Assignment2

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2025-10-27

```
## Warning: package 'magick' was built under R version 4.5.1
```

```
## Linking to ImageMagick 6.9.13.29
## Enabled features: cairo, freetype, fftw, ghostscript, heic, lcms, pango, raw, rsvg, webp
## Disabled features: fontconfig, x11
```

```
## Warning: package 'GA' was built under R version 4.5.1
```

```
## Loading required package: foreach
```

```
## Loading required package: iterators
```

```
## Package 'GA' version 3.2.4
## Type 'citation("GA")' for citing this R package in publications.
```

```
##
## Attaching package: 'GA'
```

```
## The following object is masked from 'package:utils':
##
##     de
```

#Q1

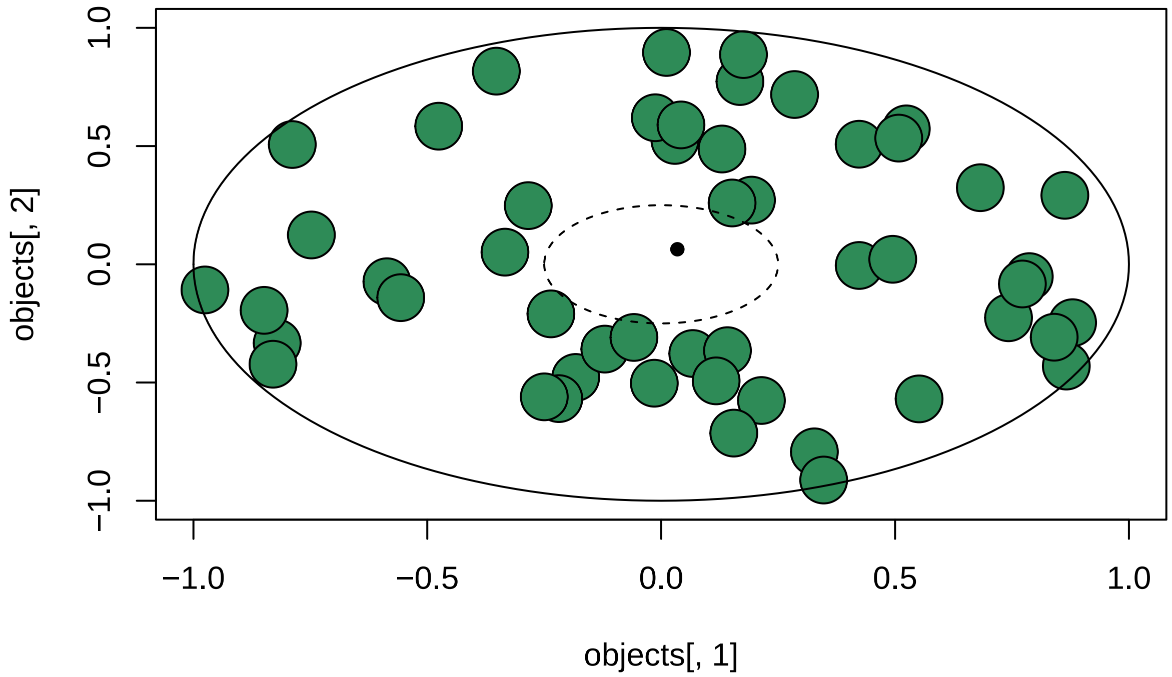
Q1a

```
game_status=function(xt,objects, rad)
{
  sk    = rep(0,dim(xt)[1])
  min_dists = rep(0,dim(xt)[1])
  J         = dim(objects)[1]
  ones      = matrix(1,J,1)
  for(i in 1:dim(xt)[1])
  {
    min_dists[i] = min(sqrt(rowSums((objects-ones%*%xt[i,])^2)))

    outRad = ((xt[i, 1])^2) + ((xt[i, 2])^2 )

    if (min_dists[i] < rad)
    {
      sk[i] = -1
    }

    else if ((outRad >= 1))
    {
      sk[i] = 1
    }
    else
    {
      sk[i] = 0
    }
  }

  #sk = 1*(xt[,2]>1)-1*((xt[,1]< -1)|(xt[,1]> +1)|(xt[,2]< -1)|(min_dists<rad))
  ret = list(status = sk, minDist = min_dists)
  return(ret)
}
```

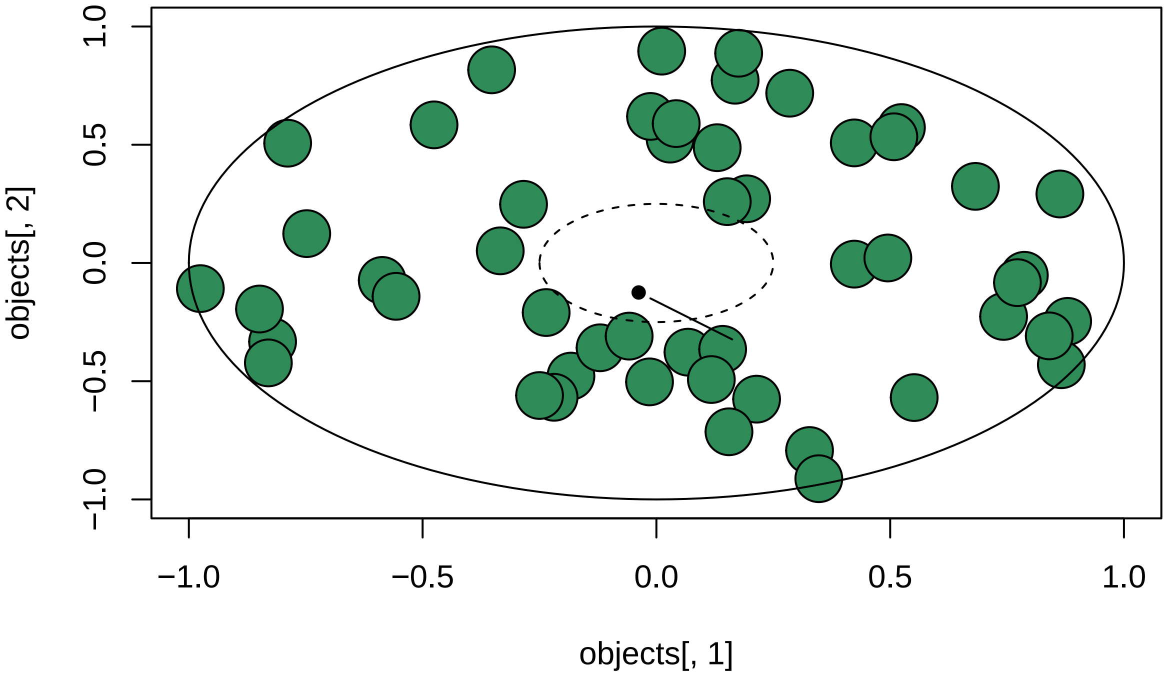
Q1b

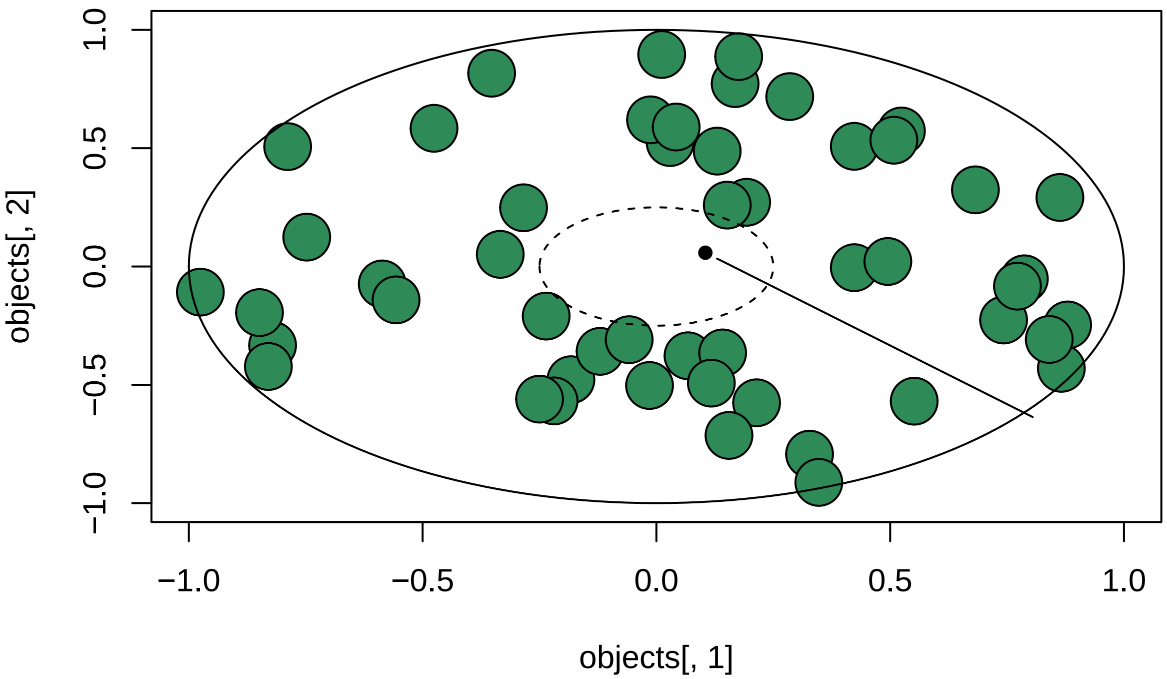
i

```
set.seed(2024)
J       =  50
objects = draw_objects(J)
xt      = draw_starts()
delt    = 0.025               # How big are the steps you can take?
rad     = 0.05                # How close to an object before you crash?

plot_game(xt,objects,rad,'black')
```



```
play_a_game = function(theta)
{
  xt    = draw_starts()
  res   = play(xt,delt,objects,rad,theta, trace = TRUE)
  score = mean(res$status==1)
  return(score)
}
# play_a_game(theta_rand)

obj = play_a_game
GA  = ga(type = 'real-valued',fitness = play_a_game,lower = rep(-10,npars),upper = rep(10,npars), popSi
#plot(GA)


theta_hat = GA@solution[1,]
#theta_hat

win = c()
for(i in 1:100)
{

  #objects = draw_objects(J)
  xt_try    = draw_starts()
  res_final = play(xt_try,delt,objects,rad,theta_hat,plt = FALSE,trace = TRUE)
  #print(typeof(res_final$trajectories))
  trajs = na.omit(res_final$trajectories)
  if (i == 1 || i == 50 || i == 100)
  {
      plot_game(xt_try,objects,rad,'black')
      lines(trajs[, 2,]~trajs[, 1, ])
  }

  win[i] = (res_final$status==1)
}
```





1.0
0.5
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objects[, 2]
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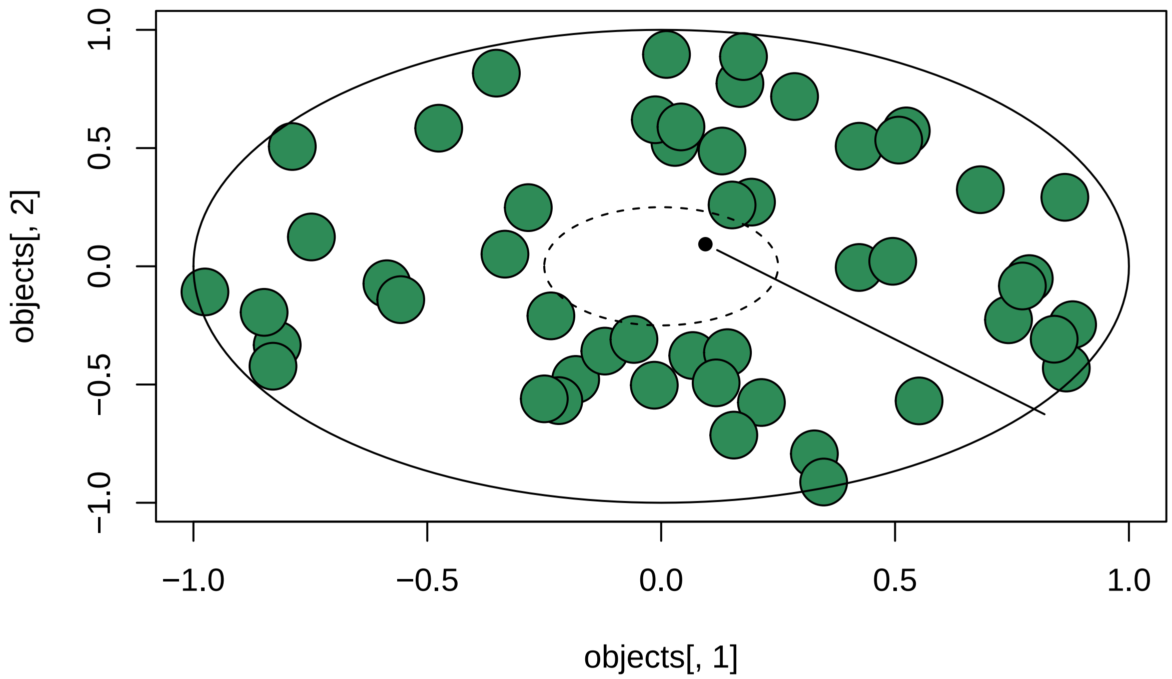
0.0
0.5
1.0
objects[, 1]

