Computing_HW2_엄상준

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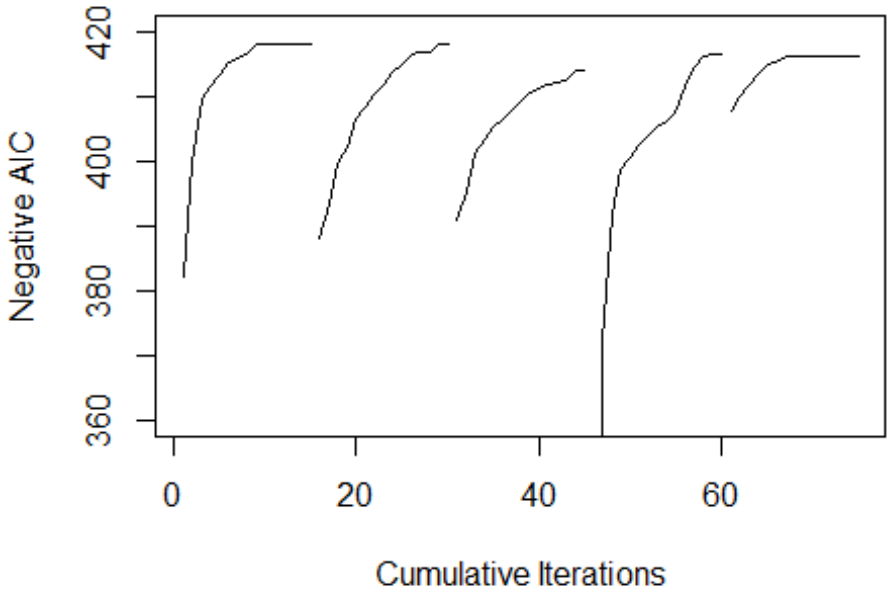
2020 10 27

```
##############################################################################
### 3.1 RANDOM STARTS LOCAL SEARCH
##############################################################################
## INITIAL VALUES
baseball.dat = read.table('baseball.dat',header=TRUE)
baseball.dat$freeagent = factor(baseball.dat$freeagent)
baseball.dat$arbitration = factor(baseball.dat$arbitration)
baseball.sub = baseball.dat[,-1]
salary.log = log(baseball.dat$salary)
n = length(salary.log) #case 개수
m = length(baseball.sub[1,]) #독립변수 개수
num.starts = 5 #random start 개수
runs = matrix(0,num.starts,m)
itr = 15
runs.aic = matrix(0,num.starts,itr)

# INITIALIZES STARTING RUNS
set.seed(1234)
for(i in 1:num.starts){runs[i,] = rbinom(m,1,.5)}
#random 으로 열을 뽑는 것을 다섯 번 시행



## MAIN
for(k in 1:num.starts){
    run.current = runs[k,]

    # ITERATES EACH RANDOM START
    for(j in 1:itr){
        run.vars = baseball.sub[,run.current==1] #1 로 선택된 변수들 뽑아내기.
        g = lm(salary.log~.,run.vars)
        run.aic = extractAIC(g)[2] #[1]은 equivalent d.f, [2]가 AIC
        run.next = run.current

        # TESTS ALL MODELS IN THE 1-NEIGHBORHOOD AND SELECTS THE
        # MODEL WITH THE LOWEST AIC
        for(i in 1:m){
            run.step = run.current
```

```
            run.step[i] = !run.current[i] #0 이라면 1 로 1 이라면 0 으로 바꿈.
            run.vars = baseball.sub[,run.step==1] #바뀐 것으로 variable 을 새로
 뽑음.
            g = lm(salary.log~.,run.vars) #model 적용
            run.step.aic = extractAIC(g)[2] #AIC 구하기
            if(run.step.aic < run.aic){
                run.next = run.step
                run.aic = run.step.aic
            } #만약 AIC 가 더 작다면 run.next 로 할당해줌. 그리고 run.aic 도 바꿔
줌
        }
        run.current = run.next #run.next 를 current 에 적용.
        runs.aic[k,j]=run.aic
    }
    runs[k,] = run.current #최종적으로 제일 작은 aic 를 가진 subset 이 골라짐.
}

## OUTPUT
runs        # LISTS OF PREDICTORS
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12] [,13]
[,14]
## [1,]    0    1    1    0    0    1    0    1    0     1     0     1     1
    1
## [2,]    0    1    1    0    0    1    0    1    0     1     0     1     1
    1
## [3,]    0    0    0    0    0    0    0    1    1     1     0     0     1
    1
## [4,]    1    0    1    0    0    0    0    1    0     1     0     0     1
    1
## [5,]    0    0    1    0    0    0    0    1    0     1     0     1     1
    1
##      [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25] [,2
6]
## [1,]     1     1     0     0     0     0     0     0     0     0     1
 1
## [2,]     1     1     0     0     0     0     0     0     0     0     1
 1
## [3,]     0     1     1     1     0     1     1     1     0     0     1
 0
## [4,]     1     1     0     0     0     0     0     0     0     1     0
 0
## [5,]     1     1     0     0     0     1     0     1     0     0     0
 0
##      [,27]
```

```
## [1,]     0
## [2,]     0
## [3,]     0
## [4,]     0
## [5,]     0

runs.aic    # AIC VALUES

##           [,1]      [,2]      [,3]      [,4]      [,5]      [,6]      [,7]
## [1,] -382.1396 -399.5996 -409.5874 -411.5453 -413.5192 -415.3651 -415.9898
## [2,] -388.0134 -393.5020 -399.7536 -402.2507 -406.3813 -408.3073 -410.2499
## [3,] -391.0411 -395.3438 -401.3549 -403.3081 -405.1843 -406.4663 -407.8866
## [4,] -199.6572 -372.1001 -391.9549 -398.5628 -400.4917 -402.3174 -404.0648
## [5,] -407.8876 -409.8851 -411.7404 -413.4253 -414.8167 -415.3757 -416.1567
##           [,8]      [,9]     [,10]     [,11]     [,12]     [,13]     [,14]
## [1,] -416.4954 -418.0000 -418.0000 -418.0000 -418.0000 -418.0000 -418.0000
## [2,] -411.9831 -413.6061 -415.1196 -416.6207 -416.7355 -416.9711 -418.0000
## [3,] -409.2473 -410.4997 -411.3319 -411.9675 -412.2386 -412.5352 -413.8955
## [4,] -405.2679 -406.2594 -407.3961 -411.5770 -414.6209 -416.2200 -416.3802
## [5,] -416.1567 -416.1567 -416.1567 -416.1567 -416.1567 -416.1567 -416.1567
##          [,15]
## [1,] -418.0000
## [2,] -418.0000
## [3,] -413.8955
## [4,] -416.3802
## [5,] -416.1567

##PLOT
plot(1:(itr*num.starts),-c(t(runs.aic)),xlab="Cumulative Iterations",
  ylab="Negative AIC",ylim=c(360,420),type="n")
for(i in 1:num.starts) {
  lines((i-1)*itr+(1:itr),-runs.aic[i,]) }
```

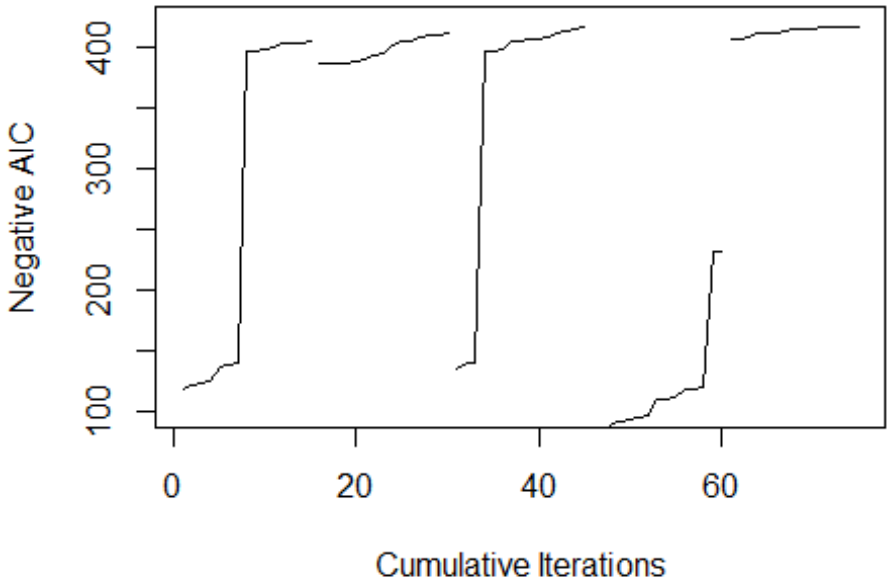



```r
##3-1(a)
#setting 은 위와 동일
runs2 = matrix(0,num.starts,m)
runs.aic2 = matrix(0,num.starts,itr)

# INITIALIZES STARTING RUNS
set.seed(1234)
for(i in 1:num.starts){runs2[i,] = rbinom(m,1,.5)}
#random 으로 열을 뽑는 것을 다섯 번 시행

for(k in 1:num.starts){
  run.current = runs2[k,]

  # ITERATES EACH RANDOM START
  for(j in 1:itr){
    run.vars = baseball.sub[,run.current==1] #1 로 선택된 변수들 뽑아내기.
    g = lm(salary.log~.,run.vars)
    run.aic = extractAIC(g)[2] #[1]은 equivalent d.f, [2]가 AIC
    run.next = run.current

    #aic 가 작은게 나오면 바로 채택
    for(i in 1:m){
      run.step = run.current
```

```
      run.step[i] = !run.current[i] #0 이라면 1 로 1 이라면 0 으로 바꿈.
      run.vars = baseball.sub[,run.step==1] #바뀐 것으로 variable 을 새로 뽑음.
      g = lm(salary.log~.,run.vars) #model 적용
      run.step.aic = extractAIC(g)[2] #AIC 구하기
      if(run.step.aic < run.aic){
        run.next = run.step
        run.aic = run.step.aic
        break
      } #만약 AIC 가 더 작다면 run.next 로 할당해줌. 그리고 run.aic 도 바꿔줌
    }
    run.current = run.next #run.next 를 current 에 적용.
    runs.aic2[k,j]=run.aic
  }
  runs2[k,] = run.current #최종적으로 제일 작은 aic 를 가진 subset 이 골라짐.
}

runs2
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12] [,13]
[,14]
## [1,]    0    1    0    1    0    0    0    1    1     1     0     1     1
    1
## [2,]    0    0    1    0    0    1    0    1    0     1     1     1     1
    1
## [3,]    0    0    1    0    0    1    0    1    0     1     1     1     1
    1
## [4,]    0    1    0    1    0    0    1    1    1     1     0     0     1
    0
## [5,]    1    0    1    0    0    1    0    1    0     1     1     0     1
    1
##      [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25] [,2
6]
## [1,]     1     1     0     0     0     0     0     0     0     0     0
 1
## [2,]     1     1     0     0     1     1     0     0     1     0     0
 1
## [3,]     1     1     0     0     0     1     0     1     0     0     0
 0
## [4,]     1     0     0     0     1     0     1     0     0     0     0
 0
## [5,]     1     1     0     0     0     0     0     0     0     1     0
 0
##      [,27]
## [1,]     1
## [2,]     1
## [3,]     1
```

```
## [4,]     0
## [5,]     1

runs.aic2

##            [,1]       [,2]       [,3]       [,4]       [,5]      [,6]
## [1,] -118.87903 -120.86363 -122.74945 -124.19637 -137.24499 -137.5626
## [2,] -385.67324 -386.28517 -386.95993 -387.20933 -388.90768 -390.4413
## [3,] -135.02096 -139.72876 -140.44932 -396.11099 -396.21333 -398.0474
## [4,]  -79.16357  -80.88432  -90.07468  -92.01331  -93.19905  -95.1881
## [5,] -406.45354 -406.96372 -408.92228 -411.03872 -411.17277 -412.3083
##            [,7]      [,8]      [,9]     [,10]     [,11]     [,12]     [,13]
## [1,] -139.26121 -395.8276 -396.1728 -397.7137 -399.6275 -402.6213 -402.713
2
## [2,] -393.34678 -395.3418 -402.2513 -404.6487 -405.4907 -407.6709 -409.342
0
## [3,] -404.31480 -404.7419 -406.6284 -406.7591 -408.6294 -411.0614 -412.708
0
## [4,]  -97.30177 -109.3067 -109.7089 -111.6231 -117.9971 -118.0441 -119.877
6
## [5,] -413.94572 -414.3590 -414.6624 -414.8042 -416.8033 -416.8033 -416.803
3
##          [,14]     [,15]
## [1,] -402.7818 -404.2657
## [2,] -409.3859 -410.8496
## [3,] -414.5081 -415.7830
## [4,] -230.9679 -232.1195
## [5,] -416.8033 -416.8033

##PLOT
plot(1:(itr*num.starts),-c(t(runs.aic2)),xlab="Cumulative Iterations",
     ylab="Negative AIC",ylim=c(100,420),type="n")
for(i in 1:num.starts) {
  lines((i-1)*itr+(1:itr),-runs.aic2[i,]) }
```



