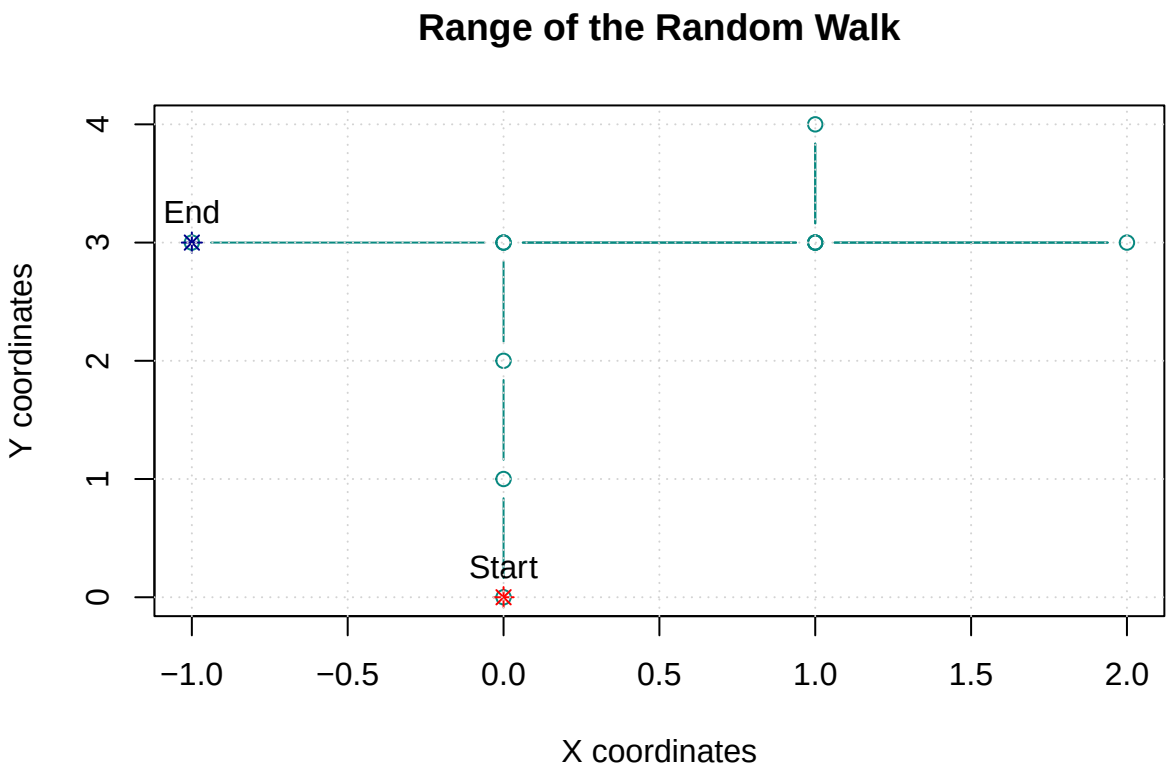
Introduction to Statistics and Computation with Data
Apple Bread Problem

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(a) n = 10 and x = 0 (origin)

