Apple Bread Problem

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(A)

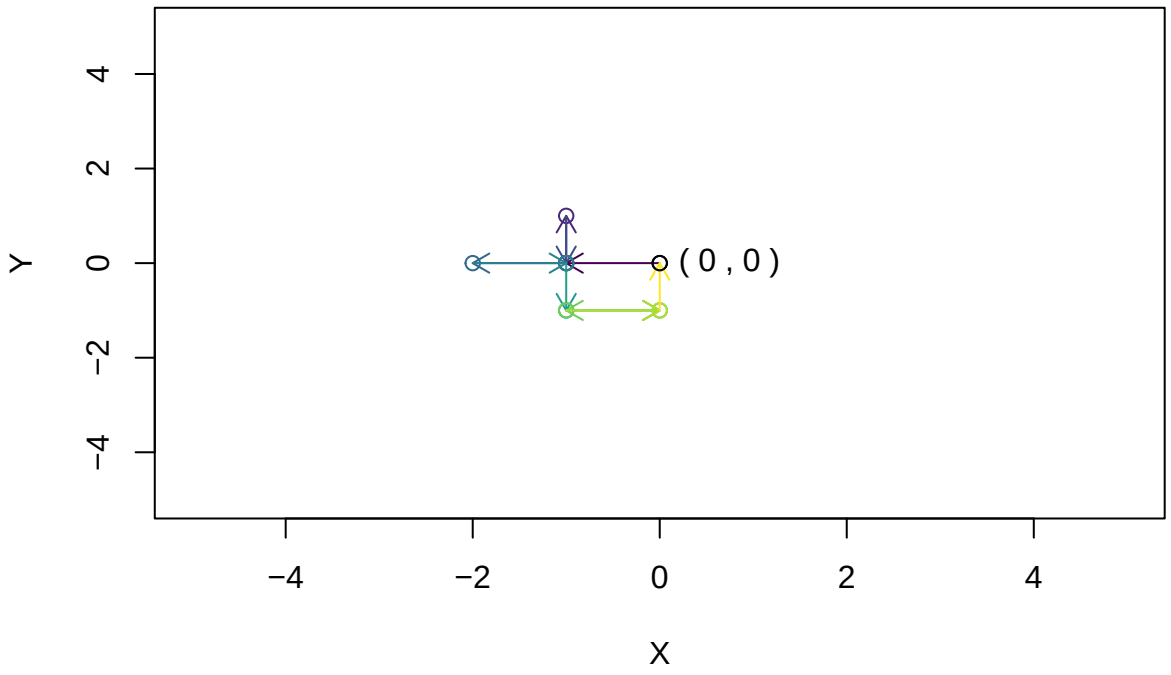
```
library(viridisLite)
rw = function() {
  x = 0
  y = 0
  plot(x, y, xlim = c(-5, 5), ylim = c(-5, 5), xlab = "X", ylab = "Y")

  A = runif(10, -1, 1)
  B = runif(10, -1, 1)
  colors = viridis(10)

  for (i in 1:9){
    x_1 = x + (-1 + (-1)^(floor(A[i])))/2*(-1)^(floor(B[i]))
    y_1 = y + (-1 + (-1)^(1 - floor(A[i])))/2*(-1)^(floor(B[i]))
    arrows(x, y, x_1, y_1, length=0.1, col = colors[i])
    points(x_1, y_1, col = colors[i])
    x = x_1
    y = y_1
  }

  # I will write another for loop to make the last position of the random walk a black dot,
  #which will be easily visible.
  for (i in 10){
    x_1 = x + (-1 + (-1)^(floor(A[i])))/2*(-1)^(floor(B[i]))
    y_1 = y + (-1 + (-1)^(1 - floor(A[i])))/2*(-1)^(floor(B[i]))
    arrows(x, y, x_1, y_1, length=0.1, col = colors[i])
    points(x_1, y_1)
    text(x_1, y_1, paste("(", round(x_1, 2), ",", round(y_1, 2), ")"), pos = 4)
    x = x_1
    y = y_1
  }
}

rw()
```