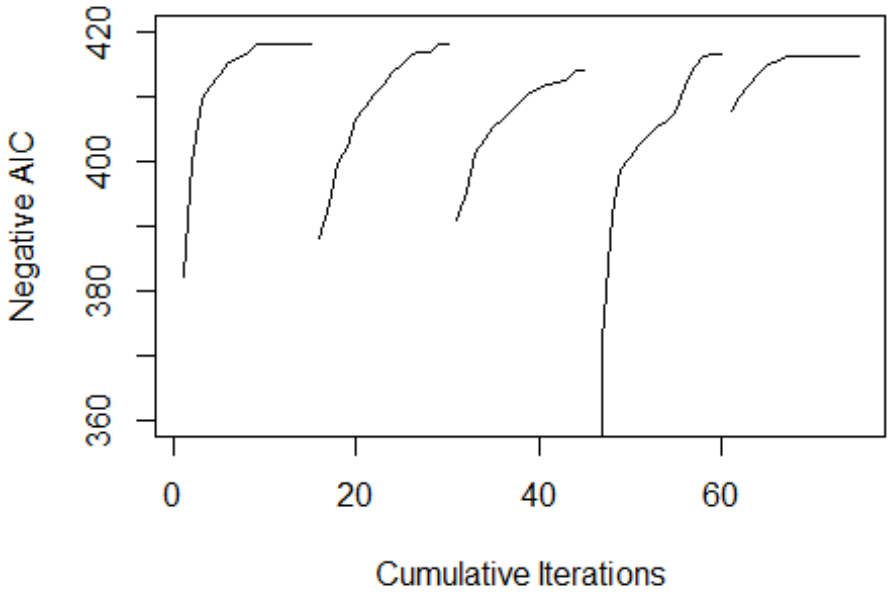
➔ 원래는 plot 의 모양이 곡선의 형태를 띄었으나 여기서는 나머지를 고려하지 않고 좋은 것을 바로 택하기 때문에 plot 의 모양이 직각에 가까운 형태를 보이고 있다.

```
##3-1(b)
#setting 은 위와 동일
#combination function 을 위해 gtools package 이용
runs3 = matrix(0,num.starts,m)
runs.aic3 = matrix(0,num.starts,itr)
library(gtools)

## Warning: package 'gtools' was built under R version 3.6.3

comb <-combinations(m,2) #독립변수에서 2 개를 뽑는 경우의 수들

# INITIALIZES STARTING RUNS
set.seed(1234)
for(i in 1:num.starts){runs3[i,] = rbinom(m,1,.5)}
#random 으로 열을 뽑는 것을 다섯 번 시행


## MAIN
for(k in 1:num.starts){
  run.current = runs3[k,]
```

```
  # ITERATES EACH RANDOM START
  for(j in 1:itr){
    run.vars = baseball.sub[,run.current==1] #1 로 선택된 변수들 뽑아내기.
    g = lm(salary.log~.,run.vars)
    run.aic = extractAIC(g)[2] #[1]은 equivalent d.f, [2]가 AIC
    run.next = run.current

    # TESTS ALL MODELS IN THE 2-NEIGHBORHOOD AND SELECTS THE
    # MODEL WITH THE LOWEST AIC
    for(i in 1:nrow(comb)){
      run.step = run.current
      run.step[comb[i,][1]] = !run.current[comb[i,][1]] #0 이라면 1 로 1 이라면
0 으로 바꿈.
      run.step[comb[i,][2]] = !run.current[comb[i,][2]]
      run.vars = baseball.sub[,run.step==1] #바뀐 것으로 variable 을 새로 뽑음.
      g = lm(salary.log~.,run.vars) #model 적용
      run.step.aic = extractAIC(g)[2] #AIC 구하기
      if(run.step.aic < run.aic){
        run.next = run.step
        run.aic = run.step.aic
      } #만약 AIC 가 더 작다면 run.next 로 할당해줌. 그리고 run.aic 도 바꿔줌
    }
    run.current = run.next #run.next 를 current 에 적용.
    runs.aic3[k,j]=run.aic
  }
  runs3[k,] = run.current #최종적으로 제일 작은 aic 를 가진 subset 이 골라짐.
}

## OUTPUT
runs3       # LISTS OF PREDICTORS
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12] [,13]
[,14]
## [1,]    1    0    1    0    0    0    0    1    0     1     0     0     1
    1
## [2,]    0    1    1    0    0    1    0    1    0     1     0     0     1
    1
## [3,]    0    1    1    0    0    1    0    1    0     1     0     0     1
    1
## [4,]    0    0    1    0    0    1    0    1    0     1     0     0     1
    1
## [5,]    0    0    1    0    0    1    0    1    0     1     0     1     1
    1
```

```
##      [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25] [,2
6]
## [1,]     1     1     0     0     0     0     0     0     0     1     1
 1
## [2,]     1     1     0     0     0     0     0     0     0     1     1
 1
## [3,]     1     1     0     0     0     0     0     0     0     1     1
 1
## [4,]     0     0     0     0     0     1     1     1     0     1     1
 0
## [5,]     1     1     0     0     0     1     0     1     0     0     1
 1
##      [,27]
## [1,]     0
## [2,]     0
## [3,]     0
## [4,]     0
## [5,]     0

runs.aic3   # AIC VALUES

##           [,1]      [,2]      [,3]      [,4]      [,5]      [,6]      [,7]
## [1,] -399.5996 -411.5453 -415.3651 -416.9711 -417.8494 -418.0125 -418.0922
## [2,] -395.3894 -400.3693 -404.3826 -408.3073 -411.9831 -415.1196 -416.7355
## [3,] -395.3438 -403.3081 -407.9346 -411.8968 -414.1540 -414.9004 -416.1567
## [4,] -372.1001 -402.9366 -411.0083 -414.8872 -415.4118 -416.4249 -416.6119
## [5,] -409.8851 -413.4253 -415.3757 -416.1318 -417.2714 -417.2714 -417.2714
##           [,8]      [,9]     [,10]     [,11]     [,12]     [,13]     [,14]
## [1,] -418.4511 -418.4511 -418.4511 -418.4511 -418.4511 -418.4511 -418.4511
## [2,] -418.0000 -418.9472 -418.9472 -418.9472 -418.9472 -418.9472 -418.9472
## [3,] -416.5907 -416.8036 -418.0818 -418.9421 -418.9472 -418.9472 -418.9472
## [4,] -416.6119 -416.6119 -416.6119 -416.6119 -416.6119 -416.6119 -416.6119
## [5,] -417.2714 -417.2714 -417.2714 -417.2714 -417.2714 -417.2714 -417.2714
##          [,15]
## [1,] -418.4511
## [2,] -418.9472
## [3,] -418.9472
## [4,] -416.6119
## [5,] -417.2714

##PLOT
plot(1:(itr*num.starts),-c(t(runs.aic3)),xlab="Cumulative Iterations",
     ylab="Negative AIC",ylim=c(360,420),type="n")
for(i in 1:num.starts) {
  lines((i-1)*itr+(1:itr),-runs.aic[i,]) }
```



➔ Example 3.3 에서의 Plot 과 거의 동일함을 알 수 있다.

➔ Steepest 방법을 사용했기 때문일 수 있다. 만약 steepest 로 하지 않고 일정 수만큼만 살펴본다면 결과값이 다를 수 있다.