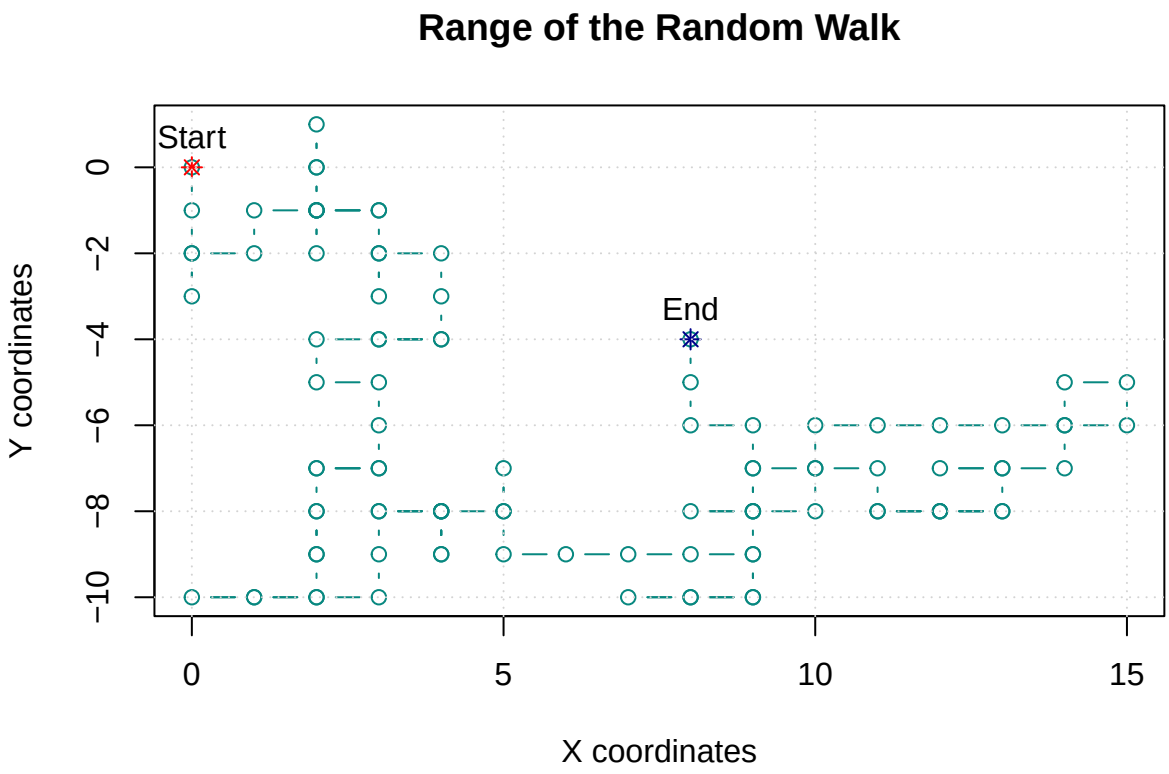
```
coord = c(0,1,2,3)
coord_prob = c(0.25,0.25,0.25,0.25)
x = c(0,0)

directions = sample(coord, 10, replace = TRUE, coord_prob)
pos = matrix(0,nrow = 11, ncol = 2)
for (i in 1:10){
  if (directions[i] == 0){
    x = x + c(1,0)
    pos[i+1,] = x
  } else if (directions[i] == 1){
    x = x + c(-1,0)
    pos[i+1,] = x
  } else if (directions[i] == 2){
    x = x + c(0,1)
    pos[i+1,] = x
  } else if (directions[i] == 3){
    x = x + c(0,-1)
    pos[i+1,] = x
  }
}
plot(pos[,1],pos[,2], type = "b", col = "#088880", main = "Range of the Random Walk",
     ylab = "Y coordinates", xlab = "X coordinates",)
points(pos[1,1],pos[1,2], col = "red", pch = 8)
points(pos[11,1],pos[11,2], col = "darkblue", pch = 8)
text(x = c(pos[1,1],pos[11,1]), y = c(pos[1,2],pos[11,2]),
     labels = c("Start","End"), pos = 3)
grid()
```


Range of the Random Walk
End
Start
Y coordinates
X coordinates
0
1
2
3
4
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0

b) n = 100 and x = 0 (origin)