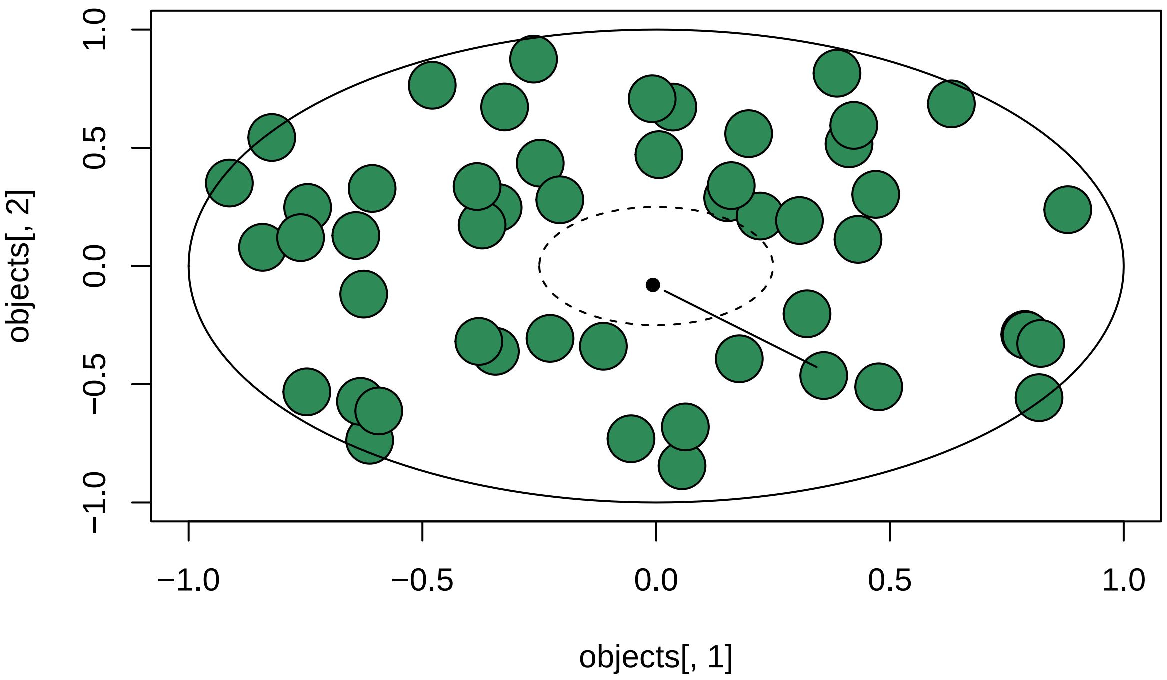


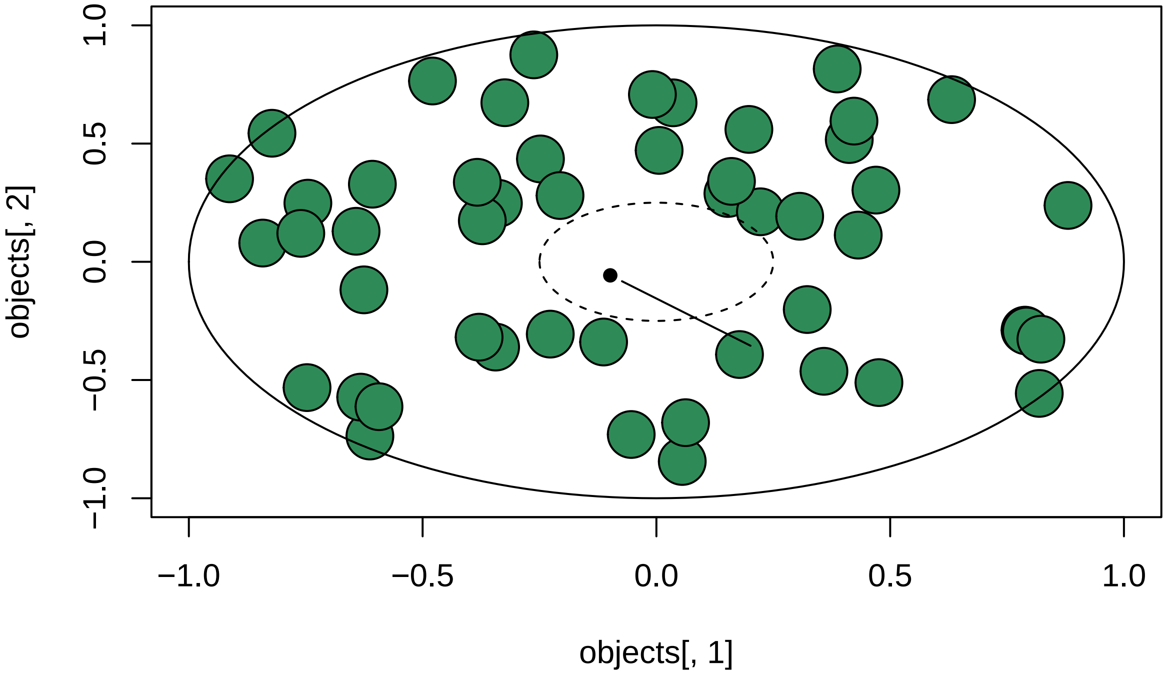
```r
propWins = data.frame("Proportion of successful navigations" = mean(win))
kable(propWins)
```

Proportion.of.successful.navigations
0.46

ii

```r
winNewObjs = c()
objectsNew = draw_objects(J)
for(i in 1:100)
{

  #objects = draw_objects(J)
  xt_try    = draw_starts()
  res_final = play(xt_try,delt,objectsNew,rad,theta_hat,plt = FALSE,trace = TRUE)
  #print(typeof(res_final$trajectories))

  trajs = na.omit(res_final$trajectories)

  if (i == 1 || i == 50 || i == 100)
  {
      plot_game(xt_try,objectsNew,rad,'black')
      lines(trajs[, 2,]~trajs[, 1, ])
  }

  winNewObjs[i] = (res_final$status==1)
}
```




1.0
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objects[, 2]
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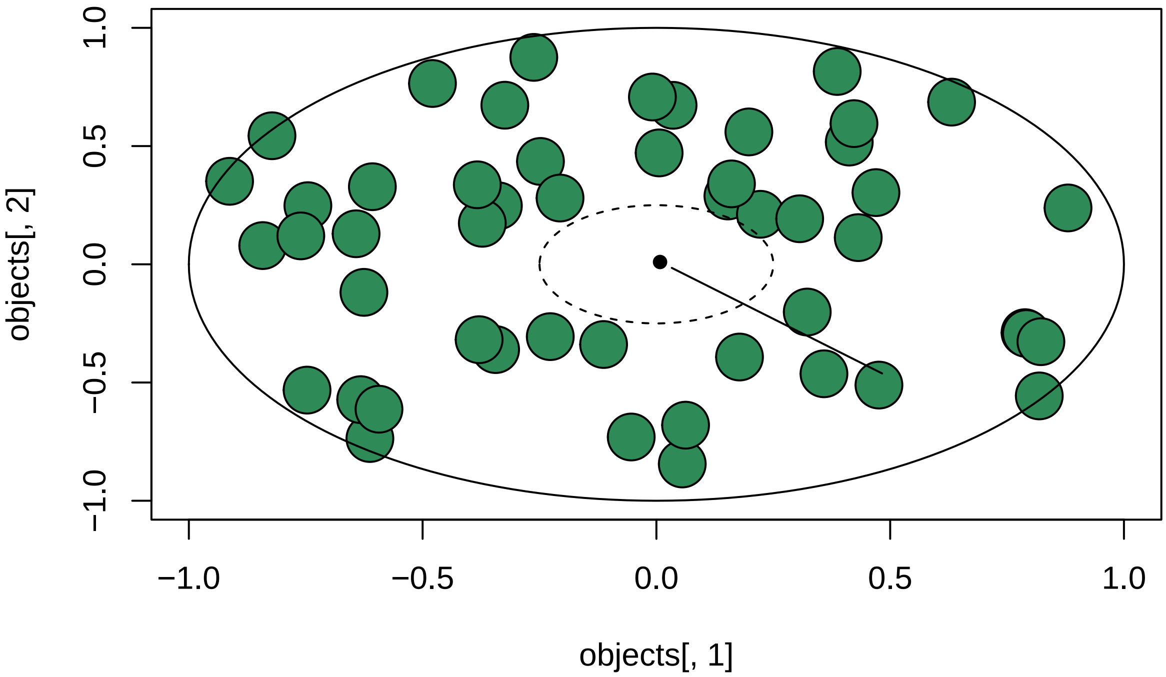
0.0
0.5
1.0
objects[, 1]



```
propNewWins = data.frame("Proportion of successful navigations" = mean(winNewObjs))
kable(propNewWins)
```

Proportion.of.successful.navigations
0.07

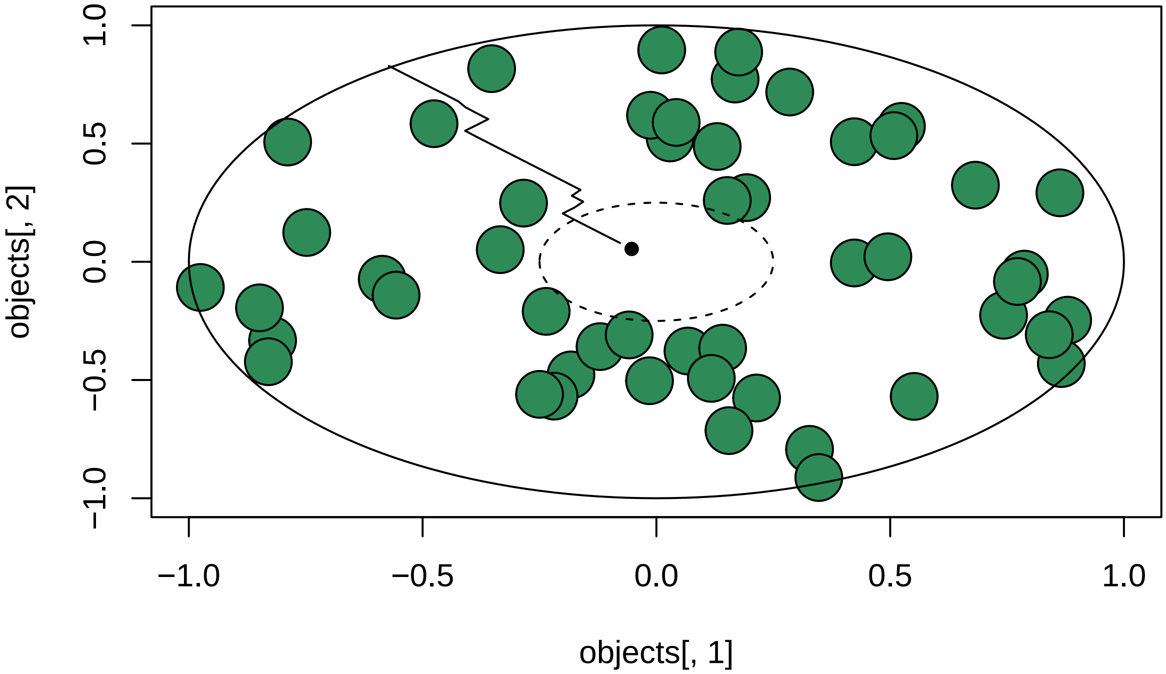
Can see that when measuring performance against the same trees, the model performs relatively well with a proportion of 0.73 passing. However, when using new trees, the model performs much worse with only a proportion of 0.21 passing. This means that the model has not learned how to avoid objects, but simply how to avoid the given set of objects.

