4611699                 1.4011830
##   X2.cell_embryo.2_Cell.1   X2.cell_embryo.2_Cell.2
##                 1.4731599                 1.5475625
##   X2.cell_embryo.3_Cell.1   X2.cell_embryo.3_Cell.2
##                 1.0501221                 0.8742180
##   X4.cell_embryo.1_Cell.1   X4.cell_embryo.1_Cell.2
##                 1.4060970                -1.8325815
```

```
##   X4.cell_embryo.1_Cell.3   X4.cell_embryo.1_Cell.4
##                 0.1856493                      -Inf
##   X4.cell_embryo.2_Cell.1   X4.cell_embryo.2_Cell.2
##                 1.1413524                      -Inf
##   X4.cell_embryo.2_Cell.3   X4.cell_embryo.2_Cell.4
##                 2.3799164               -0.9288695
##   X4.cell_embryo.3_Cell.1   X4.cell_embryo.3_Cell.2
##                 1.5411591                1.7523254
##   X4.cell_embryo.3_Cell.3   X4.cell_embryo.3_Cell.4
##                 1.5091755                1.7288197
##   X8.cell_embryo.1_Cell.1   X8.cell_embryo.1_Cell.2
##                 3.5036336                3.6047095
##   X8.cell_embryo.1_Cell.3   X8.cell_embryo.1_Cell.4
##                 2.8523237                3.7815954
##   X8.cell_embryo.2_Cell.1   X8.cell_embryo.2_Cell.2
##                 2.7822296                1.7838953
##   X8.cell_embryo.2_Cell.3   X8.cell_embryo.2_Cell.4
##                 2.0550208                3.6057967
##   X8.cell_embryo.2_Cell.5   X8.cell_embryo.2_Cell.6
##                 2.8845213                2.2490788
##   X8.cell_embryo.2_Cell.7   X8.cell_embryo.2_Cell.8
##                 2.2758304                2.9764475
##   X8.cell_embryo.3_Cell.1   X8.cell_embryo.3_Cell.2
##                 3.2518463                3.4940196
##   X8.cell_embryo.3_Cell.3   X8.cell_embryo.3_Cell.4
##                 4.0421210                3.8096580
##   X8.cell_embryo.3_Cell.5   X8.cell_embryo.3_Cell.6
##                 3.6084554                2.3880286
##   X8.cell_embryo.3_Cell.7   X8.cell_embryo.3_Cell.8
##                 2.9516759                4.0716217
##          Morulae.1_Cell.1          Morulae.1_Cell.2
##                 3.9599366                3.4106195
##          Morulae.1_Cell.3          Morulae.1_Cell.4
##                -0.1086994                3.2040464
##          Morulae.1_Cell.5          Morulae.1_Cell.6
##                 3.0037004                4.1114475
##          Morulae.1_Cell.7          Morulae.1_Cell.8
##                 3.7993021               -0.8141855
##          Morulae.2_Cell.1          Morulae.2_Cell.2
##                 3.0061775                4.1204670
##          Morulae.2_Cell.3          Morulae.2_Cell.4
##                 3.9427656                3.4452781
##          Morulae.2_Cell.5          Morulae.2_Cell.6
##                 3.0906333                3.1098642
##          Morulae.2_Cell.7          Morulae.2_Cell.8
##                 3.8282935                4.1413236
##  Late_blastocyst.1_Cell.1  Late_blastocyst.1_Cell.2
##                 0.3133498                2.3487050
##  Late_blastocyst.1_Cell.3  Late_blastocyst.1_Cell.4
##                 3.4520489                2.5867861
##  Late_blastocyst.1_Cell.5  Late_blastocyst.1_Cell.6
##                 4.2983325                3.2938349
##  Late_blastocyst.1_Cell.7  Late_blastocyst.1_Cell.8
##                 2.2683042                1.4092782
```

```
##  Late_blastocyst.1_Cell.9 Late_blastocyst.1_Cell.10
##                      -Inf                 3.0728322
## Late_blastocyst.1_Cell.11 Late_blastocyst.1_Cell.12
##                 1.8878269                 2.3270826
##  Late_blastocyst.2_Cell.1  Late_blastocyst.2_Cell.2
##                 2.2086040                 2.9670756
##  Late_blastocyst.2_Cell.3  Late_blastocyst.2_Cell.4
##                 3.2008340                -0.3768777
##  Late_blastocyst.2_Cell.5  Late_blastocyst.2_Cell.6
##                -0.2256467                 2.8136107
##  Late_blastocyst.2_Cell.7  Late_blastocyst.2_Cell.8
##                -0.8462984                 2.6758713
##  Late_blastocyst.2_Cell.9 Late_blastocyst.2_Cell.10
##                 1.4768204                 2.1813210
##  Late_blastocyst.3_Cell.1  Late_blastocyst.3_Cell.2
##                 2.0725428                 1.3790180
##  Late_blastocyst.3_Cell.3  Late_blastocyst.3_Cell.4
##                 2.3051817                 2.4216118
##  Late_blastocyst.3_Cell.5  Late_blastocyst.3_Cell.6
##                 3.4375293                -1.9661129
##  Late_blastocyst.3_Cell.7  Late_blastocyst.3_Cell.8
##                -0.9314044                 1.9226415
```

```
print(dd)
```

```
## NULL
```

(iv) directly apply qubic from the QUBIC package

We are trying save the result to a file first.