(B)

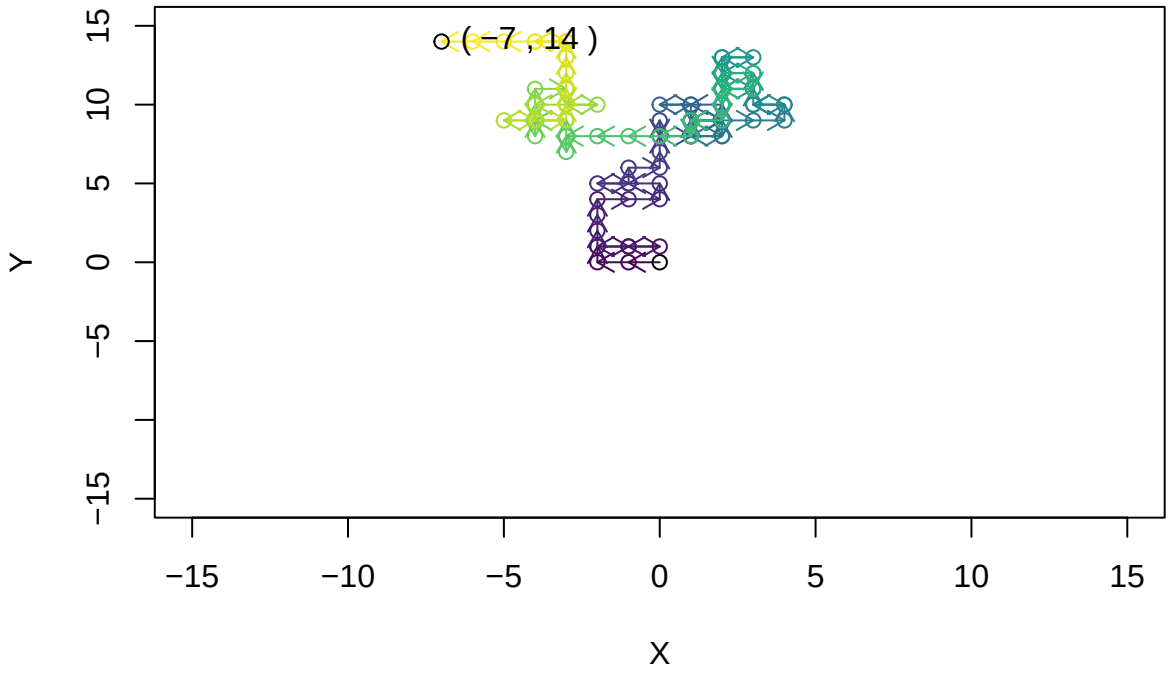
```
library(viridisLite)
rw = function() {
  x = 0
  y = 0
  plot(x, y, xlim = c(-15, 15), ylim = c(-15, 15), xlab = "X", ylab = "Y")

  A = runif(100, -1, 1)
  B = runif(100, -1, 1)
  colors = viridis(100)

  for (i in 1:100){
    x_1 = x + (-1 + (-1)^(floor(A[i])))/2*(-1)^(floor(B[i]))
    y_1 = y + (-1 + (-1)^(1 - floor(A[i])))/2*(-1)^(floor(B[i]))
    arrows(x, y, x_1, y_1, length=0.1, col = colors[i])
    points(x_1, y_1, col = colors[i])
    x = x_1
    y = y_1
  }

  # I will write another for loop to make the last position of the random walk a black dot,
  #which will be easily visible.
  for (i in 100){
    x_1 = x + (-1 + (-1)^(floor(A[i])))/2*(-1)^(floor(B[i]))
    y_1 = y + (-1 + (-1)^(1 - floor(A[i])))/2*(-1)^(floor(B[i]))
    arrows(x, y, x_1, y_1, length=0.1, col = colors[i])
    points(x_1, y_1)
    text(x_1, y_1, paste("(", round(x_1, 2), ",", round(y_1, 2), ")"), pos = 4)
    x = x_1
    y = y_1
  }
}
```

```
rw()
```