Q1c

i

```
playAdj = function(x0,delt,objects,rad,theta,plt = FALSE,trace = FALSE)
{
  k            =    0 # Count how many steps
  xt           = x0   # Set the initial coordinate(s) for the drone.
  trajectories = NULL
  # Check the game status:
  #print(xt)
  #print(rad)
  res_status  = game_status(xt, objects, rad)
  status      = res_status$status
  minDists = res_status$minDist
  #print(minDists)

  inverseDist = 1/pmax((minDists - rad), 1e-6)
  # Check which games are still active:
  terminal      = (status != 0)
  if(trace)
  {
    trajectories = array(dim = c(dim(xt)[1],dim(xt)[2],101))
    trajectories[,,1] = xt
  }
  if(plt){plot_game(xt,objects,rad,'black')}
  while((any(status==0))&(k<100))
  {
    k = k + 1

    # Now, let the model update the position of the pieces:
    #print("1")
    ct = controlAdjusted(xt, theta, inverseDist)
    #print(ct)
    xt = xt+ct*delt*cbind(1-terminal,1-terminal)

    # Checkk the game status after the positions are updates:
    res_status  = game_status(xt, objects, rad)
    status      = res_status$status
    minDists = res_status$minDist
    inverseDist = 1/(minDists-rad)
    terminal    = (status != 0)
    if(trace){trajectories[,,k] = xt}
    if(plt){plot_game(xt,objects,rad,c('red','black','green')[status+2])}
  }
  return(list(k = k, status = status,xt= xt,trajectories = trajectories))
}


controlAdjusted = function(xt,pars, inverseDist)
{
  xt_aug = cbind(xt, inverseDist)
  res_model = model(xt_aug,pars,rep(nodes,2))
  #print(res_model)
  return(res_model$a3)
}

play_a_game_adj = function(theta)
{
  xt    = draw_starts()
  res   = playAdj(xt,delt,objects,rad,theta, trace = TRUE)
  score = mean(res$status==1)
  return(score)
}
```

```
p     = 3
q     = 2
nodes = 3
npars = p*nodes+nodes*nodes+nodes*q+nodes+nodes+q
# npars
theta_rand = runif(npars,-1,1)

objAdj = play_a_game_adj
GA_adj  = ga(type = 'real-valued',fitness = play_a_game_adj,lower = rep(-10,npars),upper = rep(10,npars
# plot(GA_adj)


theta_hat_adj = GA_adj@solution[1,]
# theta_hat_adj

win_adj = c()
for(i in 1:100)
{

  #objects = draw_objects(J)
  xt_try    = draw_starts()
  res_final = playAdj(xt_try,delt,objects,rad,theta_hat_adj,plt = FALSE,trace = TRUE)
  #print(typeof(res_final$trajectories))

  trajs = na.omit(res_final$trajectories)

  if (i == 1 || i == 50 || i == 100)
  {
      plot_game(xt_try,objects,rad,'black')
      lines(trajs[, 2,]~trajs[, 1, ])
  }

  win_adj[i] = (res_final$status==1)
}
```


1.0
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objects[, 2]
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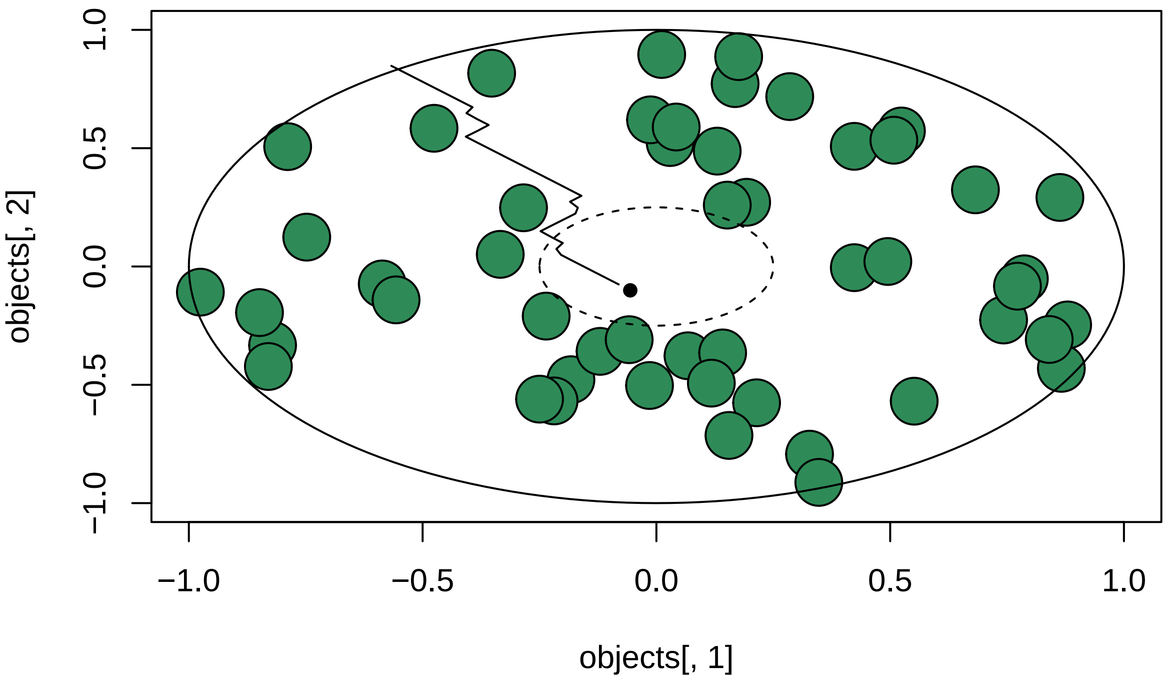
objects[, 1]


objects[, 2]
1.0
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−1.0
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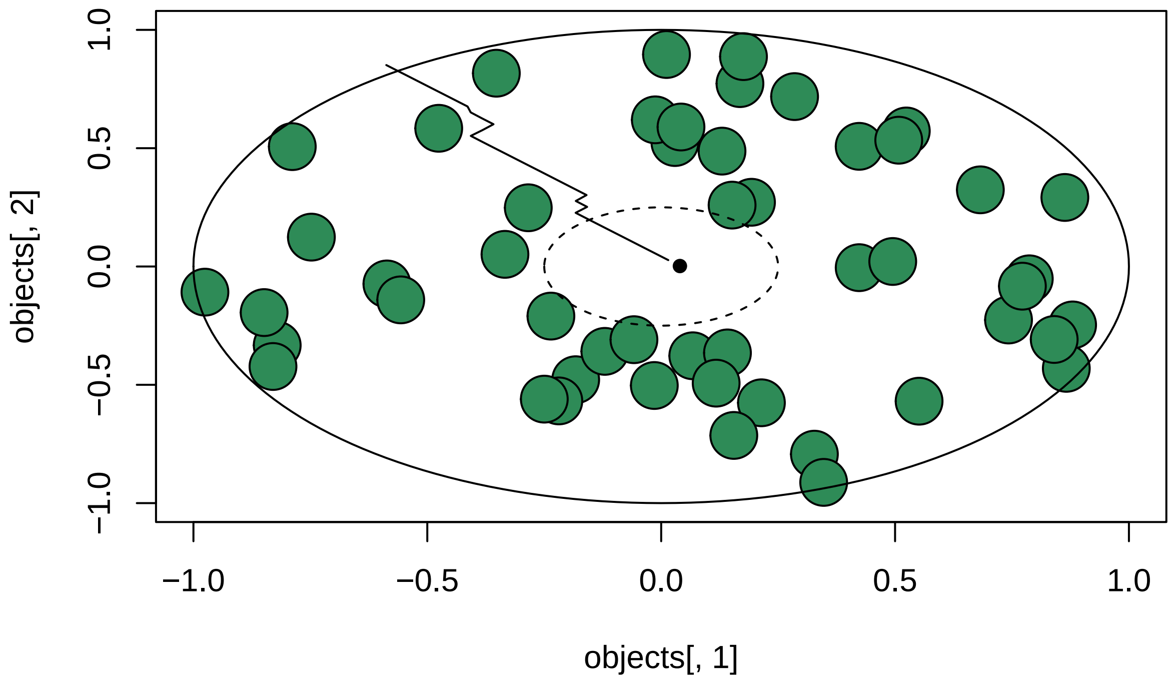
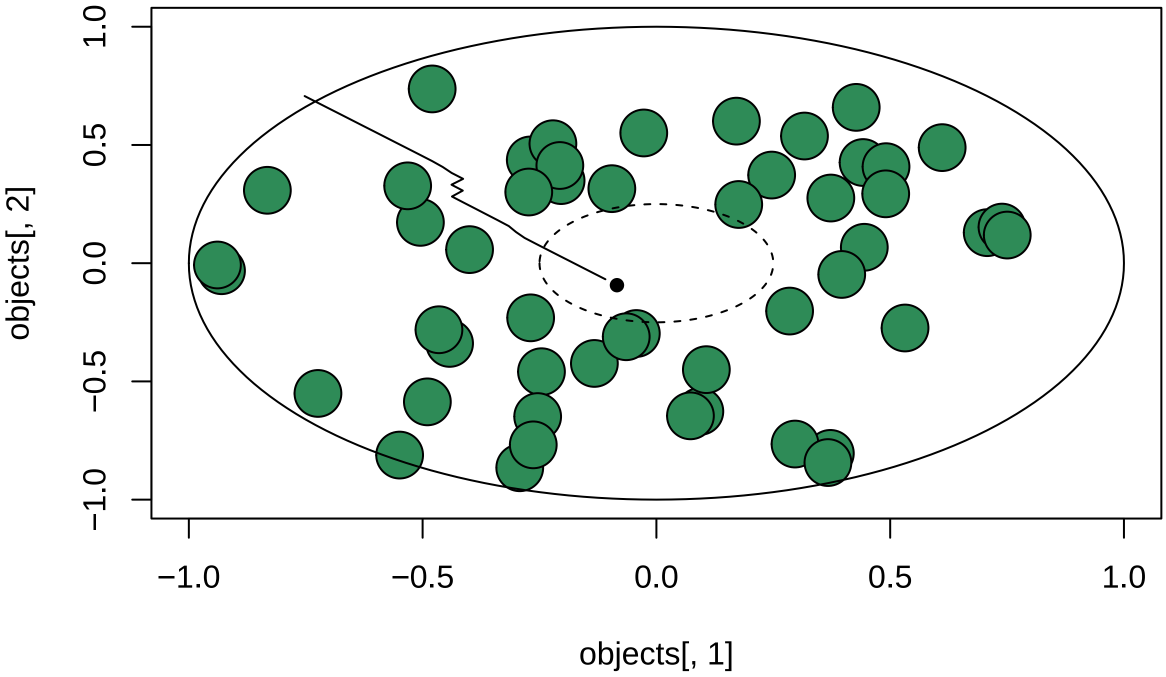
0.0
0.5
1.0
objects[, 1]