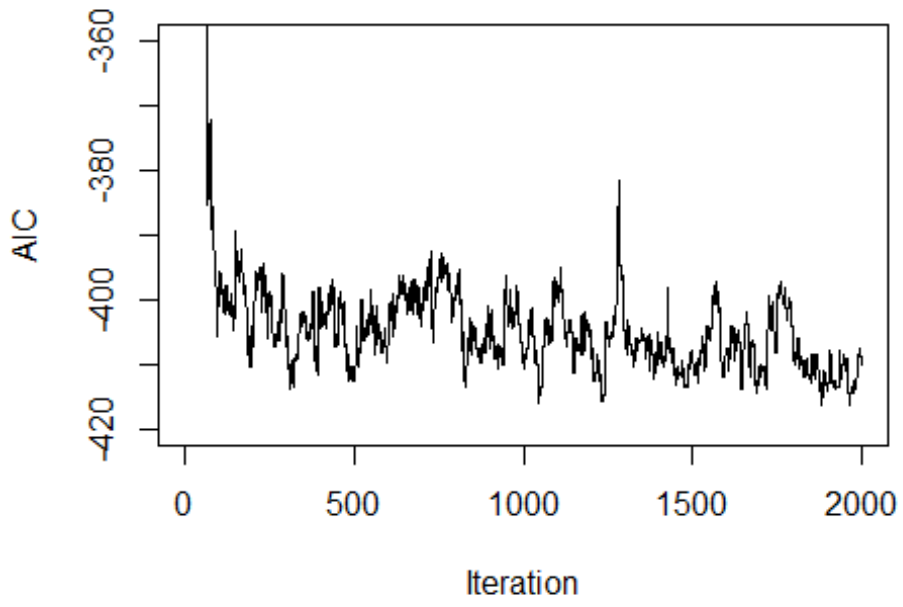
```
##############################################################################
### 3.3 SIMULATED ANNEALING
##############################################################################
## INITIAL VALUES
baseball.dat = read.table('baseball.dat',header=TRUE)
baseball.dat$freeagent = factor(baseball.dat$freeagent)
baseball.dat$arbitration = factor(baseball.dat$arbitration)
baseball.sub = baseball.dat[,-1]
salary.log = log(baseball.dat$salary)
n = length(salary.log)
m = length(baseball.sub[1,])
cooling = c(rep(60,5),rep(120,5),rep(220,5)) #cooling schedule
tau.start = 10 #시작 온도
tau = rep(tau.start,15)
aics = NULL


# INITIALIZES STARTING RUN, TEMPERATURE SCHEDULE
set.seed(1234)
```

```r
run = rbinom(m,1,.5)
run.current = run
run.vars = baseball.sub[,run.current==1]
g = lm(salary.log~.,run.vars)
run.aic = extractAIC(g)[2]
best.aic = run.aic
aics = run.aic #여기까지는 3.3 과 동일
for(j in 2:15){tau[j] = 0.9*tau[j-1]} #온도가 이전의 0.9 배로 줄어들도록 설정.


## MAIN
for(j in 1:15){

    # Model 에서 더하거나 뺄 predictor 를 랜덤으로 선택하고
    # 더 나은지 확인한다. 더 낫다면 선택.
    for(i in 1:cooling[j]){
        pos = sample(1:m,1) #독립변수 중 한 개를 랜덤으로 선택
        run.step = run.current
        run.step[pos] = !run.current[pos] #선택된 독립변수를 flip
        run.vars = baseball.sub[,run.step==1] #flip 된 변수 적용
        g = lm(salary.log~.,run.vars)
        run.step.aic = extractAIC(g)[2]
        p = min(1,exp((run.aic-extractAIC(g)[2])/tau[j]))
        if(run.step.aic < run.aic){
            run.current = run.step
            run.aic = run.step.aic}
        if(rbinom(1,1,p)){ #만약 run.step.aic 가 run.aic 보다 크다면 p 의 확률로
run.step 을 채택
            run.current = run.step
            run.aic = run.step.aic}
        if(run.step.aic < best.aic){
          #지금까지 나온 aic 중 제일 작다면 best aic 로 선택하고 best predictor s
ubset 으로 설정
            run = run.step
            best.aic = run.step.aic}
        aics = c(aics,run.aic)
    }
}

## OUTPUT
run         # BEST LIST OF PREDICTORS FOUND

##  [1] 0 0 1 0 0 1 0 1 0 1 1 1 1 1 0 0 0 0 0 1 1 1 0 0 0 0 0
```

```
best.aic    # AIC VALUE
```

```
## [1] -416.214
```

```
## PLOT OF AIC VALUES
plot(aics,ylim=c(-420,-360),type="n",ylab="AIC", xlab="Iteration")
lines(aics)
```

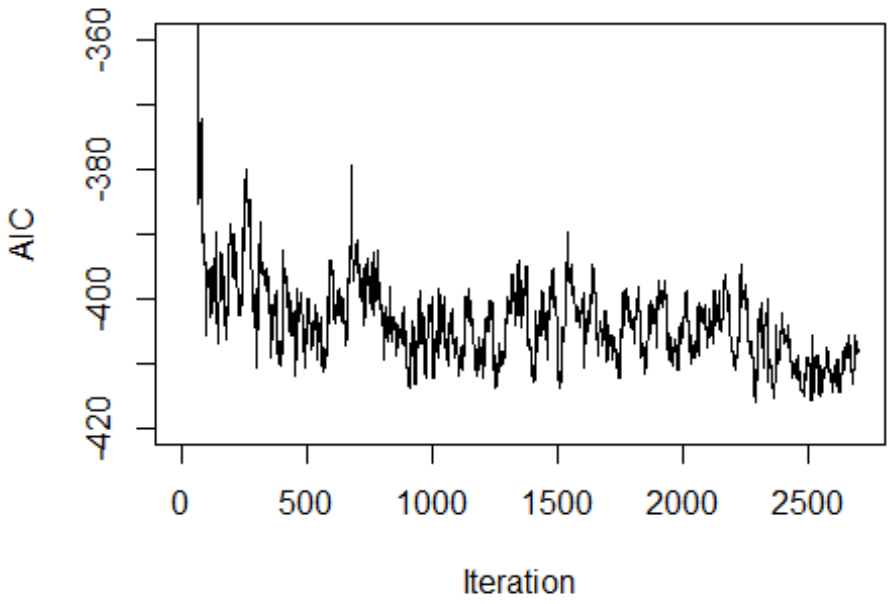



```
(1:2001)[aics==min(aics)]
```

```
## [1] 1965
```

```
##3-3(a)
#우선 cooling schedule 에서 횟수들을 올려보자.
baseball.dat = read.table('baseball.dat',header=TRUE)
baseball.dat$freeagent = factor(baseball.dat$freeagent)
baseball.dat$arbitration = factor(baseball.dat$arbitration)
baseball.sub = baseball.dat[,-1]
salary.log = log(baseball.dat$salary)
n = length(salary.log)
m = length(baseball.sub[1,])
cooling2 = c(rep(100,5),rep(160,5),rep(280,5)) #cooling schedule
tau.start = 10 #시작 온도
tau = rep(tau.start,15)
aics2 = NULL
```

```r
set.seed(1234)
run2 = rbinom(m,1,.5)
run.current = run2
run.vars = baseball.sub[,run.current==1]
g = lm(salary.log~.,run.vars)
run.aic = extractAIC(g)[2]
best.aic2 = run.aic
aics2 = run.aic
for(j in 2:15){tau[j] = 0.9*tau[j-1]}

for(j in 1:15){

  for(i in 1:cooling2[j]){
    pos = sample(1:m,1)
    run.step = run.current
    run.step[pos] = !run.current[pos]
    run.vars = baseball.sub[,run.step==1]
    g = lm(salary.log~.,run.vars)
    run.step.aic = extractAIC(g)[2]
    p = min(1,exp((run.aic-extractAIC(g)[2])/tau[j]))
    if(run.step.aic < run.aic){
      run.current = run.step
      run.aic = run.step.aic}
    if(rbinom(1,1,p)){
      run.current = run.step
      run.aic = run.step.aic}
    if(run.step.aic < best.aic2){
      run2 = run.step
      best.aic2 = run.step.aic}
    aics2 = c(aics2,run.aic)
  }
}

## OUTPUT
run2        # BEST LIST OF PREDICTORS FOUND

##  [1] 0 0 1 0 0 1 0 1 0 1 0 0 1 1 1 1 1 0 0 1 0 1 0 1 1 1 0

best.aic2   # AIC VALUE

## [1] -416.0132

## PLOT OF AIC VALUES
plot(aics2,ylim=c(-420,-360),type="n",ylab="AIC", xlab="Iteration")
lines(aics2)
```



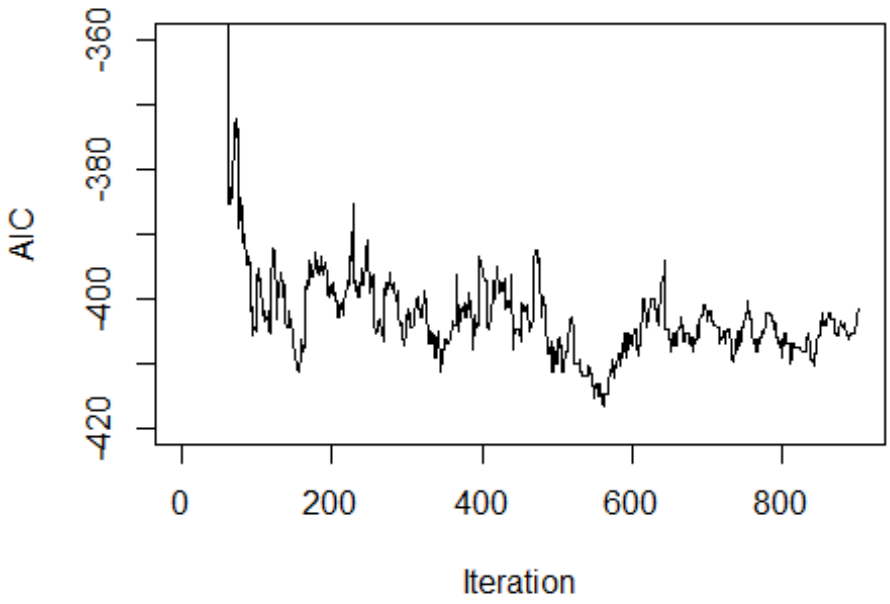
➔ 진동이 훨씬 촘촘해졌음을 알 수 있다.

```
(1:2701)[aics2==min(aics2)]
```

```
## [1] 2287 2288
```

```
#이번에는 cooling schedule 의 횟수를 낮춰보자.
baseball.dat = read.table('baseball.dat',header=TRUE)
baseball.dat$freeagent = factor(baseball.dat$freeagent)
baseball.dat$arbitration = factor(baseball.dat$arbitration)
baseball.sub = baseball.dat[,-1]
salary.log = log(baseball.dat$salary)
n = length(salary.log)
m = length(baseball.sub[1,])
cooling3 = c(rep(40,5),rep(60,5),rep(80,5)) #cooling schedule
tau.start = 10 #시작 온도
tau = rep(tau.start,15)
aics3 = NULL

set.seed(1234)
run3 = rbinom(m,1,.5)
run.current = run3
run.vars = baseball.sub[,run.current==1]
g = lm(salary.log~.,run.vars)
run.aic = extractAIC(g)[2]
```

```r
best.aic3 = run.aic
aics3 = run.aic
for(j in 2:15){tau[j] = 0.9*tau[j-1]}

for(j in 1:15){

  for(i in 1:cooling3[j]){
    pos = sample(1:m,1)
    run.step = run.current
    run.step[pos] = !run.current[pos]
    run.vars = baseball.sub[,run.step==1]
    g = lm(salary.log~.,run.vars)
    run.step.aic = extractAIC(g)[2]
    p = min(1,exp((run.aic-extractAIC(g)[2])/tau[j]))
    if(run.step.aic < run.aic){
      run.current = run.step
      run.aic = run.step.aic}
    if(rbinom(1,1,p)){
      run.current = run.step
      run.aic = run.step.aic}
    if(run.step.aic < best.aic3){
      run3 = run.step
      best.aic3 = run.step.aic}
    aics3 = c(aics3,run.aic)
  }
}

## OUTPUT
run3        # BEST LIST OF PREDICTORS FOUND

##  [1] 1 0 1 0 0 0 0 1 0 1 1 0 1 1 1 1 1 1 0 0 0 0 0 1 1 1 0

best.aic3   # AIC VALUE

## [1] -416.5059

## PLOT OF AIC VALUES
plot(aics3,ylim=c(-420,-360),type="n",ylab="AIC", xlab="Iteration")
lines(aics3)
```