```
WriteQubicInput <- function(file.name, data0, genes, q = 0, err = 1e-10) {
  cat("o", colnames(data0), "\n", file = file.name)
  for (i in genes) {
    cat(i, colnames(data0), "\n", file = "progress")
    x <- data0[i, ]
    Zcut0 <- q
    best <- GetBestK(x = x, n = 1000, q = Zcut0, err = 1e-10)
    if (best$k == 0) {
      next
    }
    pp <- calculate_prob_sep_Zcut(x, Zcut0, best$result[, 1], best$result[, 2], best$result[, 3])
    cc <- discretization_method_1_LLR_mean(x, best$result, pp, LLR_cut = 0.1)
    dd <- Build_R_matrix(cc, Zcut0, best$result[, 2], rownames(data0)[i])
    write.table(dd, file = file.name, col.names = FALSE, append = TRUE, quote = FALSE)
  }
}
```

```
system.time(WriteQubicInput("qubic_input_head30", data0, head(selected.genes, 30)))
```

```
## [1] "Only one class"
## [1] "Only one class"
```

```
## [1] "Only one class"
## [1] "Only one class"
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## [1] "Only one class"
## [1] "Only one class"
```

```
##    user  system elapsed
##    6.00    0.07    6.17
```

This may be slow…

```
print(length(selected.genes))
```

```
## [1] 14542
```

```
qubic.file = "qubic_input"
if (!file.exists(qubic.file)) {
  WriteQubicInput(qubic.file, data0, selected.genes)
}
```

It is the time to read all the data back.

```
qubic.input <- as.matrix(read.table(qubic.file, row.names = 1, header = TRUE))
```

Run QUBIC(Zhang et al. 2017), need several minute.

```
library(QUBIC)
if (!file.exists("res.RData")) {
  res <- qubiclust_d(qubic.input)
  save(res, file="res.RData")
} else {
  load("res.RData")
}
```

(v) results summary

```
res
```

```
##
## An object of class Biclust
##
## call:
##  NULL
##
## Number of Clusters found:  100
##
## First  5  Cluster sizes:
##                     BC 1 BC 2 BC 3 BC 4 BC 5
## Number of Rows:      934  931  921  959  941
## Number of Columns:    73   73   73   70   71
```

```
biclust::summary(res)
```

```
##
## An object of class Biclust
##
## call:
##  NULL
##
## Number of Clusters found:  100
##
## Cluster sizes:
##                     BC 1 BC 2 BC 3 BC 4 BC 5 BC 6 BC 7 BC 8
## Number of Rows:      934  931  921  959  941  911  909  884
## Number of Columns:    73   73   73   70   71   73   73   75
##                     BC 9 BC 10 BC 11 BC 12 BC 13 BC 14 BC 15
## Number of Rows:      882   917   902   966   885   872   872
## Number of Columns:    75    72    73    68    74    75    75
##                     BC 16 BC 17 BC 18 BC 19 BC 20 BC 21
## Number of Rows:       894   892   891   910   897   907
## Number of Columns:     73    73    73    71    72    71
##                     BC 22 BC 23 BC 24 BC 25 BC 26 BC 27
## Number of Rows:       870   870   905   866   850   849
## Number of Columns:     74    74    71    74    75    75
##                     BC 28 BC 29 BC 30 BC 31 BC 32 BC 33
## Number of Rows:       846   845   832   832   832   832
## Number of Columns:     75    74    75    75    75    75
##                     BC 34 BC 35 BC 36 BC 37 BC 38 BC 39
## Number of Rows:       831   831   831   831   831   831
## Number of Columns:     75    75    75    75    75    75
##                     BC 40 BC 41 BC 42 BC 43 BC 44 BC 45
## Number of Rows:       831   838   826   826   826   826
## Number of Columns:     75    74    75    75    75    75
##                     BC 46 BC 47 BC 48 BC 49 BC 50 BC 51
## Number of Rows:       832   831   863   808   814   792
## Number of Columns:     74    74    71    75    73    75
```

```
##                     BC 52 BC 53 BC 54 BC 55 BC 56 BC 57
## Number of Rows:       792   792   792   792   792   792
## Number of Columns:     75    75    75    75    75    75
##                     BC 58 BC 59 BC 60 BC 61 BC 62 BC 63
## Number of Rows:       792   792   792   792   792   792
## Number of Columns:     75    75    75    75    75    75
##                     BC 64 BC 65 BC 66 BC 67 BC 68 BC 69
## Number of Rows:       792   792   792   792   792   792
## Number of Columns:     75    75    75    75    75    75
##                     BC 70 BC 71 BC 72 BC 73 BC 74 BC 75
## Number of Rows:       792   792   792   792   792   792
## Number of Columns:     75    75    75    75    75    75
##                     BC 76 BC 77 BC 78 BC 79 BC 80 BC 81
## Number of Rows:       792   792   792   792   792   792
## Number of Columns:     75    75    75    75    75    75
##                     BC 82 BC 83 BC 84 BC 85 BC 86 BC 87
## Number of Rows:       792   792   792   792   792   792
## Number of Columns:     75    75    75    75    75    75
##                     BC 88 BC 89 BC 90 BC 91 BC 92 BC 93
## Number of Rows:       792   792   792   791   792   792
## Number of Columns:     75    75    75    75    74    74
##                     BC 94 BC 95 BC 96 BC 97 BC 98 BC 99
## Number of Rows:       792   792   739   725   699   683
## Number of Columns:     74    74    77    76    78    77
##                     BC 100
## Number of Rows:        668
## Number of Columns:      78
```

References

Zhang, Yu, Juan Xie, Jinyu Yang, Anne Fennell, Chi Zhang, and Qin Ma. 2017. "QUBIC: A Bioconductor Package for Qualitative Biclustering Analysis of Gene Co- Expression Data." *Bioinformatics* 33 (3): 450–52. https://doi.org/10.1093/bioinformatics/btw635.