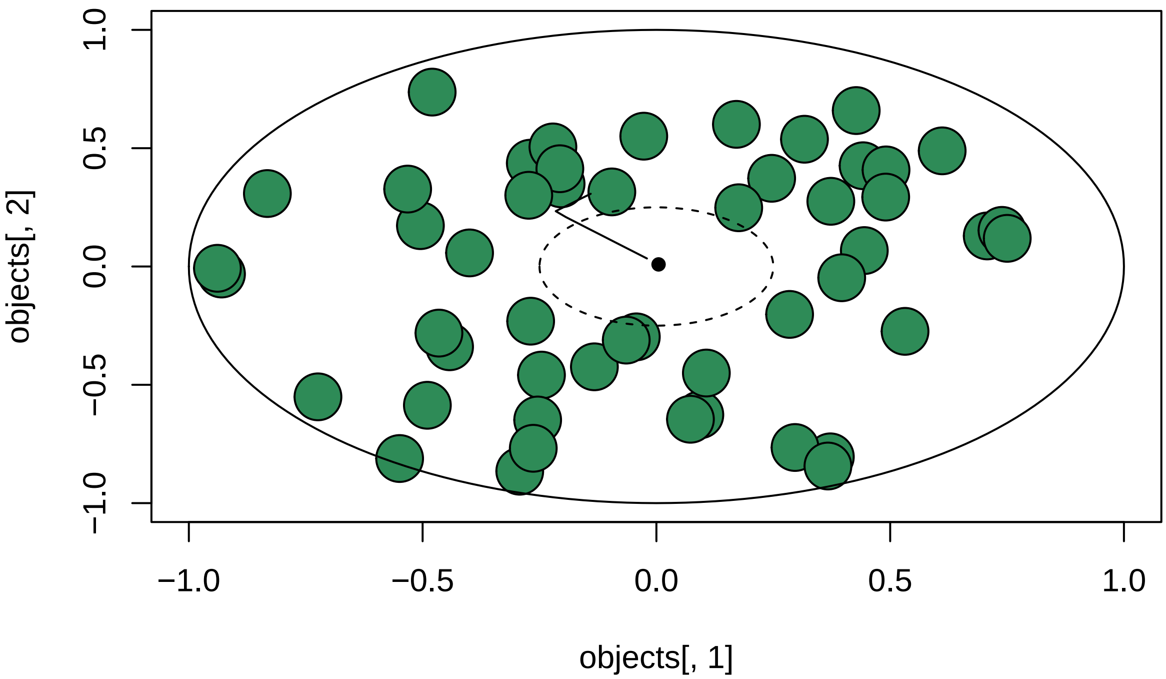


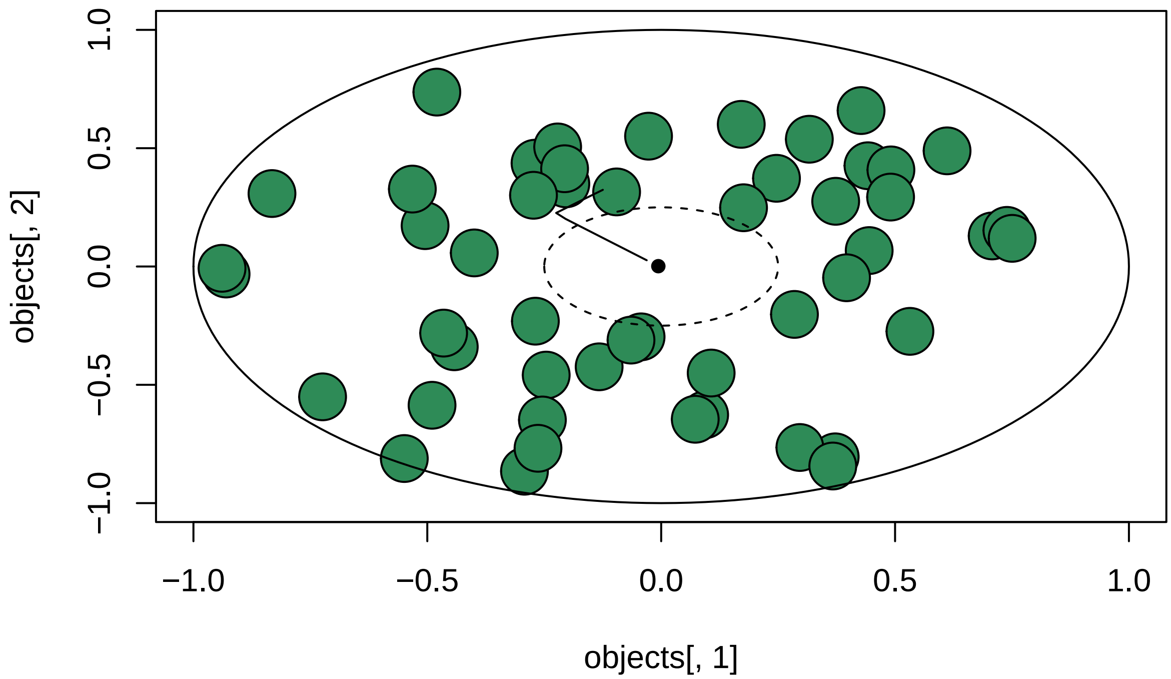
```
propWinsAdj = data.frame("Proportion of successful navigations" = mean(win_adj))
kable(propWinsAdj)
```

Proportion.of.successful.navigations
0.93

```
winNewObjs_adj = c()

objectsNew = draw_objects(J)
for(i in 1:100)
{
  xt_try    = draw_starts()

  res_final = playAdj(xt_try,delt,objectsNew,rad,theta_hat_adj,plt = FALSE,trace = TRUE)
  #print(typeof(res_final$trajectories))

  trajs = na.omit(res_final$trajectories)

  if (i == 1 || i == 50 || i == 100)
  {
      plot_game(xt_try,objectsNew,rad,'black')
      lines(trajs[, 2,]~trajs[, 1, ])
  }
  winNewObjs_adj[i] = (res_final$status==1)
}
```




objects[, 2]
1.0
0.5
0.0
−0.5
−1.0
−1.0
−0.5
0.0
0.5
1.0
objects[, 1]

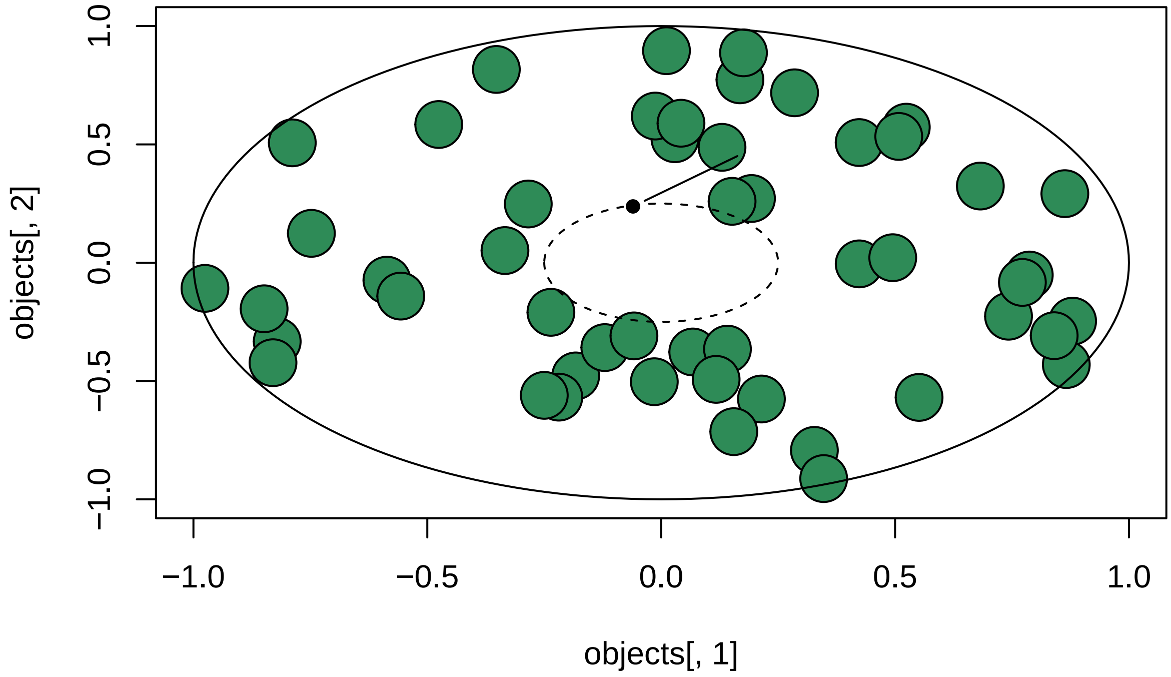


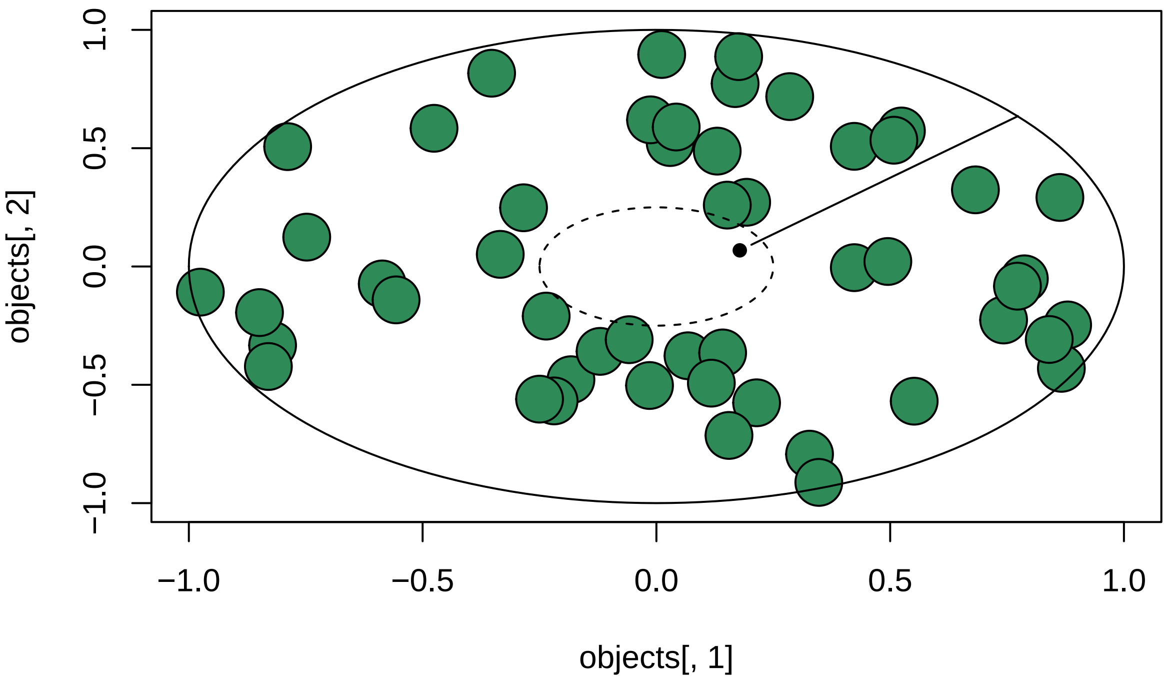
```
#mean(winNewObjs_adj)
propNewWinsAdj = data.frame("Proportion of successful navigations" = mean(winNewObjs_adj))
kable(propNewWinsAdj)
```

Proportion.of.successful.navigations
0.18

Q1d

```
### d
play_a_game_adj_newObs = function(theta)
{
  xt      = draw_starts()
  objects = draw_objects(J)
  res     = playAdj(xt,delt,objects,rad,theta, trace = TRUE)
  score = mean(res$status==1)
  return(score)
}


objAdj = play_a_game_adj_newObs
GA_adj_newObs  = ga(type = 'real-valued',fitness = play_a_game_adj_newObs,lower = rep(-10,npars),upper =
# plot(GA_adj_newObs)


theta_hat_adj_newObs = GA_adj_newObs@solution[1,]
# theta_hat_adj_newObs

win_adj_newObs = c()
for(i in 1:100)
{

  #objects = draw_objects(J)
  xt_try    = draw_starts()
  res_final = playAdj(xt_try,delt,objects,rad,theta_hat_adj_newObs,plt = FALSE,trace = TRUE)
  #print(typeof(res_final$trajectories))

  trajs = na.omit(res_final$trajectories)

  if (i == 1 || i == 50 || i == 100)
  {
      plot_game(xt_try,objects,rad,'black')
      lines(trajs[, 2,]~trajs[, 1, ])
  }

  win_adj_newObs[i] = (res_final$status==1)
}
```