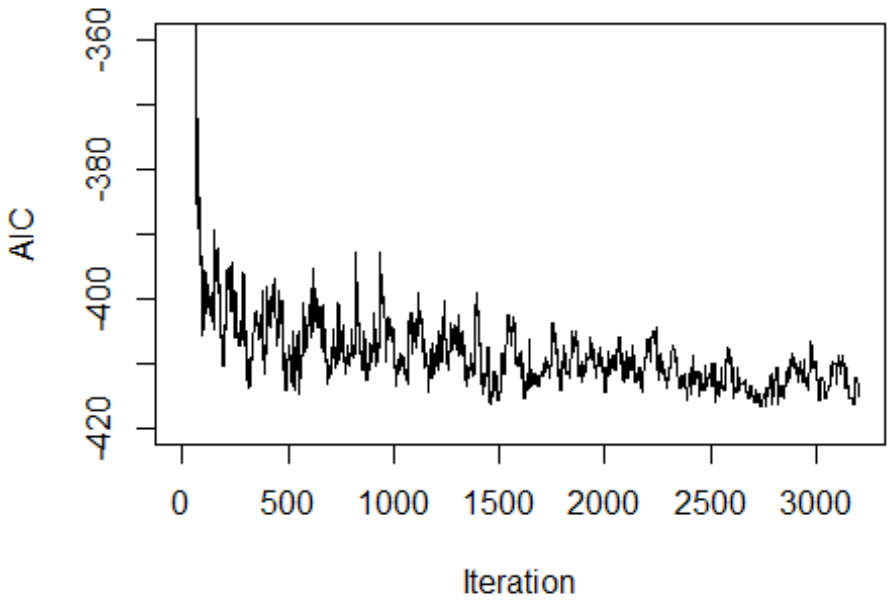
➔ 횟수가 줄어든 만큼, 간격이 더욱 듬성듬성하다는 것을 알 수 있다.

```
(1:901)[aics3==min(aics3)]
```

```
## [1] 561 562
```

```
#duration 을 높여보자.
baseball.dat = read.table('baseball.dat',header=TRUE)
baseball.dat$freeagent = factor(baseball.dat$freeagent)
baseball.dat$arbitration = factor(baseball.dat$arbitration)
baseball.sub = baseball.dat[,-1]
salary.log = log(baseball.dat$salary)
n = length(salary.log)
m = length(baseball.sub[1,])
cooling4 = c(rep(60,8),rep(120,8),rep(220,8)) #cooling schedule
tau.start = 10
tau = rep(tau.start,24)
aics4 = NULL

set.seed(1234)
run4 = rbinom(m,1,.5)
run.current = run4
run.vars = baseball.sub[,run.current==1]
g = lm(salary.log~.,run.vars)
run.aic = extractAIC(g)[2]
```

```r
best.aic4 = run.aic
aics4 = run.aic
for(j in 2:24){tau[j] = 0.9*tau[j-1]}

for(j in 1:24){

  for(i in 1:cooling4[j]){
    pos = sample(1:m,1)
    run.step = run.current
    run.step[pos] = !run.current[pos]
    run.vars = baseball.sub[,run.step==1]
    g = lm(salary.log~.,run.vars)
    run.step.aic = extractAIC(g)[2]
    p = min(1,exp((run.aic-extractAIC(g)[2])/tau[j]))
    if(run.step.aic < run.aic){
      run.current = run.step
      run.aic = run.step.aic}
    if(rbinom(1,1,p)){
      run.current = run.step
      run.aic = run.step.aic}
    if(run.step.aic < best.aic4){
      run4 = run.step
      best.aic4 = run.step.aic}
    aics4 = c(aics4,run.aic)
  }
}

## OUTPUT
run4        # BEST LIST OF PREDICTORS FOUND

##  [1] 0 1 1 0 0 0 0 1 0 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 1 0

best.aic4   # AIC VALUE

## [1] -416.4663

## PLOT OF AIC VALUES
plot(aics4,ylim=c(-420,-360),type="n",ylab="AIC", xlab="Iteration")
lines(aics4)
```



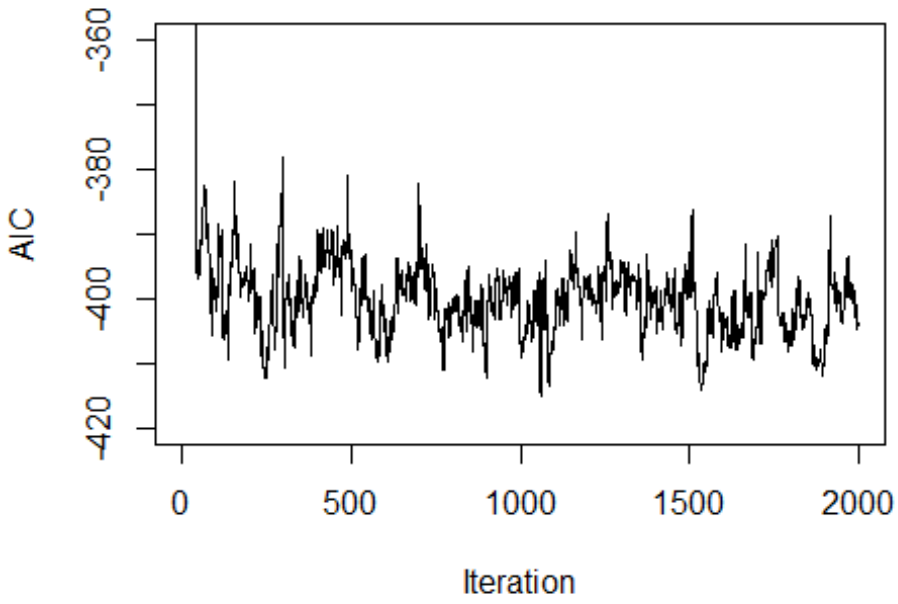
➔ 간격은 촘촘해졌지만 진동의 폭은 비교적 크지 않다는 것을 알 수 있다.

```
(1:3201)[aics4==min(aics4)]
```

```
## [1] 2732 2733 2744 2745 2746 2747 2748 2760 2761
```

```
#시작 온도를 높여보자.
baseball.dat = read.table('baseball.dat',header=TRUE)
baseball.dat$freeagent = factor(baseball.dat$freeagent)
baseball.dat$arbitration = factor(baseball.dat$arbitration)
baseball.sub = baseball.dat[,-1]
salary.log = log(baseball.dat$salary)
n = length(salary.log)
m = length(baseball.sub[1,])
cooling = c(rep(60,5),rep(120,5),rep(220,5)) #cooling schedule
tau.start = 20 #10 --> 20
tau = rep(tau.start,15)
aics5 = NULL

set.seed(1234)
run5 = rbinom(m,1,.5)
run.current = run5
run.vars = baseball.sub[,run.current==1]
g = lm(salary.log~.,run.vars)
run.aic = extractAIC(g)[2]
```

```r
best.aic5 = run.aic
aics5 = run.aic
for(j in 2:15){tau[j] = 0.9*tau[j-1]}

for(j in 1:15){

  for(i in 1:cooling[j]){
    pos = sample(1:m,1)
    run.step = run.current
    run.step[pos] = !run.current[pos]
    run.vars = baseball.sub[,run.step==1]
    g = lm(salary.log~.,run.vars)
    run.step.aic = extractAIC(g)[2]
    p = min(1,exp((run.aic-extractAIC(g)[2])/tau[j]))
    if(run.step.aic < run.aic){
      run.current = run.step
      run.aic = run.step.aic}
    if(rbinom(1,1,p)){
      run.current = run.step
      run.aic = run.step.aic}
    if(run.step.aic < best.aic5){
      run5 = run.step
      best.aic5 = run.step.aic}
    aics5 = c(aics5,run.aic)
  }
}

## OUTPUT
run5        # BEST LIST OF PREDICTORS FOUND

##  [1] 0 1 1 0 0 0 0 1 1 1 0 1 1 1 1 1 0 1 0 0 0 0 0 0 1 1 0

best.aic5   # AIC VALUE

## [1] -415.0361

## PLOT OF AIC VALUES
plot(aics5,ylim=c(-420,-360),type="n",ylab="AIC", xlab="Iteration")
lines(aics5)
```



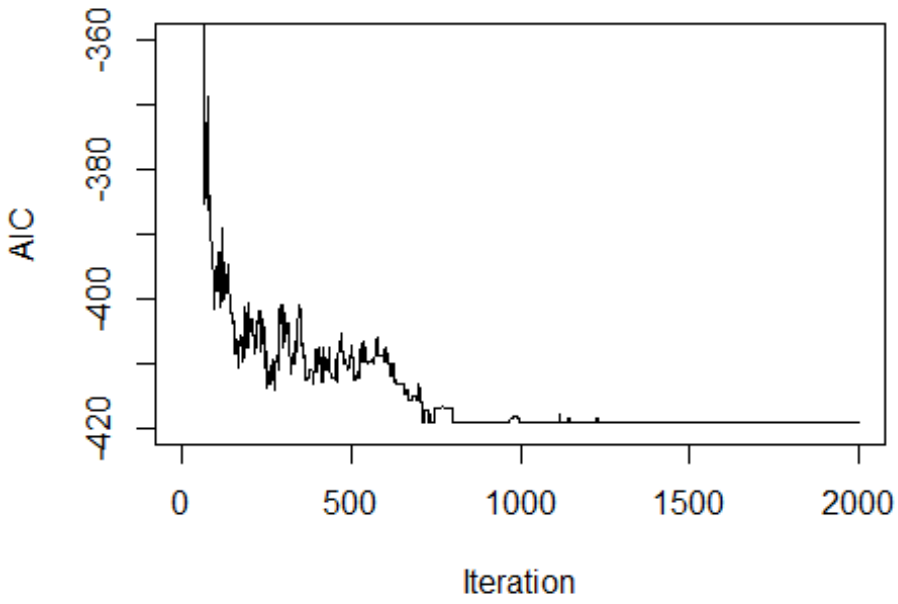
➔ 진동의 폭이 크다는 것을 알 수 있다.

```
(1:2001)[aics5==min(aics5)]
```

```
## [1] 1060
```

```
#온도의 강하율을 높여보자.
baseball.dat = read.table('baseball.dat',header=TRUE)
baseball.dat$freeagent = factor(baseball.dat$freeagent)
baseball.dat$arbitration = factor(baseball.dat$arbitration)
baseball.sub = baseball.dat[,-1]
salary.log = log(baseball.dat$salary)
n = length(salary.log)
m = length(baseball.sub[1,])
cooling = c(rep(60,5),rep(120,5),rep(220,5)) #cooling schedule
tau.start = 10
tau = rep(tau.start,15)
aics6 = NULL

set.seed(1234)
run6 = rbinom(m,1,.5)
run.current = run6
run.vars = baseball.sub[,run.current==1]
g = lm(salary.log~.,run.vars)
run.aic = extractAIC(g)[2]
```

```r
best.aic6 = run.aic
aics6 = run.aic
for(j in 2:15){tau[j] = 0.7*tau[j-1]} #0.9 에서 0.7 로 변경

for(j in 1:15){

  for(i in 1:cooling[j]){
    pos = sample(1:m,1)
    run.step = run.current
    run.step[pos] = !run.current[pos]
    run.vars = baseball.sub[,run.step==1]
    g = lm(salary.log~.,run.vars)
    run.step.aic = extractAIC(g)[2]
    p = min(1,exp((run.aic-extractAIC(g)[2])/tau[j]))
    if(run.step.aic < run.aic){
      run.current = run.step
      run.aic = run.step.aic}
    if(rbinom(1,1,p)){
      run.current = run.step
      run.aic = run.step.aic}
    if(run.step.aic < best.aic6){
      run6 = run.step
      best.aic6 = run.step.aic}
    aics6 = c(aics6,run.aic)
  }
}

## OUTPUT
run6        # BEST LIST OF PREDICTORS FOUND

##  [1] 0 1 1 0 0 1 0 1 0 1 0 0 1 1 1 1 0 0 0 0 0 0 0 1 1 1 0

best.aic6   # AIC VALUE

## [1] -418.9472

## PLOT OF AIC VALUES
plot(aics6,ylim=c(-420,-360),type="n",ylab="AIC", xlab="Iteration")
lines(aics6)
```



➔ 기준 온도가 갈수록 급격하게 떨어지기 때문에 추후에는

➔ `exp((run.aic-extractAIC(g)[2])/tau[j])`가 매우 크게 나와 무조건 `p=1` 이 선택되게 된다.