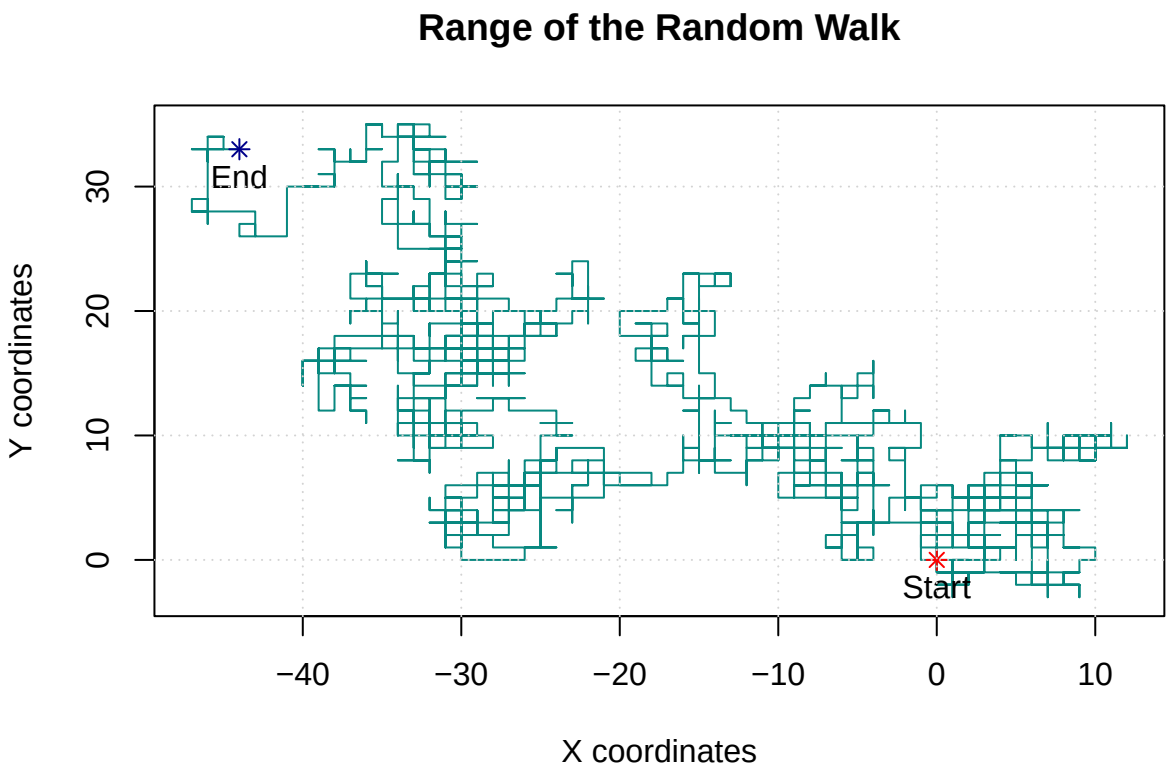
```
coord = c(0,1,2,3)
coord_prob = c(0.25,0.25,0.25,0.25)
directions = sample(coord, 100, replace = TRUE, coord_prob)
x = c(0,0)
pos = matrix(0,nrow = 101, ncol = 2)
for (i in 1:100){
  if (directions[i] == 0){
    x = x + c(1,0)
    pos[i+1,] = x
  } else if (directions[i] == 1){
    x = x + c(-1,0)
    pos[i+1,] = x
  } else if (directions[i] == 2){
    x = x + c(0,1)
    pos[i+1,] = x
  } else if (directions[i] == 3){
    x = x + c(0,-1)
    pos[i+1,] = x
  }
}
plot(pos[,1],pos[,2], type = "b",
     col = "#088880",
     main = "Range of the Random Walk",
     ylab = "Y coordinates",
     xlab = "X coordinates",)
points(pos[1,1],pos[1,2], col = "red", pch = 8)
points(pos[101,1],pos[101,2], col = "darkblue", pch = 8)
text(x = c(pos[1,1],pos[101,1]),
     y = c(pos[1,2],pos[101,2]),
     labels = c("Start","End"),
     pos = 3)
grid()
```


Range of the Random Walk
Start
End
Y coordinates
0
−2
−4
−6
−8
−10
0
5
10
15
X coordinates