1.0
0.5
0.0
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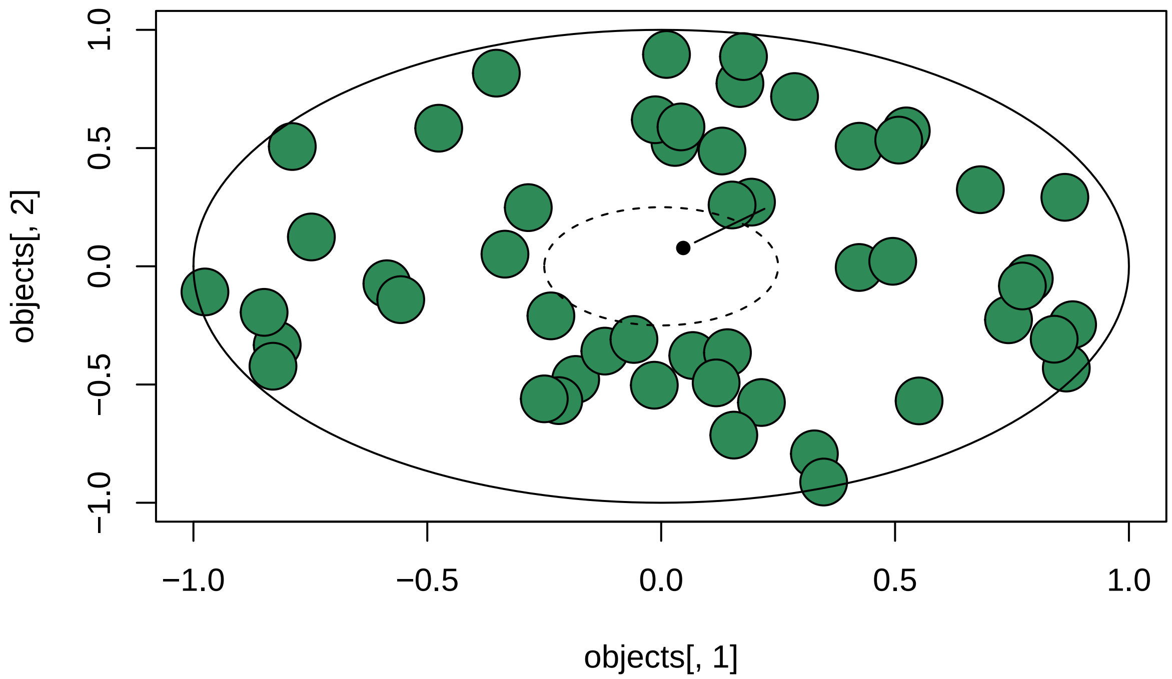
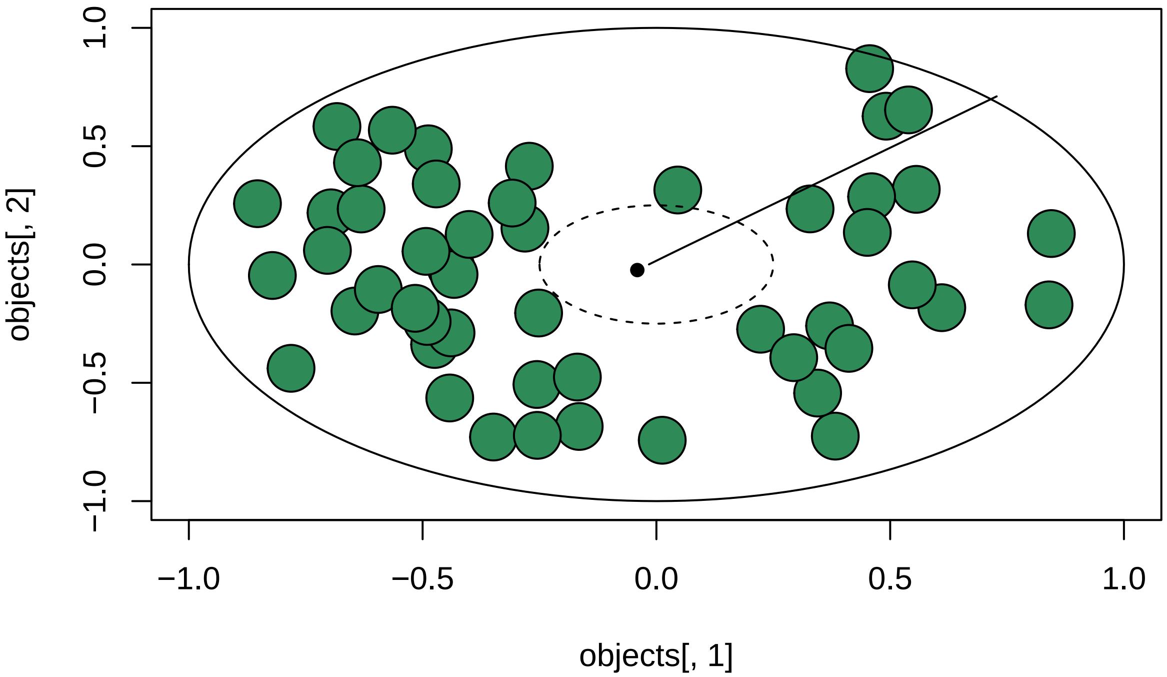
−1.0
objects[, 2]
−1.0
−0.5
0.0
0.5
1.0
objects[, 1]

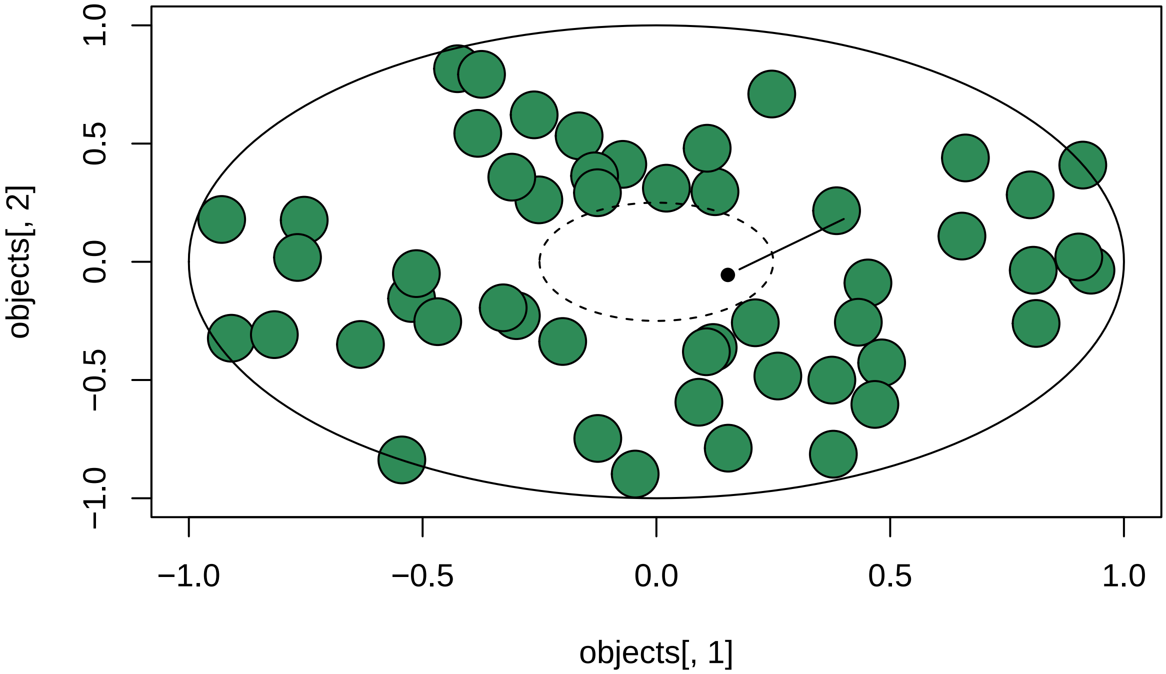


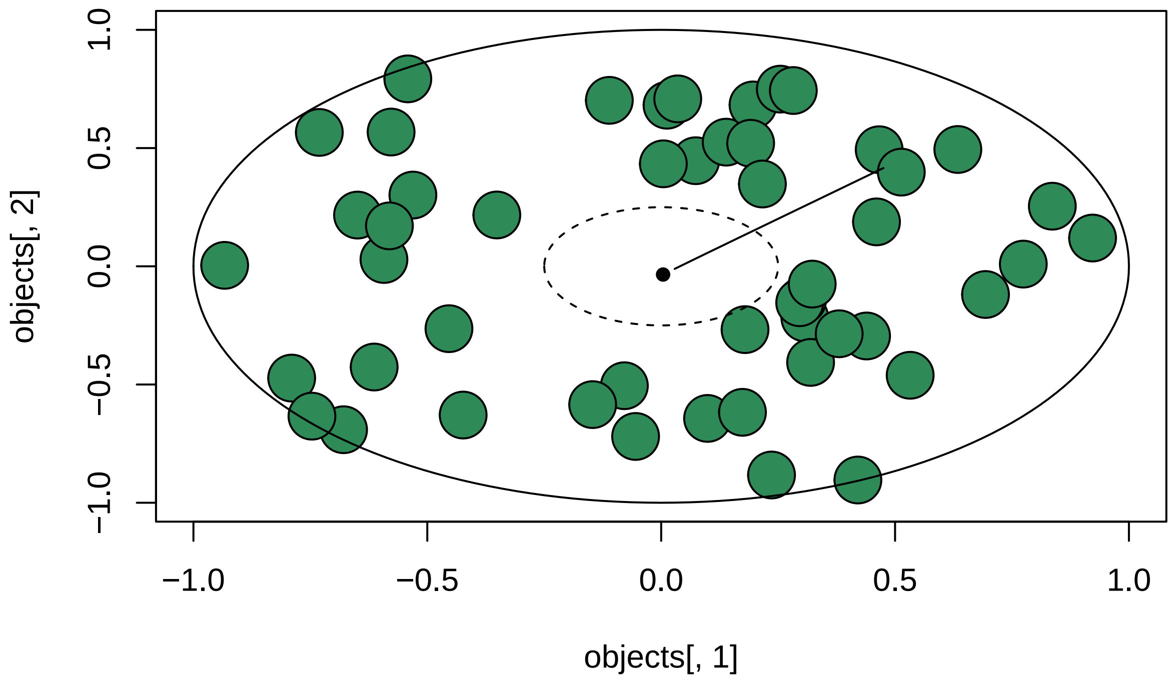
```
prop_win_adj_newObs = data.frame("Proportion of successful navigations" = mean(win_adj_newObs))
kable(prop_win_adj_newObs)
```

Proportion.of.successful.navigations
0.5

```
winNewObjs_adj_genNewObs = c()

for(i in 1:100)
{

  objects = draw_objects(J)
  xt_try    = draw_starts()
  res_final = playAdj(xt_try,delt,objects,rad,theta_hat_adj_newObs,plt = FALSE,trace = TRUE)
  #print(typeof(res_final$trajectories))

  trajs = na.omit(res_final$trajectories)
  if (i == 1 || i == 50 || i == 100)
  {
      plot_game(xt_try,objects,rad,'black')
      lines(trajs[, 2,]~trajs[, 1, ])
  }
  winNewObjs_adj_genNewObs[i] = (res_final$status==1)
}
```


objects[, 2]
objects[, 1]
−1.0
−0.5
0.0
0.5
1.0
−1.0
−0.5
0.0
0.5
1.0


objects[, 2]
1.0
0.5
0.0
−0.5
−1.0
−1.0
−0.5
0.0
0.5
1.0
objects[, 1]



```
prop_winNewObjs_adj_genNewObs = data.frame("Proportion of successful navigations" = mean(winNewObjs_adj_
kable(prop_winNewObjs_adj_genNewObs)
```