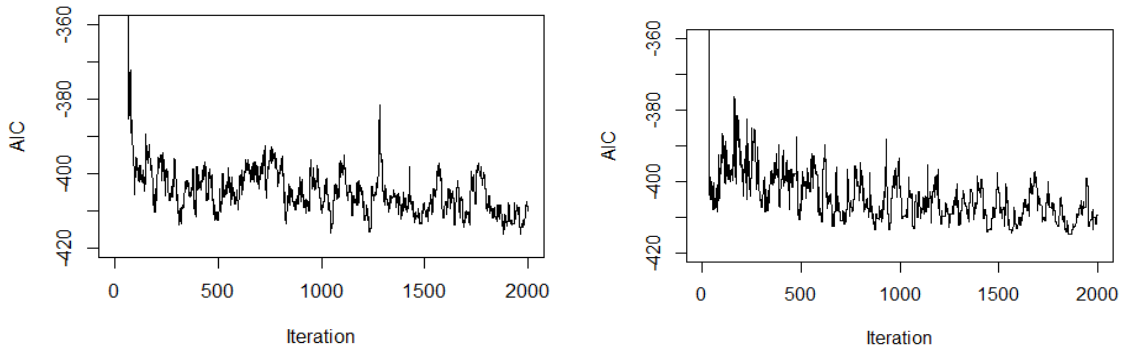
```
(1:2001)[aics6==min(aics6)]
```

```
## [1] 712 713 714 715 716 717 726 727
```

```
##3-3(b)
#2-neighborhood
baseball.dat = read.table('baseball.dat',header=TRUE)
baseball.dat$freeagent = factor(baseball.dat$freeagent)
baseball.dat$arbitration = factor(baseball.dat$arbitration)
baseball.sub = baseball.dat[,-1]
salary.log = log(baseball.dat$salary)
n = length(salary.log)
m = length(baseball.sub[1,])
cooling = c(rep(60,5),rep(120,5),rep(220,5)) #cooling schedule
tau.start = 10 #시작 온도
tau = rep(tau.start,15)
aics7 = NULL
```

```r
# INITIALIZES STARTING RUN, TEMPERATURE SCHEDULE(이부분은 동일)
set.seed(1234)
run7 = rbinom(m,1,.5)
run.current = run7
run.vars = baseball.sub[,run.current==1]
g = lm(salary.log~.,run.vars)
run.aic = extractAIC(g)[2]
best.aic7 = run.aic
aics7 = run.aic
for(j in 2:15){tau[j] = 0.9*tau[j-1]}


## MAIN
for(j in 1:15){

  for(i in 1:cooling[j]){
    pos = sample(1:m,2) #독립변수 중 두 개를 랜덤으로 선택
    run.step = run.current
    run.step[pos] = !run.current[pos] #선택된 독립변수를 flip
    run.vars = baseball.sub[,run.step==1] #flip 된 변수 적용
    g = lm(salary.log~.,run.vars)
    run.step.aic = extractAIC(g)[2]
    p = min(1,exp((run.aic-extractAIC(g)[2])/tau[j]))
    if(run.step.aic < run.aic){
      run.current = run.step
      run.aic = run.step.aic}
    if(rbinom(1,1,p)){
      run.current = run.step
      run.aic = run.step.aic}
    if(run.step.aic < best.aic7){
      run7 = run.step
      best.aic7 = run.step.aic}
    aics7 = c(aics7,run.aic)
  }
}

## OUTPUT
run7        # BEST LIST OF PREDICTORS FOUND

##  [1] 0 1 1 0 0 1 0 1 0 1 0 1 1 1 1 1 0 0 0 1 0 0 0 0 1 0 1

best.aic7   # AIC VALUE

## [1] -414.8066
```

```
## PLOT OF AIC VALUES
plot(aics7,ylim=c(-420,-360),type="n",ylab="AIC", xlab="Iteration")
lines(aics7)
```



➔ 왼쪽이 1-neighborhood, 오른쪽이 2-neighborhood

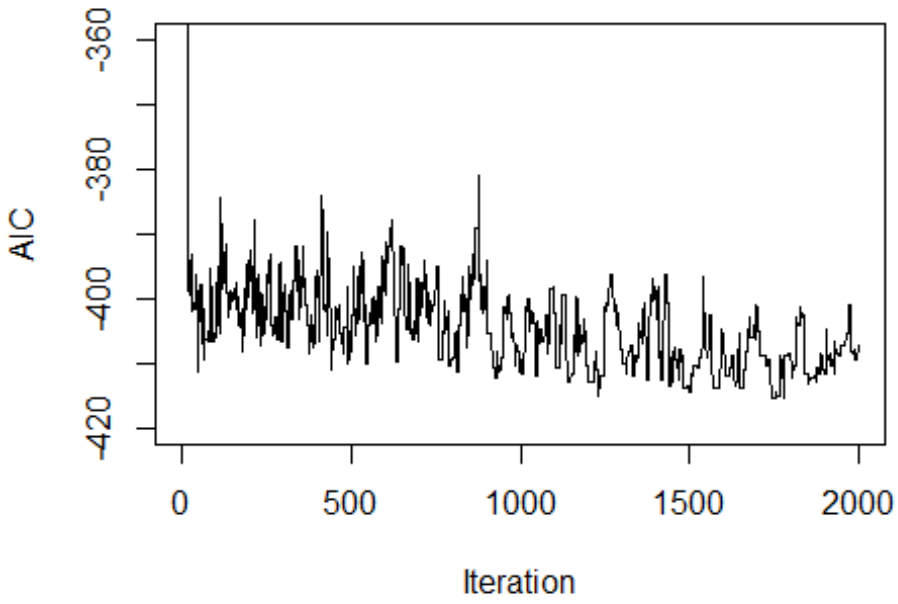
➔ 2-neighborhood 의 경우가 조금 더 진동이 안정적으로 나타나는 모습이다.

```
(1:2001)[aics7==min(aics7)]
```

```
##  [1] 1852 1853 1854 1855 1856 1857 1858 1859 1860 1861 1862 1863 1864 1865
 1866
## [16] 1867 1868 1869 1870 1871 1872 1873
```

```
#3-neighborhood
baseball.dat = read.table('baseball.dat',header=TRUE)
baseball.dat$freeagent = factor(baseball.dat$freeagent)
baseball.dat$arbitration = factor(baseball.dat$arbitration)
baseball.sub = baseball.dat[,-1]
salary.log = log(baseball.dat$salary)
n = length(salary.log)
m = length(baseball.sub[1,])
cooling = c(rep(60,5),rep(120,5),rep(220,5)) #cooling schedule
tau.start = 10 #시작 온도
tau = rep(tau.start,15)
aics8 = NULL


# INITIALIZES STARTING RUN, TEMPERATURE SCHEDULE(이부분은 동일)
set.seed(1234)
run8 = rbinom(m,1,.5)
run.current = run8
run.vars = baseball.sub[,run.current==1]
g = lm(salary.log~.,run.vars)
```

```
run.aic = extractAIC(g)[2]
best.aic8 = run.aic
aics8 = run.aic
for(j in 2:15){tau[j] = 0.9*tau[j-1]}


## MAIN
for(j in 1:15){

  for(i in 1:cooling[j]){
    pos = sample(1:m,3) #독립변수 중 세 개를 랜덤으로 선택
    run.step = run.current
    run.step[pos] = !run.current[pos] #선택된 독립변수를 flip
    run.vars = baseball.sub[,run.step==1] #flip 된 변수 적용
    g = lm(salary.log~.,run.vars)
    run.step.aic = extractAIC(g)[2]
    p = min(1,exp((run.aic-extractAIC(g)[2])/tau[j]))
    if(run.step.aic < run.aic){
      run.current = run.step
      run.aic = run.step.aic}
    if(rbinom(1,1,p)){
      run.current = run.step
      run.aic = run.step.aic}
    if(run.step.aic < best.aic8){
      run8 = run.step
      best.aic8 = run.step.aic}
    aics8 = c(aics8,run.aic)
  }
}

## OUTPUT
run8        # BEST LIST OF PREDICTORS FOUND

##  [1] 0 1 1 0 0 1 0 1 1 1 0 0 1 1 1 1 1 0 0 1 0 0 0 1 1 1 0

best.aic8   # AIC VALUE

## [1] -415.3731

## PLOT OF AIC VALUES
plot(aics8,ylim=c(-420,-360),type="n",ylab="AIC", xlab="Iteration")
lines(aics8)
```



➔ Best.aic 가 2-neighborhood 때보다 약간 더 좋지만 매우 미미한 수준.

➔ 많은 차이는 모이지 않는다.