(c). x = 0 and till the first time the walk hits a point at a distance 55 from the origin.

```
randomwalk = function(a,b, pos_x, pos_y){
  coord = c(0,1,2,3)
  x = c(a,b)
  repeat
  {
    directions = sample(coord, 1)
    if (directions == 0){
      x = x + c(1,0)
    } else if (directions == 1){
      x = x + c(-1,0)
    } else if (directions == 2){
      x = x + c(0,1)
    } else if (directions == 3){
      x = x + c(0,-1)
    }
    pos_x[length(pos_x) + 1] = x[1]
    pos_y[length(pos_y) + 1] = x[2]
    if(x[1]^2 + x[2]^2 == 3025)
    {
      break
    }
  }
  plot(pos_x,pos_y, type = "l",
     col = "#088880",
     main = "Range of the Random Walk",
     ylab = "Y coordinates",
     xlab = "X coordinates",)
  points(0,0, col = "red", pch = 8)
  points(pos_x[length(pos_x)],pos_y[length(pos_y)], col = "darkblue", pch = 8)
  text(x = c(0,pos_x[length(pos_x)]),
       y = c(0,pos_y[length(pos_y)]),
       labels = c("Start","End"),
       pos = 1)
  grid()

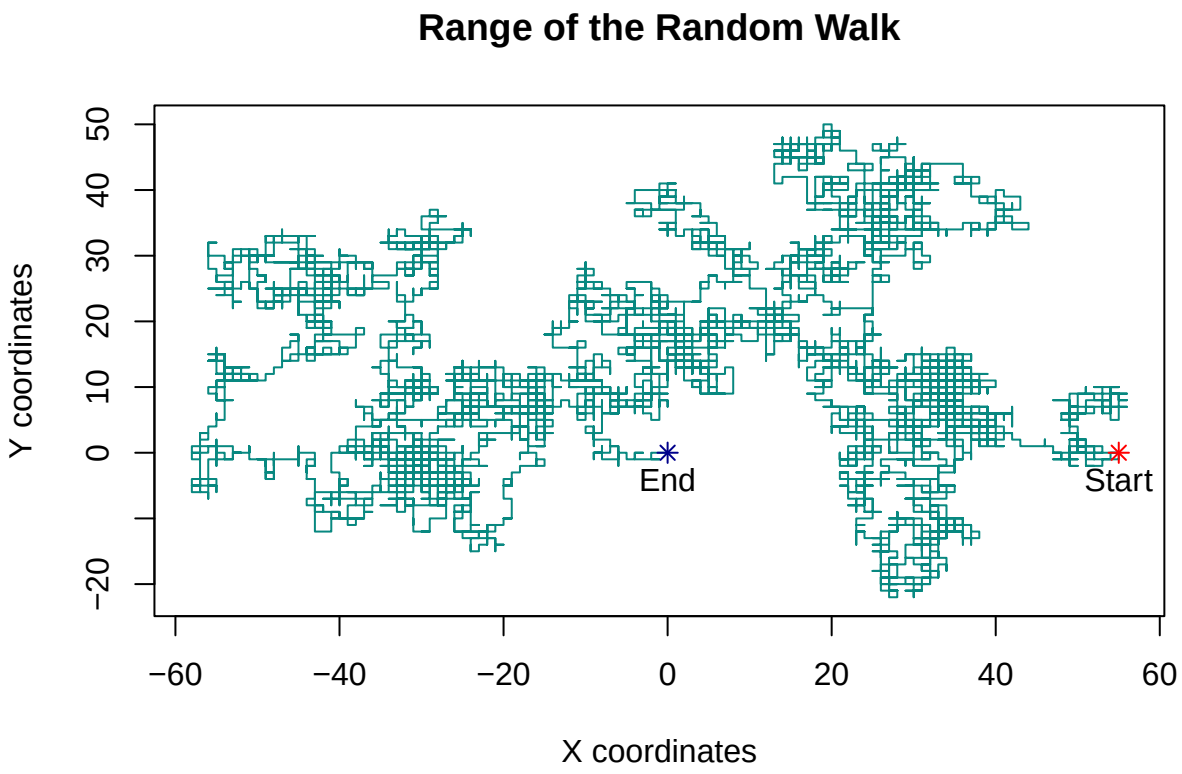
}
randomwalk(0,0, c(0), c(0))
```


Range of the Random Walk
End
Start
Y coordinates
X coordinates
0
10
20
30
−40
−30
−20
−10
0
10

(d) x = (55,0) and till the first time the walk hits the origin.

```
randomwalk = function(a,b, pos_x, pos_y){
  coord = c(0,1,2,3)
  x = c(a,b)
  repeat
  {
    directions = sample(coord, 1)
    if (directions == 0){
      x = x + c(1,0)
    } else if (directions == 1){
      x = x + c(-1,0)
    } else if (directions == 2){
      x = x + c(0,1)
    } else if (directions == 3){
      x = x + c(0,-1)
    }
    pos_x[length(pos_x) + 1] = x[1]
    pos_y[length(pos_y) + 1] = x[2]
    if(x[1] == 0 & x[2] == 0)
    {
      break
    }
  }
  plot(pos_x, pos_y, type = "l",
       col = "#088880",
       main = "Range of the Random Walk",
       ylab = "Y coordinates",
       xlab = "X coordinates")
  points(55,0, col = "red", pch = 8)
  points(0,0, col = "darkblue", pch = 8)
  text(x = c(55,0),
       y = c(0,0),
       labels = c("Start","End"),
       pos = 1)

}
randomwalk(55,0,c(55),c(0))
```


Range of the Random Walk
Y coordinates
50
40
30
20
10
0
−20
−60
−40
−20
0
20
40
60
X coordinates
End
Start