Proportion.of.successful.navigations
0.23

Q2

Q2a

```
game_tree= function(m,k, currMoves = 0, maxMoves = 9)
{
  g = c()
  game_state = rho(m,S)
  if(game_state$terminal)
  {
    g = c(g,game_state$winner)
    return(g)
  }
  else if(currMoves == maxMoves)
  {
    g = c(g, 2)
    return(g)
  }

  else{
    Index = which(m == 0)
    for(i in 1:length(Index))
    {
      x = m
      x[Index[i]]=k
      g = c(g,game_tree(x,-1*k, currMoves + 1, maxMoves))
    }
    return(g)
  }
}

m = as.matrix(c(0,0,0,0,0,0,0,0,0))

res5 = game_tree(m,1, 0, 5)
n_g5  =     length(res5)
Xwins5 = sum(res5==-1)
Draws5 = sum(res5== 0)
Owins5 = sum(res5==+1)
Unfinished5 = sum(res5==+2)
#Games5 = c(n_g5,Xwins5,Draws5,Owins5, Unfinished5)
games5 = data.frame("Number of moves" = 5, "Number of games" = n_g5, "X wins" = Xwins5, "O wins" = Owins

res8 = game_tree(m,1, 0, 8)
n_g8  =     length(res8)
Xwins8 = sum(res8==-1)
Draws8 = sum(res8== 0)
Owins8 = sum(res8==+1)
Unfinished8 = sum(res8==+2)
#Games8 = c(n_g8,Xwins8,Draws8,Owins8, Unfinished8)
games8 = data.frame("Number of moves" = 8, "Number of games" = n_g8, "X wins" = Xwins8, "O wins" = Owins

res9 = game_tree(m,1, 0, 9)
n_g9  =     length(res9)
Xwins9 = sum(res9==-1)
Draws9 = sum(res9== 0)
Owins9 = sum(res9==+1)
Unfinished9 = sum(res9==+2)
CombinedFull = data.frame("Number of Games" = n_g9,"X wins" = Xwins9,"Draws" = Draws9, "O wins" = Owins9
CombinedFullWinProb = data.frame("Prop X wins" = Xwins9/n_g9,"Prop Draws" = Draws9/n_g9, "Prop O wins" =

datQ2A = rbind(games5, games8)
kable(datQ2A)
```

Number.of.moves	Number.of.games	X.wins	O.wins	Draws
5	15120	0	1440	0
8	255168	77904	49392	23040

Q2b

```
mcts = function(m, k, alpha)
{
  g = c()
  game_state = rho(m,S)

  randAlpha = runif(1, 0, 1)

  if(game_state$terminal)
  {
    g = c(g,game_state$winner)
    return(g)
  }

  else
  {
    if (randAlpha <= alpha)
    {
      Index = which(m == 0)
      for(i in 1:length(Index))
      {
        x = m
        x[Index[i]]=k
        g = c(g,mcts(x,-1*k, alpha))
      }
      return(g)
    }
    else
    {
      g = c(g,2)
      return(g)
    }

  }
}

m = as.matrix(c(1,1,0,0,0,0,0,0,-1))

resMCTS = mcts(m,-1, 0.95)
n_gMCTS  =  length(resMCTS)
XwinsMCTS = sum(resMCTS==-1)
DrawsMCTS = sum(resMCTS== 0)
OwinsMCTS = sum(resMCTS==+1)
UnfinishedMCTS = sum(resMCTS==+2)
MCTS = data.frame("Games" = n_gMCTS,"X Wins" = XwinsMCTS, "Draws" = DrawsMCTS, "O wins" = OwinsMCTS, "U
MCTSWinProb = data.frame("Prop X wins" = XwinsMCTS/n_gMCTS, "Prop Draws" = DrawsMCTS/n_gMCTS,"Prop O wi

kable(MCTS, caption = "Table of results using Monte Carlo Tree Search, alpha = 0.95")
```

Table 8: Table of results using Monte Carlo Tree Search, alpha = 0.95

Games	X.Wins	Draws	O.wins	Unfinished.Games
307	119	47	126	15

```r
kable(CombinedFull, caption = "Table of results using Tree Search")
```

Table 9: Table of results using Tree Search

Number.of.Games	X.wins	Draws	O.wins	Unfinished.games
255168	77904	46080	131184	0

```r
kable(MCTSWinProb, caption = "Table of proportions using Monte Carlo Tree Search, alpha = 0.95")
```

Table 10: Table of proportions using Monte Carlo Tree Search, alpha = 0.95

Prop.X.wins	Prop.Draws	Prop.O.wins
0.3876221	0.1530945	0.4104235

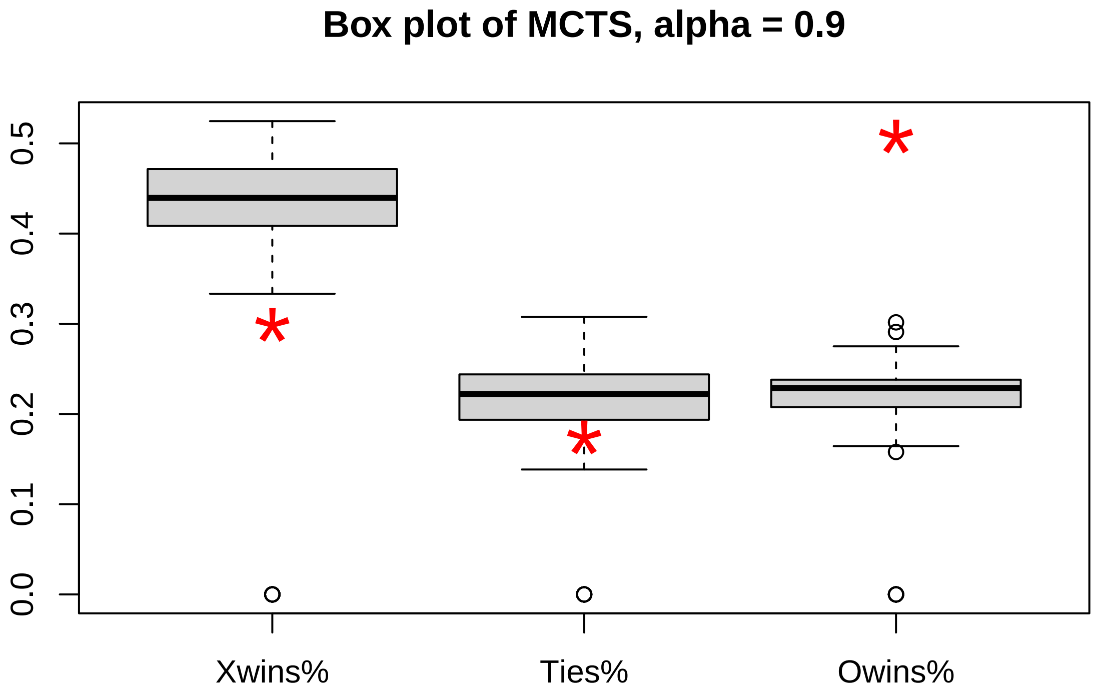
```r
kable(CombinedFullWinProb, caption = "Table of proportions using Tree Search")
```

Table 11: Table of proportions using Tree Search

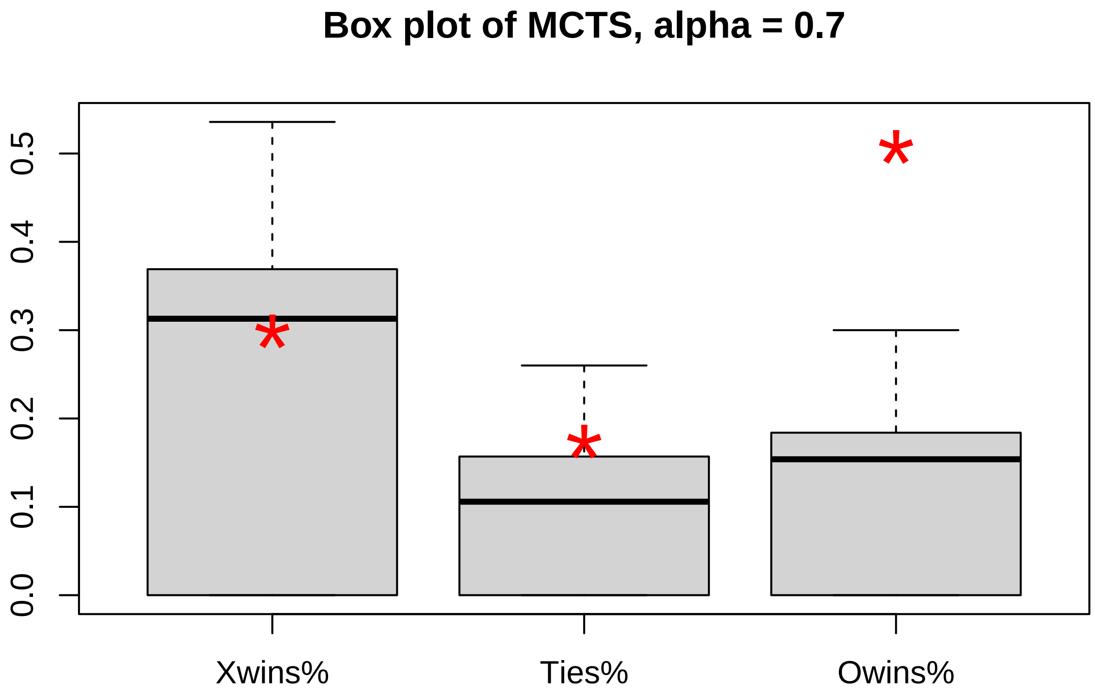
Prop.X.wins	Prop.Draws	Prop.O.wins
0.3053047	0.1805869	0.5141084

Q2c

```r
m = as.matrix(c(1,1,-1,0,0,0,0,0,-1))

df90 = data.frame()
df70 = data.frame()

for(i in 1:100)
{
  resMCTS90 = mcts(m,1, 0.9)
  resMCTS70 = mcts(m,1, 0.7)

  n_gMCTS90  =  length(resMCTS90)
  XwinsMCTS90 = sum(resMCTS90==-1)
  DrawsMCTS90 = sum(resMCTS90== 0)
  OwinsMCTS90 = sum(resMCTS90==+1)
  UnfinishedMCTS90 = sum(resMCTS==+2)
  Combined90 = c(n_gMCTS90,XwinsMCTS90/n_gMCTS90,DrawsMCTS90/n_gMCTS90,OwinsMCTS90/n_gMCTS90, Unfinishe

  n_gMCTS70  =  length(resMCTS70)
  XwinsMCTS70 = sum(resMCTS70==-1)
  DrawsMCTS70 = sum(resMCTS70== 0)
  OwinsMCTS70 = sum(resMCTS70==+1)
  UnfinishedMCTS70 = sum(resMCTS70==+2)
  Combined70 = c(n_gMCTS70,XwinsMCTS70/n_gMCTS70,DrawsMCTS70/n_gMCTS70,OwinsMCTS70/n_gMCTS70, Unfinishe

  df90 = rbind(df90, Combined90)
  df70 = rbind(df70, Combined70)
}

colnames(df90) = c("Games", "Xwins%", "Ties%", "Owins%", "Incomplete")
colnames(df70) = c("Games", "Xwins%", "Ties%", "Owins%", "Incomplete")

boxplot(df90[, 2:4], main = "Box plot of MCTS, alpha = 0.9")
points(c(CombinedFullWinProb$Prop.X.wins, CombinedFullWinProb$Prop.Draws, CombinedFullWinProb$Prop.O.wi
```

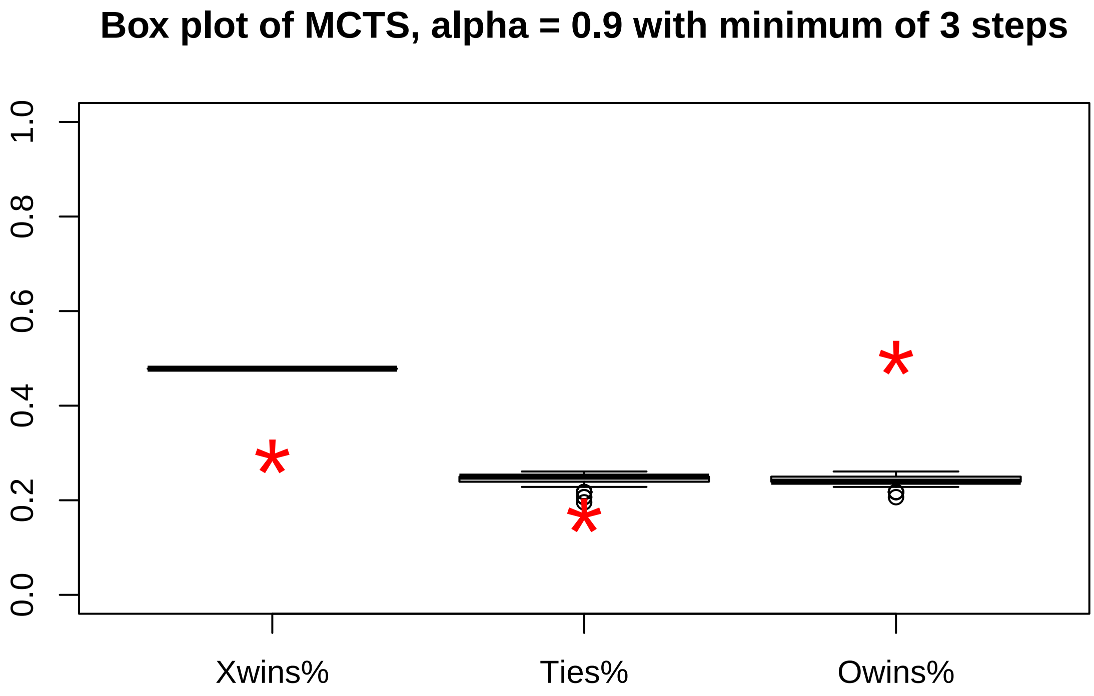


```
boxplot(df70[, 2:4], main = "Box plot of MCTS, alpha = 0.7")
points(c(CombinedFullWinProb$Prop.X.wins, CombinedFullWinProb$Prop.Draws, CombinedFullWinProb$Prop.O.wi
```