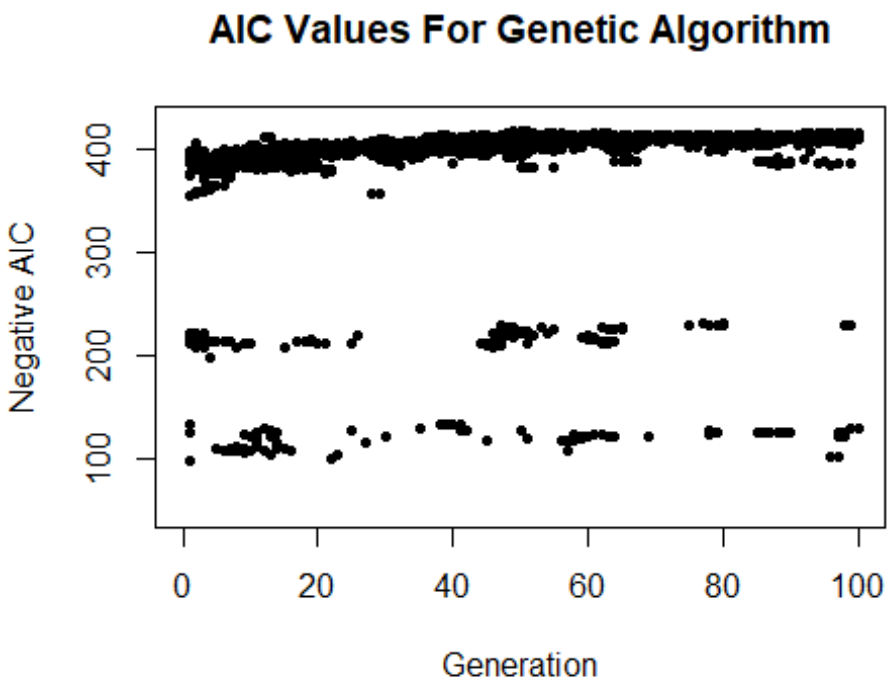
```
(1:2001)[aics8==min(aics8)]
```

```
##  [1] 1742 1743 1744 1745 1746 1747 1748 1749 1750 1751 1752 1753 1754
```

```
#############################################################################
### 3.4
#############################################################################
## INITIAL VALUES
baseball.dat = read.table('baseball.dat',header=TRUE)
baseball.dat$freeagent = factor(baseball.dat$freeagent)
baseball.dat$arbitration = factor(baseball.dat$arbitration)
baseball.sub = baseball.dat[,-1]
salary.log = log(baseball.dat$salary)
n = length(salary.log)
m = length(baseball.sub[1,])
P = 20 #각 generation 의 크기
itr = 100 #generation 을 몇 번 돌릴 것인지
```

```r
m.rate = .01 #mutation rate
r = matrix(0,P,1) #Generation 의 AIC rank
phi = matrix(0,P,1)#Generation 의 fitness values
runs = matrix(0,P,m)
runs.next = matrix(0,P,m)
runs.aic = matrix(0,P,1)
aics = matrix(0,P,itr)
run = NULL
best.aic = 0
best.aic.gen = rep(0,itr)

#Starting generation 설정, FITNESS VALUES
set.seed(1234)
for(i in 1:P){
    runs[i,] = rbinom(m,1,.5) #random 으로 variable selection
    run.vars = baseball.sub[,runs[i,]==1]
    g = lm(salary.log~.,run.vars)
    runs.aic[i] = extractAIC(g)[2]
    aics[i,1] = runs.aic[i]
    if(runs.aic[i] < best.aic){
        run = runs[i,]
        best.aic = runs.aic[i]
    }
}

r = rank(-runs.aic) #starting genertation 의 aic 에 rank 를 매겨주자.
phi = 2*r/(P*(P+1)) #rank 를 이용하여 fitness value 구해줌.
best.aic.gen[1]=best.aic #starting genertation 의 best.aic 값.


## MAIN
for(j in 1:itr-1){

    # Generation 을 이어가자. 부모 중 첫 번째는 Fitness value 를 기준으로 좋은 것을 뽑고
    # 두 번째는 완전히 랜덤으로 뽑는다.
    for(i in 1:10){
      p1 = sample(1:P,1,prob=phi)
      parent.1 = runs[p1,]
      parent.2 = runs[sample(c(1:P)[-p1],1),] #중복이 되지 않도록 하자.
        pos = sample(1:(m-1),1) #분리가 되는 지점을 정해주자.
        mutate = rbinom(m,1,m.rate) #mutation rate 에 기반해서 돌연변이가 일어나
```

```
는 변수를 선택
        runs.next[i,] = c(parent.1[1:pos],parent.2[(pos+1):m]) #다음 세대 앞 부분(돌연변이 적용 전)
        runs.next[i,] = (runs.next[i,]+mutate)%%2 #다음 세대 앞 부분(돌연변이 적용)
        mutate = rbinom(m,1,m.rate)
        runs.next[P+1-i,] = c(parent.2[1:pos],parent.1[(pos+1):m]) #다음 세대 뒷 부분(돌연변이 적용 전)
        runs.next[P+1-i,] = (runs.next[P+1-i,]+mutate)%%2 #다음 세대 뒷 부분(돌연변이 적용)
    }
    runs = runs.next

    # New generation 에서의 aic 와 fitness value 업데이트.
    for(i in 1:P){
        run.vars = baseball.sub[,runs[i,]==1]
        g = lm(salary.log~.,run.vars)
        runs.aic[i] = extractAIC(g)[2]
        aics[i,j+1] = runs.aic[i]
        if(runs.aic[i] < best.aic){
            run = runs[i,]
            best.aic = runs.aic[i]
        }
    }
    best.aic.gen[j+1]=best.aic
    r = rank(-runs.aic)
    phi = 2*r/(P*(P+1))
}

## OUTPUT
run         # BEST LIST OF PREDICTORS FOUND

##  [1] 0 0 1 0 0 1 0 1 0 1 0 0 1 1 1 1 0 0 0 1 0 0 0 1 1 1 0

best.aic    # AIC VALUE

## [1] -416.8813

## PLOT OF AIC VALUES
plot(-aics,xlim=c(0,itr),ylim=c(50,425),type="n",ylab="Negative AIC",
    xlab="Generation",main="AIC Values For Genetic Algorithm")
for(i in 1:itr){points(rep(i,P),-aics[,i],pch=20)}
```




```r
##3-4(a)
#mutation rates 를 조금 높게 설정해보자.
baseball.dat = read.table('baseball.dat',header=TRUE)
baseball.dat$freeagent = factor(baseball.dat$freeagent)
baseball.dat$arbitration = factor(baseball.dat$arbitration)
baseball.sub = baseball.dat[,-1]
salary.log = log(baseball.dat$salary)
n = length(salary.log)
m = length(baseball.sub[1,])
P = 20
itr = 100
m.rate = .1 #mutation rate 0.01 --> 0.1
r = matrix(0,P,1)
phi = matrix(0,P,1)
runs = matrix(0,P,m)
runs.next = matrix(0,P,m)
runs.aic = matrix(0,P,1)
aics = matrix(0,P,itr)
run = NULL
best.aic = 0
best.aic.gen = rep(0,itr)

set.seed(1234)
for(i in 1:P){
  runs[i,] = rbinom(m,1,.5)
```

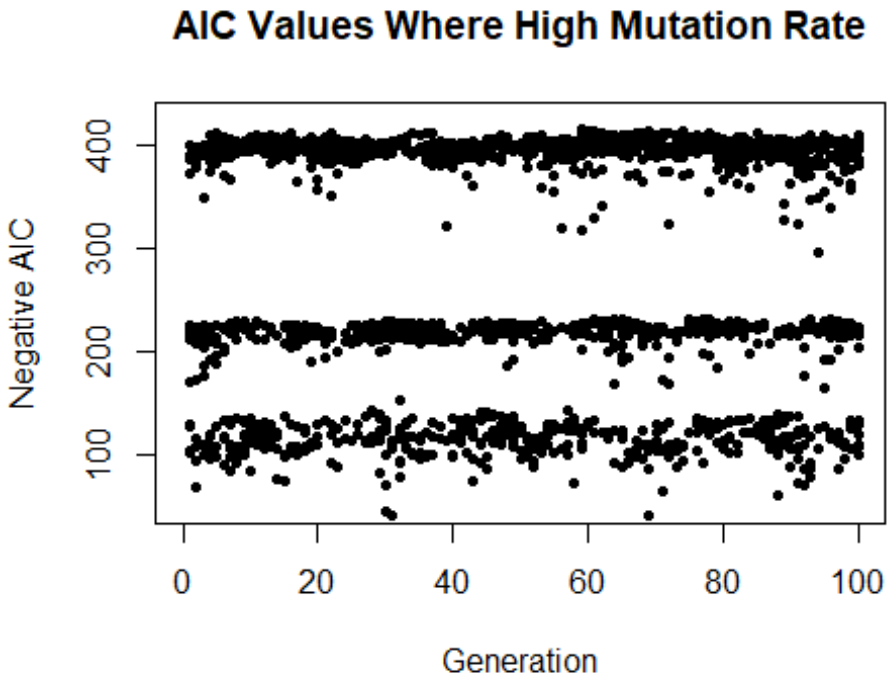
```
  run.vars = baseball.sub[,runs[i,]==1]
  g = lm(salary.log~.,run.vars)
  runs.aic[i] = extractAIC(g)[2]
  aics[i,1] = runs.aic[i]
  if(runs.aic[i] < best.aic){
    run = runs[i,]
    best.aic = runs.aic[i]
  }
}

r = rank(-runs.aic)
phi = 2*r/(P*(P+1))
best.aic.gen[1]=best.aic


for(j in 1:itr-1){

  for(i in 1:10){
    p1 = sample(1:P,1,prob=phi)
    parent.1 = runs[p1,]
    parent.2 = runs[sample(c(1:P)[-p1],1),]
    pos = sample(1:(m-1),1)
    mutate = rbinom(m,1,m.rate)
    runs.next[i,] = c(parent.1[1:pos],parent.2[(pos+1):m])
    runs.next[i,] = (runs.next[i,]+mutate)%%2
    mutate = rbinom(m,1,m.rate)
    runs.next[P+1-i,] = c(parent.2[1:pos],parent.1[(pos+1):m])
    runs.next[P+1-i,] = (runs.next[P+1-i,]+mutate)%%2
  }
  runs = runs.next

  for(i in 1:P){
    run.vars = baseball.sub[,runs[i,]==1]
    g = lm(salary.log~.,run.vars)
    runs.aic[i] = extractAIC(g)[2]
    aics[i,j+1] = runs.aic[i]
    if(runs.aic[i] < best.aic){
      run = runs[i,]
      best.aic = runs.aic[i]
    }
  }
  best.aic.gen[j+1]=best.aic
  r = rank(-runs.aic)
  phi = 2*r/(P*(P+1))
}

## OUTPUT
run
```

```
##  [1] 1 1 1 0 0 0 0 1 0 1 0 1 1 1 1 1 0 0 0 1 0 0 0 0 1 1 0
```

```
best.aic
```

```
## [1] -414.2821
```

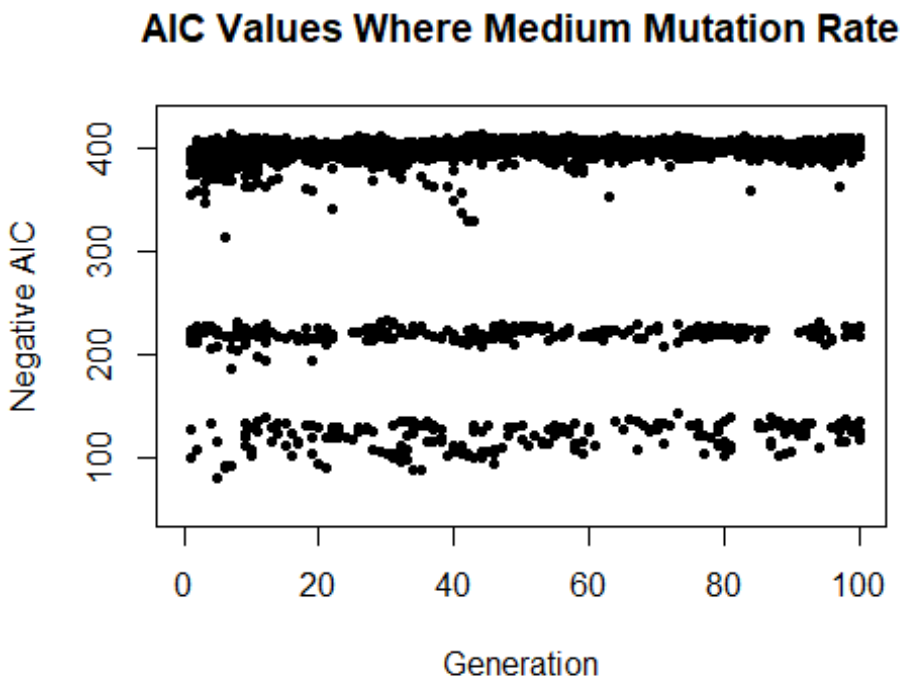
```
## PLOT OF AIC VALUES
plot(-aics,xlim=c(0,itr),ylim=c(50,425),type="n",ylab="Negative AIC",
     xlab="Generation",main="AIC Values Where High Mutation Rate")
for(i in 1:itr){points(rep(i,P),-aics[,i],pch=20)}
```

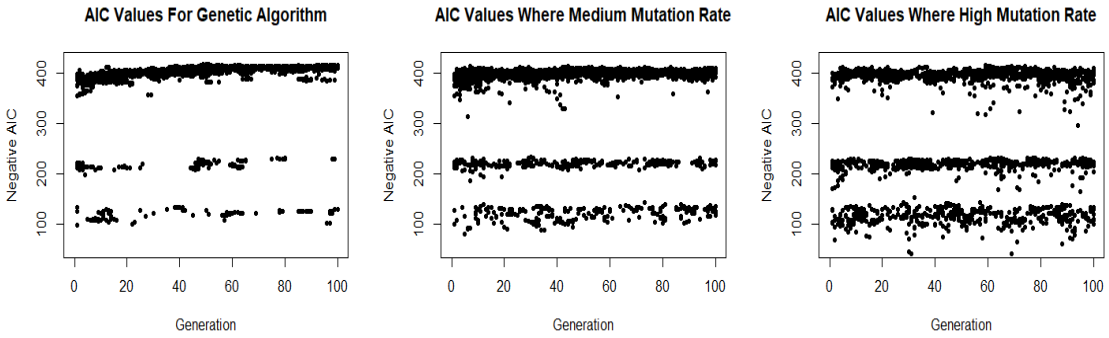



```
#이번에는 그 중간으로 설정
baseball.dat = read.table('baseball.dat',header=TRUE)
baseball.dat$freeagent = factor(baseball.dat$freeagent)
baseball.dat$arbitration = factor(baseball.dat$arbitration)
baseball.sub = baseball.dat[,-1]
salary.log = log(baseball.dat$salary)
n = length(salary.log)
m = length(baseball.sub[1,])
P = 20
itr = 100
m.rate = .05 #mutation rate 0.01 --> 0.05
r = matrix(0,P,1)
phi = matrix(0,P,1)
runs = matrix(0,P,m)
runs.next = matrix(0,P,m)
```

```
runs.aic = matrix(0,P,1)
aics = matrix(0,P,itr)
run = NULL
best.aic = 0
best.aic.gen = rep(0,itr)

set.seed(1234)
for(i in 1:P){
  runs[i,] = rbinom(m,1,.5)
  run.vars = baseball.sub[,runs[i,]==1]
  g = lm(salary.log~.,run.vars)
  runs.aic[i] = extractAIC(g)[2]
  aics[i,1] = runs.aic[i]
  if(runs.aic[i] < best.aic){
    run = runs[i,]
    best.aic = runs.aic[i]
  }
}

r = rank(-runs.aic)
phi = 2*r/(P*(P+1))
best.aic.gen[1]=best.aic


for(j in 1:itr-1){

  for(i in 1:10){
    p1 = sample(1:P,1,prob=phi)
    parent.1 = runs[p1,]
    parent.2 = runs[sample(c(1:P)[-p1],1),]
    pos = sample(1:(m-1),1)
    mutate = rbinom(m,1,m.rate)
    runs.next[i,] = c(parent.1[1:pos],parent.2[(pos+1):m])
    runs.next[i,] = (runs.next[i,]+mutate)%%2
    mutate = rbinom(m,1,m.rate)
    runs.next[P+1-i,] = c(parent.2[1:pos],parent.1[(pos+1):m])
    runs.next[P+1-i,] = (runs.next[P+1-i,]+mutate)%%2
  }
  runs = runs.next

  for(i in 1:P){
    run.vars = baseball.sub[,runs[i,]==1]
    g = lm(salary.log~.,run.vars)
    runs.aic[i] = extractAIC(g)[2]
    aics[i,j+1] = runs.aic[i]
    if(runs.aic[i] < best.aic){
      run = runs[i,]
      best.aic = runs.aic[i]
```

```
    }
  }
  best.aic.gen[j+1]=best.aic
  r = rank(-runs.aic)
  phi = 2*r/(P*(P+1))
}

## OUTPUT
run

##  [1] 0 1 1 1 0 0 0 1 1 1 0 0 1 1 1 1 0 0 0 1 0 0 1 1 1 1 0

best.aic

## [1] -412.5183

## PLOT OF AIC VALUES
plot(-aics,xlim=c(0,itr),ylim=c(50,425),type="n",ylab="Negative AIC",
     xlab="Generation",main="AIC Values Where Medium Mutation Rate")
for(i in 1:itr){points(rep(i,P),-aics[,i],pch=20)}
```





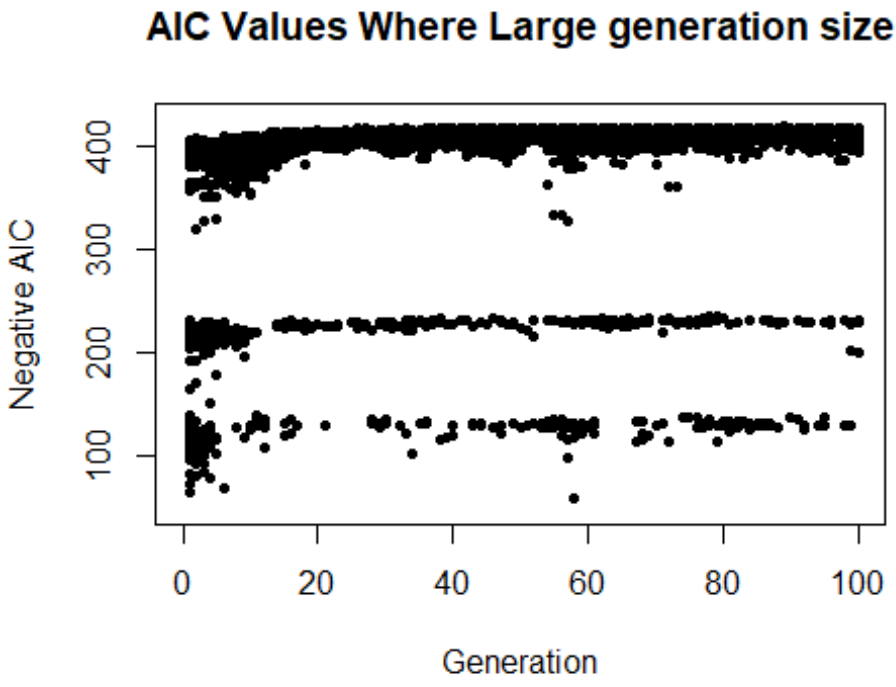
➔ Mutation rate 를 낮출수록 Converge 하고 높일수록 Diverge 하는 모습을 알 수 있다.

➔ 만약 local optimum 이 걱정된다면 mutation rate 를 조금 높이는 것이 방법이 될 수 있다.

```
##3-4(b)
#generation size 를 굉장히 크게 해보자.
baseball.dat = read.table('baseball.dat',header=TRUE)
baseball.dat$freeagent = factor(baseball.dat$freeagent)
baseball.dat$arbitration = factor(baseball.dat$arbitration)
baseball.sub = baseball.dat[,-1]
salary.log = log(baseball.dat$salary)
n = length(salary.log)
m = length(baseball.sub[1,])
P = 80
itr = 100
m.rate = .01
r = matrix(0,P,1)
phi = matrix(0,P,1)
runs = matrix(0,P,m)
runs.next = matrix(0,P,m)
runs.aic = matrix(0,P,1)
aics = matrix(0,P,itr)
run = NULL
best.aic = 0
best.aic.gen = rep(0,itr)

set.seed(1234)
for(i in 1:P){
  runs[i,] = rbinom(m,1,.5)
  run.vars = baseball.sub[,runs[i,]==1]
  g = lm(salary.log~.,run.vars)
  runs.aic[i] = extractAIC(g)[2]
  aics[i,1] = runs.aic[i]
```

```
  if(runs.aic[i] < best.aic){
    run = runs[i,]
    best.aic = runs.aic[i]
  }
}

r = rank(-runs.aic)
phi = 2*r/(P*(P+1))
best.aic.gen[1]=best.aic

for(j in 1:itr-1){

  for(i in 1:40){
    p1 = sample(1:P,1,prob=phi)
    parent.1 = runs[p1,]
    parent.2 = runs[sample(c(1:P)[-p1],1),]
    pos = sample(1:(m-1),1)
    mutate = rbinom(m,1,m.rate)
    runs.next[i,] = c(parent.1[1:pos],parent.2[(pos+1):m])
    runs.next[i,] = (runs.next[i,]+mutate)%%2
    mutate = rbinom(m,1,m.rate)
    runs.next[P+1-i,] = c(parent.2[1:pos],parent.1[(pos+1):m])
    runs.next[P+1-i,] = (runs.next[P+1-i,]+mutate)%%2
  }
  runs = runs.next

  for(i in 1:P){
    run.vars = baseball.sub[,runs[i,]==1]
    g = lm(salary.log~.,run.vars)
    runs.aic[i] = extractAIC(g)[2]
    aics[i,j+1] = runs.aic[i]
    if(runs.aic[i] < best.aic){
      run = runs[i,]
      best.aic = runs.aic[i]
    }
  }
  best.aic.gen[j+1]=best.aic
  r = rank(-runs.aic)
  phi = 2*r/(P*(P+1))
}

## OUTPUT
run

##  [1] 1 0 1 0 0 1 0 1 0 1 0 0 1 1 1 1 0 0 0 0 0 0 0 1 1 1 0

best.aic

## [1] -418.9421
```

```r
## PLOT OF AIC VALUES
plot(-aics,xlim=c(0,itr),ylim=c(50,425),type="n",ylab="Negative AIC",
     xlab="Generation",main="AIC Values Where Large generation size")
for(i in 1:itr){points(rep(i,P),-aics[,i],pch=20)}
```