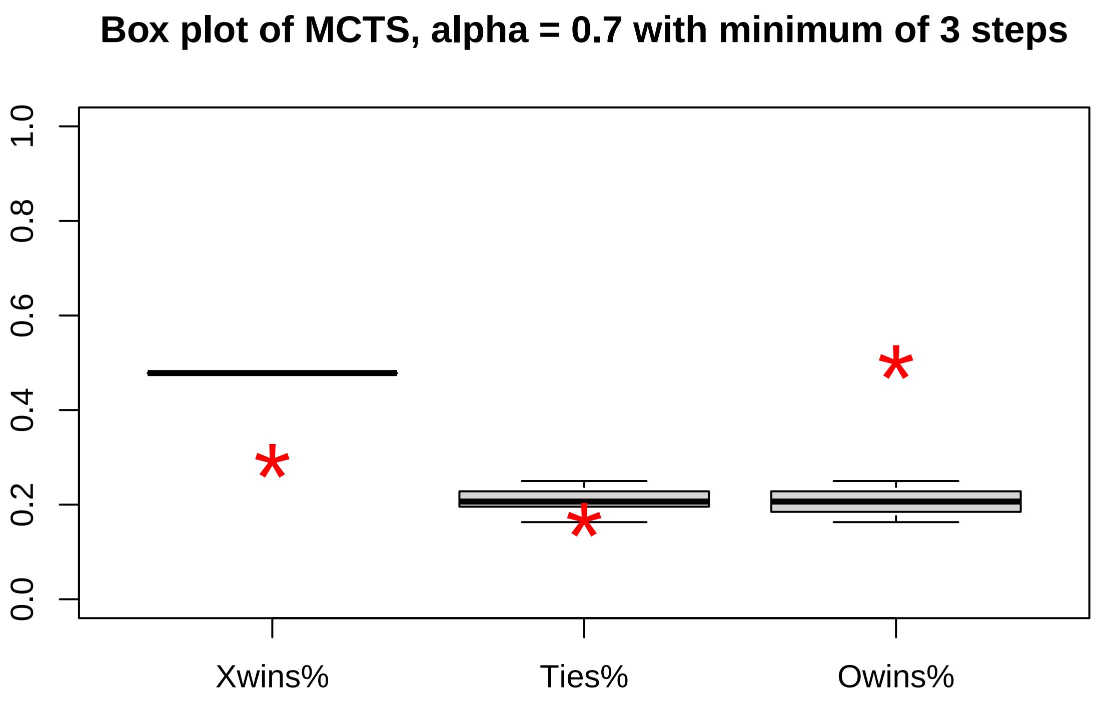


Box plot of MCTS, alpha = 0.7

```
mcts_minBranch = function(m, k, alpha, currMoves, minBranch)
{
  g = c()
  game_state = rho(m,S)

  randAlpha = runif(1, 0, 1)

  if(game_state$terminal)
  {
    g = c(g,game_state$winner)
    return(g)
  }

  else
  {
    if (currMoves <= minBranch)
    {
      Index = which(m == 0)
      for(i in 1:length(Index))
      {
        x = m
        x[Index[i]]=k
        g = c(g,mcts_minBranch(x,-1*k, alpha, currMoves + 1, minBranch))
      }
      return(g)
    }
    else
    {
      if (randAlpha <= alpha)
      {
        Index = which(m == 0)
        for(i in 1:length(Index))
        {
          x = m
          x[Index[i]]=k
          g = c(g,mcts_minBranch(x,-1*k, alpha, currMoves + 1, minBranch))
        }
        return(g)
      }
      else
      {
        g = c(g,2)
        return(g)
      }
    }

  }
}

# m = as.matrix(c(1,1,0,0,0,0,0,0,-1))
#
# resMCTS_Branch = mcts_minBranch(m,-1, 0.95, 3, 9)
# n_gMCTS_Branch  =     length(resMCTS_Branch)
# XwinsMCTS_Branch = sum(resMCTS_Branch==-1)
# DrawsMCTS_Branch = sum(resMCTS_Branch== 0)
# OwinsMCTS_Branch = sum(resMCTS_Branch==+1)
# UnfinishedMCTS_Branch = sum(resMCTS_Branch==+2)
# c(n_gMCTS_Branch,XwinsMCTS_Branch,DrawsMCTS_Branch,OwinsMCTS_Branch, UnfinishedMCTS_Branch)

m = as.matrix(c(1,1,-1,0,0,0,0,0,-1))

df90_Branch_new = data.frame()
df70_Branch_new = data.frame()

for(i in 1:100)
{
  resMCTS90_new = mcts_minBranch(m,1, 0.9, 4, 7)
  resMCTS70_new = mcts_minBranch(m,1, 0.7, 4, 7)

  n_gMCTS90_new  =  length(resMCTS90_new)
  XwinsMCTS90_new = sum(resMCTS90_new==-1)
  DrawsMCTS90_new = sum(resMCTS90_new== 0)
  OwinsMCTS90_new = sum(resMCTS90_new==+1)
  UnfinishedMCTS90_new = sum(resMCTS90_new==+2)
  Combined90_new = c(n_gMCTS90_new,XwinsMCTS90_new/n_gMCTS90_new,
                     DrawsMCTS90_new/n_gMCTS90_new,OwinsMCTS90_new/n_gMCTS90_new, UnfinishedMCTS90_new)

  n_gMCTS70_new  =  length(resMCTS70_new)
  XwinsMCTS70_new = sum(resMCTS70_new==-1)
  DrawsMCTS70_new = sum(resMCTS70_new== 0)
  OwinsMCTS70_new = sum(resMCTS70_new==+1)
  UnfinishedMCTS70_new = sum(resMCTS70_new==+2)
  Combined70_new = c(n_gMCTS70_new,XwinsMCTS70_new/n_gMCTS70_new,
                     DrawsMCTS70_new/n_gMCTS70_new,OwinsMCTS70_new/n_gMCTS70_new, UnfinishedMCTS70_new)

  df90_Branch_new = rbind(df90_Branch_new, Combined90_new)
  df70_Branch_new = rbind(df70_Branch_new, Combined70_new)
}

colnames(df90_Branch_new) = c("Games", "Xwins%", "Ties%", "Owins%", "Incomplete")
colnames(df70_Branch_new) = c("Games", "Xwins%", "Ties%", "Owins%", "Incomplete")

boxplot(df90_Branch_new[, 2:4], ylim = c(0, 1), main = "Box plot of MCTS, alpha = 0.9 with minimum of 3
points(c(CombinedFullWinProb$Prop.X.wins, CombinedFullWinProb$Prop.Draws, CombinedFullWinProb$Prop.O.wi
```



```
boxplot(df70_Branch_new[, 2:4], ylim = c(0, 1), main = "Box plot of MCTS, alpha = 0.7 with minimum of 3
points(c(CombinedFullWinProb$Prop.X.wins, CombinedFullWinProb$Prop.Draws, CombinedFullWinProb$Prop.O.wi
```