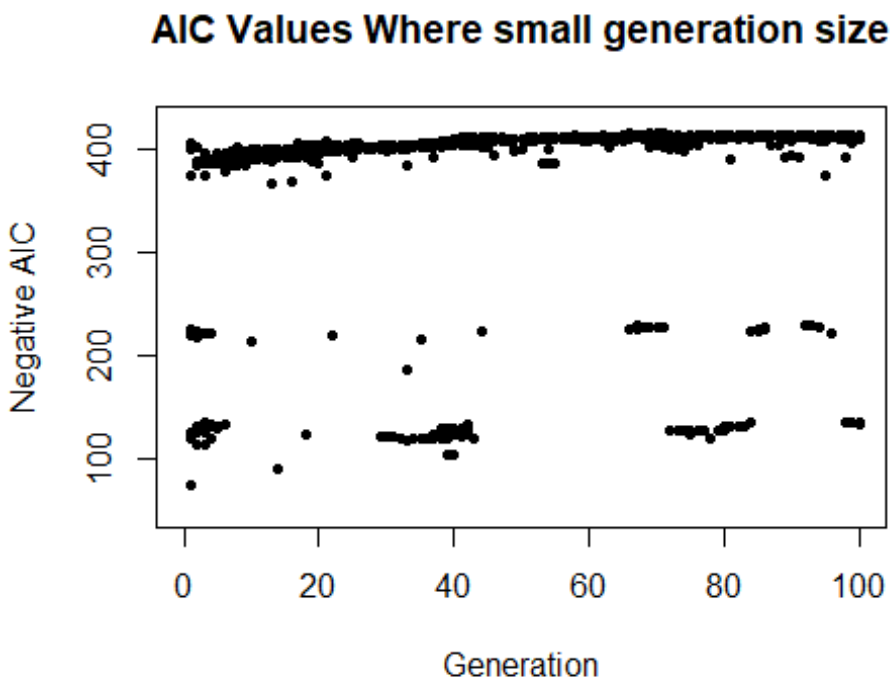


➔ 점의 수가 많아졌지만 전체적인 추이는 비슷하다.

```r
#generation size 를 굉장히 작게 해보자.
baseball.dat = read.table('baseball.dat',header=TRUE)
baseball.dat$freeagent = factor(baseball.dat$freeagent)
baseball.dat$arbitration = factor(baseball.dat$arbitration)
baseball.sub = baseball.dat[,-1]
salary.log = log(baseball.dat$salary)
n = length(salary.log)
m = length(baseball.sub[1,])
P = 8
itr = 100
m.rate = .01
r = matrix(0,P,1)
phi = matrix(0,P,1)
runs = matrix(0,P,m)
runs.next = matrix(0,P,m)
runs.aic = matrix(0,P,1)
aics = matrix(0,P,itr)
run = NULL
```

```
best.aic = 0
best.aic.gen = rep(0,itr)

set.seed(1234)
for(i in 1:P){
  runs[i,] = rbinom(m,1,.5)
  run.vars = baseball.sub[,runs[i,]==1]
  g = lm(salary.log~.,run.vars)
  runs.aic[i] = extractAIC(g)[2]
  aics[i,1] = runs.aic[i]
  if(runs.aic[i] < best.aic){
    run = runs[i,]
    best.aic = runs.aic[i]
  }
}

r = rank(-runs.aic)
phi = 2*r/(P*(P+1))
best.aic.gen[1]=best.aic


for(j in 1:itr-1){

  for(i in 1:4){
    p1 = sample(1:P,1,prob=phi)
    parent.1 = runs[p1,]
    parent.2 = runs[sample(c(1:P)[-p1],1),]
    pos = sample(1:(m-1),1)
    mutate = rbinom(m,1,m.rate)
    runs.next[i,] = c(parent.1[1:pos],parent.2[(pos+1):m])
    runs.next[i,] = (runs.next[i,]+mutate)%%2
    mutate = rbinom(m,1,m.rate)
    runs.next[P+1-i,] = c(parent.2[1:pos],parent.1[(pos+1):m])
    runs.next[P+1-i,] = (runs.next[P+1-i,]+mutate)%%2
  }
  runs = runs.next

  for(i in 1:P){
    run.vars = baseball.sub[,runs[i,]==1]
    g = lm(salary.log~.,run.vars)
    runs.aic[i] = extractAIC(g)[2]
    aics[i,j+1] = runs.aic[i]
    if(runs.aic[i] < best.aic){
      run = runs[i,]
      best.aic = runs.aic[i]
    }
  }
  best.aic.gen[j+1]=best.aic
```

```
  r = rank(-runs.aic)
  phi = 2*r/(P*(P+1))
}

## OUTPUT
run

##  [1] 0 1 1 0 0 0 0 1 0 1 0 0 1 1 1 1 1 0 0 0 0 0 0 1 0 0 0

best.aic

## [1] -414.7214

## PLOT OF AIC VALUES
plot(-aics,xlim=c(0,itr),ylim=c(50,425),type="n",ylab="Negative AIC",
     xlab="Generation",main="AIC Values Where small generation size")
for(i in 1:itr){points(rep(i,P),-aics[,i],pch=20)}
```

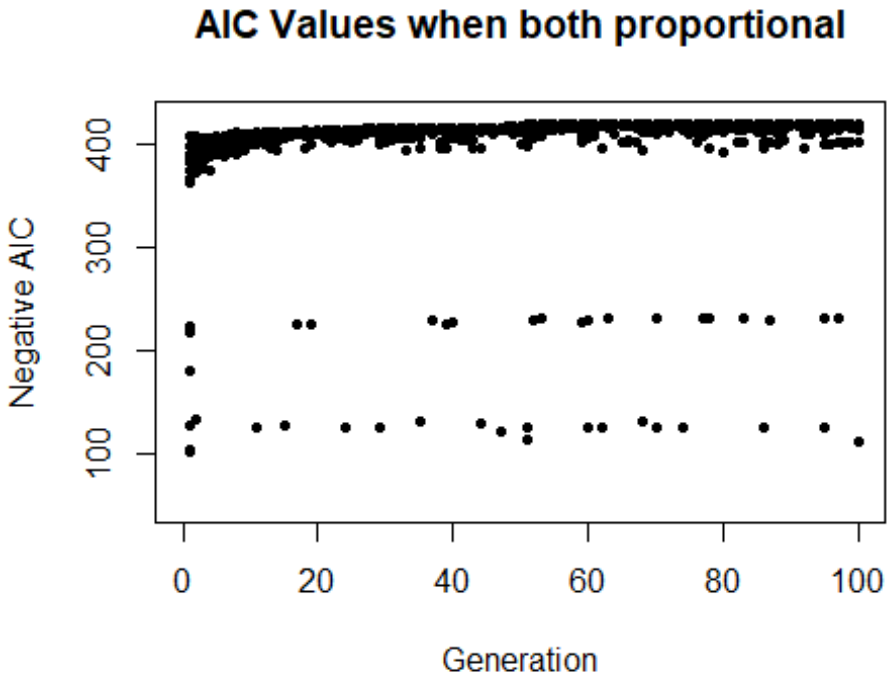


➔ 역시 수가 적어지기는 했지만, 전체적인 추이는 비슷하다는 것을 알 수 있다. 따라서 generation 수는 너무 많을 필요는 없고 신뢰성을 가질 수 있을 만큼 적절하게 조절하는 것이 좋다.

```
##3-4(c)
#i 는 위에서 했던 방식과 동일하다.
#ii
```

```r
baseball.dat = read.table('baseball.dat',header=TRUE)
baseball.dat$freeagent = factor(baseball.dat$freeagent)
baseball.dat$arbitration = factor(baseball.dat$arbitration)
baseball.sub = baseball.dat[,-1]
salary.log = log(baseball.dat$salary)
n = length(salary.log)
m = length(baseball.sub[1,])
P = 20
itr = 100
m.rate = .01
r = matrix(0,P,1)
phi = matrix(0,P,1)
runs = matrix(0,P,m)
runs.next = matrix(0,P,m)
runs.aic = matrix(0,P,1)
aics = matrix(0,P,itr)
run = NULL
best.aic = 0
best.aic.gen = rep(0,itr)

set.seed(1234)
for(i in 1:P){
  runs[i,] = rbinom(m,1,.5)
  run.vars = baseball.sub[,runs[i,]==1]
  g = lm(salary.log~.,run.vars)
  runs.aic[i] = extractAIC(g)[2]
  aics[i,1] = runs.aic[i]
  if(runs.aic[i] < best.aic){
    run = runs[i,]
    best.aic = runs.aic[i]
  }
}

r = rank(-runs.aic)
phi = 2*r/(P*(P+1))
best.aic.gen[1]=best.aic


## MAIN
for(j in 1:itr-1){

  for(i in 1:10){
    p1 = sample(1:P,1,prob=phi)
    parent.1 = runs[p1,]
    parent.2 = runs[sample(c(1:P)[-p1],1, prob=phi[-p1]),] #prob 를 추가해주자.
    pos = sample(1:(m-1),1)
    mutate = rbinom(m,1,m.rate)
    runs.next[i,] = c(parent.1[1:pos],parent.2[(pos+1):m])
```

```
    runs.next[i,] = (runs.next[i,]+mutate)%%2
    mutate = rbinom(m,1,m.rate)
    runs.next[P+1-i,] = c(parent.2[1:pos],parent.1[(pos+1):m])
    runs.next[P+1-i,] = (runs.next[P+1-i,]+mutate)%%2
  }
  runs = runs.next

  # New generation 에서의 aic 와 fitness value 업데이트.
  for(i in 1:P){
    run.vars = baseball.sub[,runs[i,]==1]
    g = lm(salary.log~.,run.vars)
    runs.aic[i] = extractAIC(g)[2]
    aics[i,j+1] = runs.aic[i]
    if(runs.aic[i] < best.aic){
      run = runs[i,]
      best.aic = runs.aic[i]
    }
  }
  best.aic.gen[j+1]=best.aic
  r = rank(-runs.aic)
  phi = 2*r/(P*(P+1))
}

## OUTPUT
run         # BEST LIST OF PREDICTORS FOUND

##  [1] 0 1 1 0 0 1 0 1 0 1 0 1 1 1 1 1 0 0 0 0 0 0 0 0 1 1 0

best.aic    # AIC VALUE

## [1] -418

## PLOT OF AIC VALUES
plot(-aics,xlim=c(0,itr),ylim=c(50,425),type="n",ylab="Negative AIC",
     xlab="Generation",main="AIC Values when both proportional")
for(i in 1:itr){points(rep(i,P),-aics[,i],pch=20)}
```



➔ 하나를 random 으로 설정했을 때보다 더욱 Converge 하는 모습을 보인다. 이는, local optimum 에는 비교적 더 확실히 다가갈 수 있지만, 반대로 생각하면 local optimum 에 빠지기 쉬울 수 있다는 것을 보여주기도 한다.