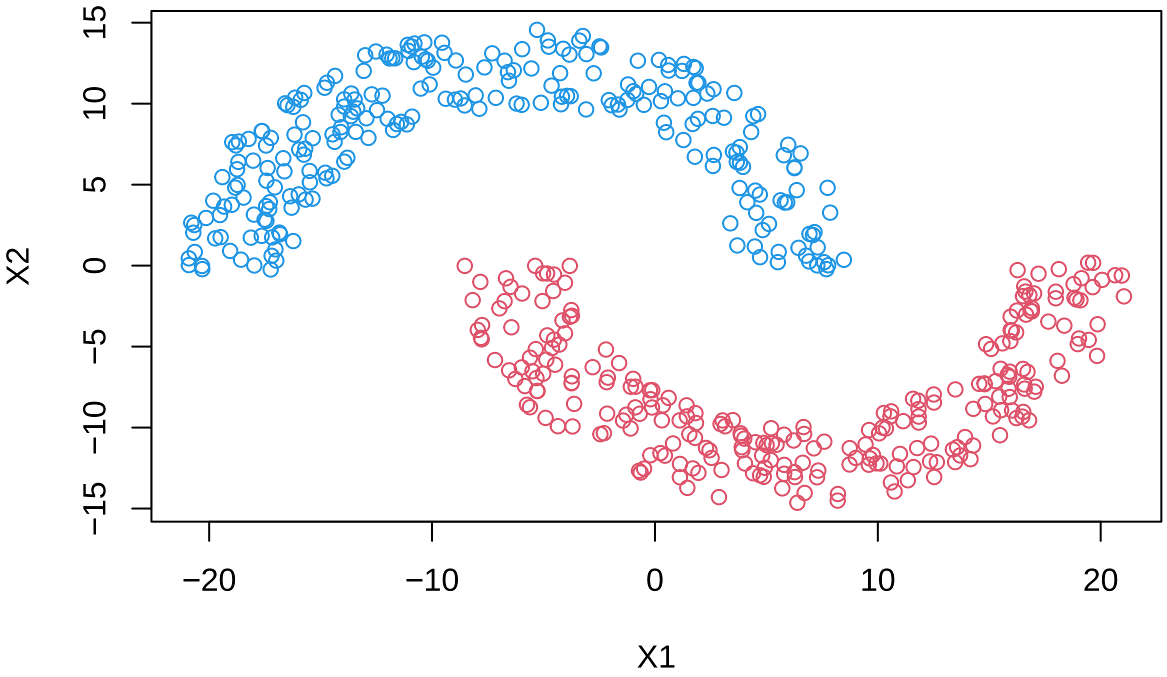
Q3

Q3a

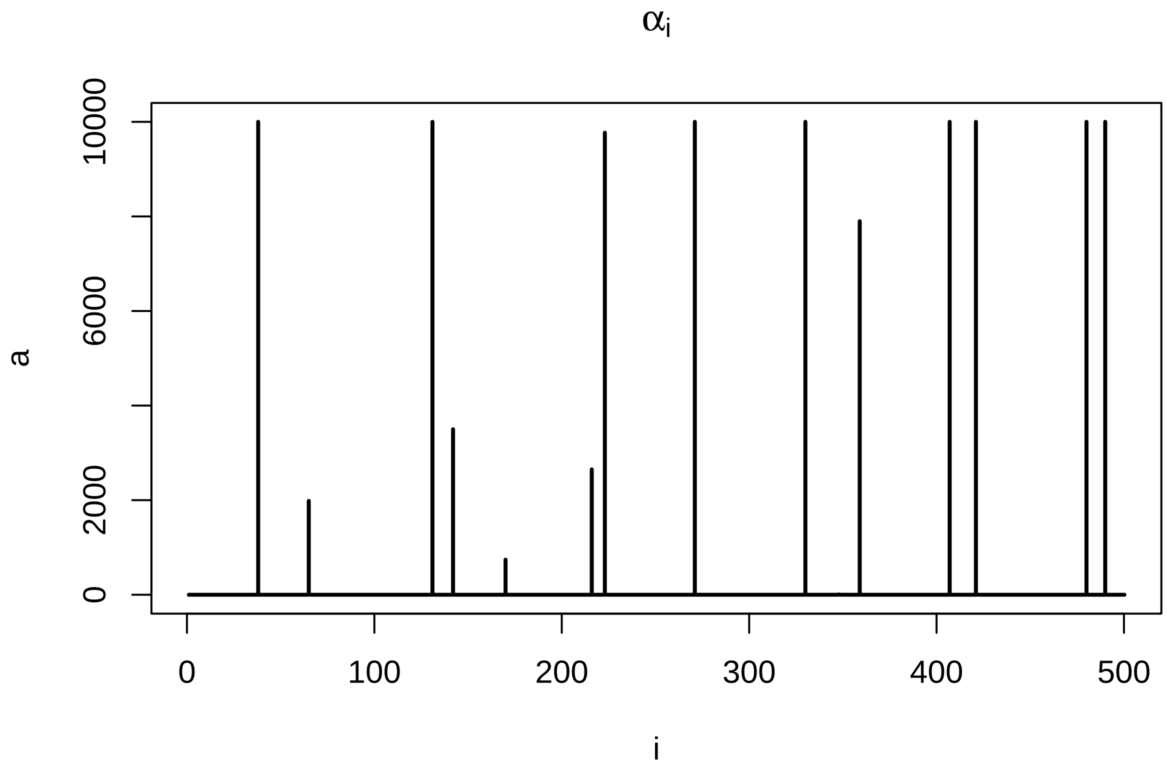
```r
library(quadprog)

polKern = function(x1, x2, gm, cf, dg)
{
  return((cf+gm*t(x1)%*%x2)^dg)
}

radialKern = function(x1, x2, gm)
{
  return(exp(-gm*(sum((x1 - x2)^2))))
}

my_svm = function(y, x, kern, cost = 0, softMarg = FALSE, gm = 0, cf = 0, dg = 0, plt = FALSE)
{
  N = dim(x)[1]
  DD = matrix(0,N,N)

  if(kern == "none")
  {
```

```
  for(i in 1:N)
  {
    for(j in 1:N)
    {
      DD[i,j]  = y[i]*y[j]*(t(x[i,])%*%x[j,])
    }
  }
}
else if (kern == "poly")
{

  for(i in 1:N)
  {
    for(j in 1:N)
    {
      KK = polKern(x[i,], x[j,], gm, cf, dg)
      DD[i,j]  = y[i]*y[j]*KK
    }
  }
}
else if (kern == "radial")
{
  for(i in 1:N)
  {
    for(j in 1:N)
    {
      KK = radialKern(x[i,], x[j,], gm)
      DD[i,j]  = y[i]*y[j]*KK
    }
  }
}

eps = 5e-6
DD  = DD+eps*diag(N)
Amat = cbind(y,diag(N)) # y will be on first row of t(Amat)
bvec = matrix(0,N+1,1)
d    = matrix(1,N,1)

if (softMarg == TRUE)
{
  negativeC = (-1)*cost
  Amat = cbind(Amat, -diag(N))
  Cvec = rep(negativeC, N)
  vec0 = rep(0, N+1)
  bvec = matrix(c(vec0, Cvec), ncol = 1, nrow = (2*N + 1))
}
#print(dim(Amat))
#print(dim(bvec))

res = solve.QP(Dmat = DD,dvec = d,Amat = Amat,bvec = bvec,meq = 1,factorized = FALSE)
a   = res$solution

if (plt == TRUE)
```

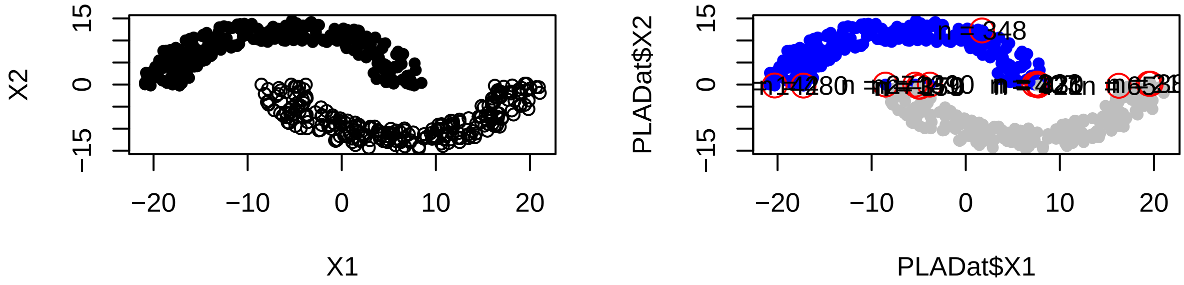
```
  {
    plot(a,type= 'h', main = expression(alpha[i]),xlab = expression(i), lwd = 2)
  }

  pad.a      = round(a,3)
  wh         = which.max(a)

  if (kern == "none")
  {
    ww = t(a*y)%*%X
    intercept = 1/y[wh] - X[wh, ]%*%t(ww)

    yhat = sign(X%*%t(ww) + intercept[1])

  }
  else if (kern == "poly")
  {

    T1 = rep(0,N)
    for(i in 1:N)
    {
      KK = polKern(x[i, ], t(X), gm, cf, dg)
      T1[i] = sum(a*y*(KK))
    }
    #print(KK)

    KKNew = polKern(x[wh,], t(x), gm, cf, dg)
    intercept = 1/y[wh]-sum(a*y*KKNew)

    yhat      = sign(T1+intercept[1])
  }
  else if (kern == "radial")
  {
    T1 = rep(0,N)
    for(i in 1:N)
    {
      T1[i] = sum(a*y*(x[i,]%*%t(x)))
    }

    KKNew = radialKern(x[wh,], t(x), gm)
    intercept = 1/y[wh]-sum(a*y*KKNew)

    yhat      = sign(T1+intercept[1])
  }

  res = list("yhat" = yhat, "padA" = pad.a, "a" = a, "intercept" = intercept)
  return(res)

}

PLADat = read.table("PLA Dynamics.txt")

plot(X2 ~ X1, col = (Y + 3), data = PLADat)
```



```
# Create data matrix:
X   = cbind(PLADat$X1,PLADat$X2)
Y = PLADat$Y

#Y[Y == -1] = 0

gm = 2
cf = 1
dg = 2

mySVM = my_svm(Y, X, "poly", 10000, TRUE, gm, cf, dg, plt = TRUE)
```



```
yhat = mySVM$yhat
padA = mySVM$padA


par(mfrow = c(2,2))
plot(X2~X1,pch = c(1,16)[(Y+1)/2+1], data = PLADat)
plot(PLADat$X2~PLADat$X1, pch = 16, col = c('grey','blue')[(yhat+1)/2+1])

wh.text = which(padA!=0)
points(PLADat$X2~PLADat$X1, pch = 1, col = c(NA,'red')[(padA>0)+1],cex=2)
text(PLADat$X2[wh.text]~PLADat$X1[wh.text],labels = paste0('n = ',wh.text))
```

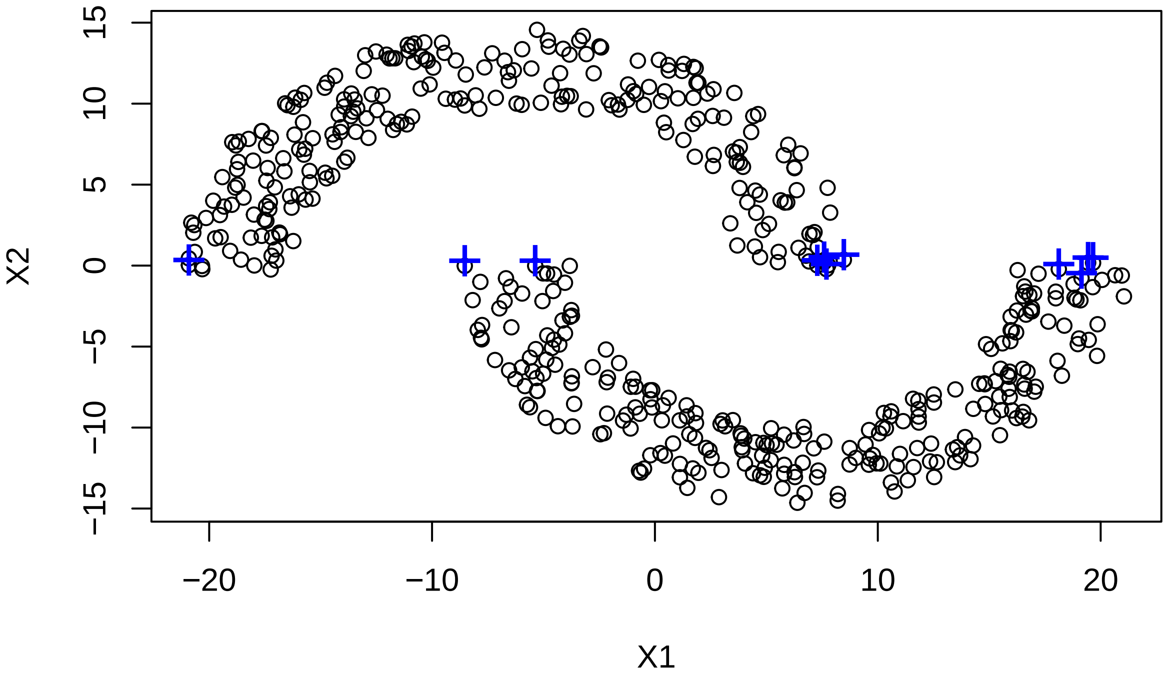


Q3b

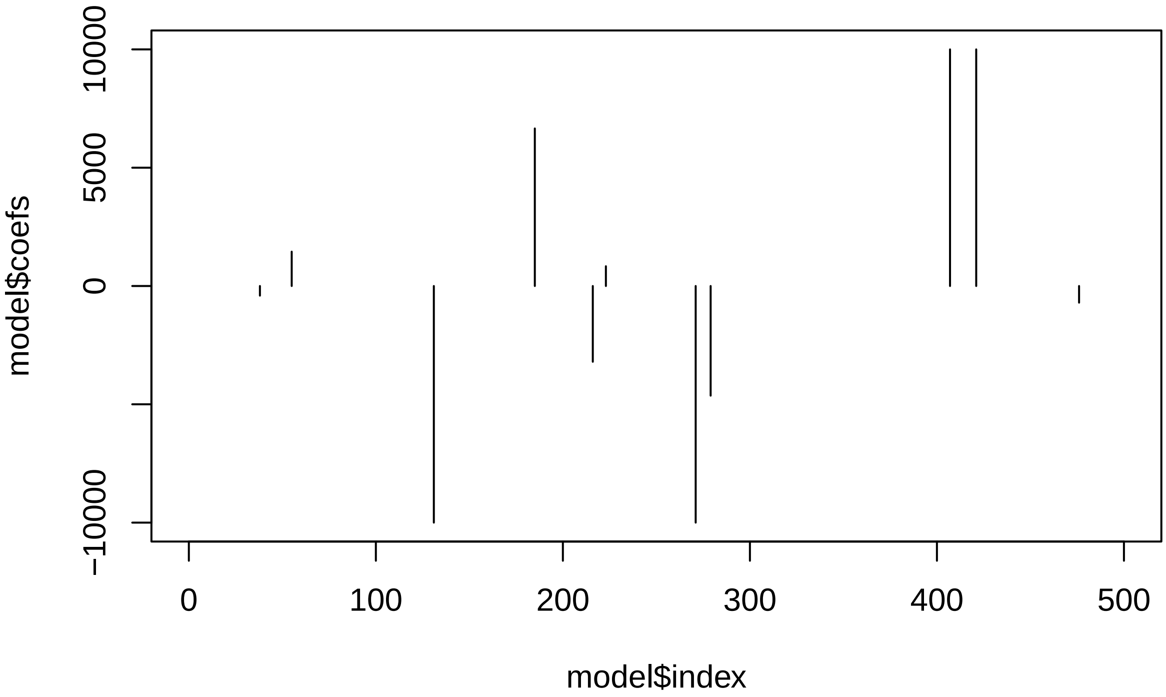
```
library('e1071')
```

```
## Warning: package 'e1071' was built under R version 4.5.1
```

```
model  = svm(Y~(X1 + X2), data = PLADat, scale = FALSE,kernel = 'polynomial',degree =dg,gamma = gm,coef(

# Our solution
plot(X2~X1, data = PLADat)

points(model$SV[,2]~model$SV[,1],pch = '+', col = 'blue',cex = 2)
```



```
N = dim(X)[1]
plot(model$coefs~model$index,type = 'h',xlim = c(0,N))
```


10000
5000
0
−10000
model$coefs
0
100
200
300
400
500
model$index