(C)

```
library(viridisLite)
rw = function() {
  x = 0
  y = 0
  plot(x, y, xlim = c(-85, 125), ylim = c(-55, 55), xlab = "X", ylab = "Y")

  A = runif(3025, -1, 1)
  B = runif(3025, -1, 1)
  colors = viridis(3025)

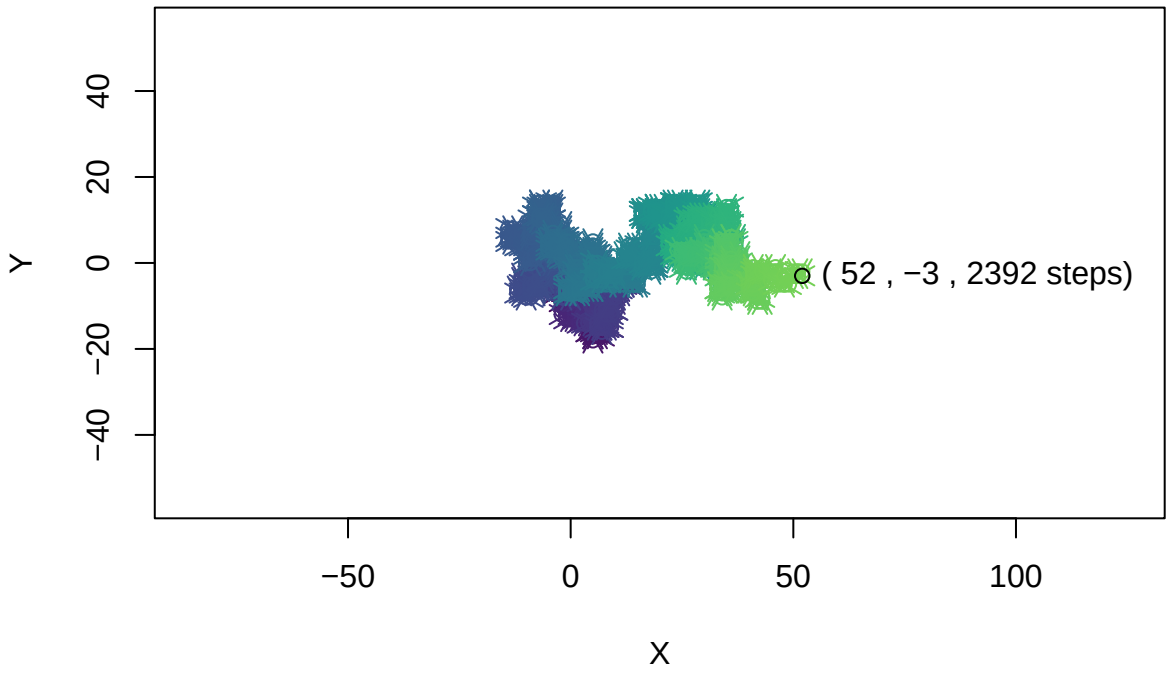
  for (i in 1:3025){
    x_1 = x + (-1 + (-1)^(floor(A[i])))/2*(-1)^(floor(B[i]))
    y_1 = y + (-1 + (-1)^(1 - floor(A[i])))/2*(-1)^(floor(B[i]))
    arrows(x, y, x_1, y_1, length=0.1, col = colors[i])
    points(x_1, y_1, col = colors[i])

    # Using taxicab distance

    if (abs(x) + abs(y) >= 55){
      points(x, y)
      text(x, y, paste("(", round(x, 2), ",", round(y, 2), ",", i, "steps)"), pos = 4)
      break;
    }

    x = x_1
    y = y_1
  }
}
```

```
rw()
```



(D)

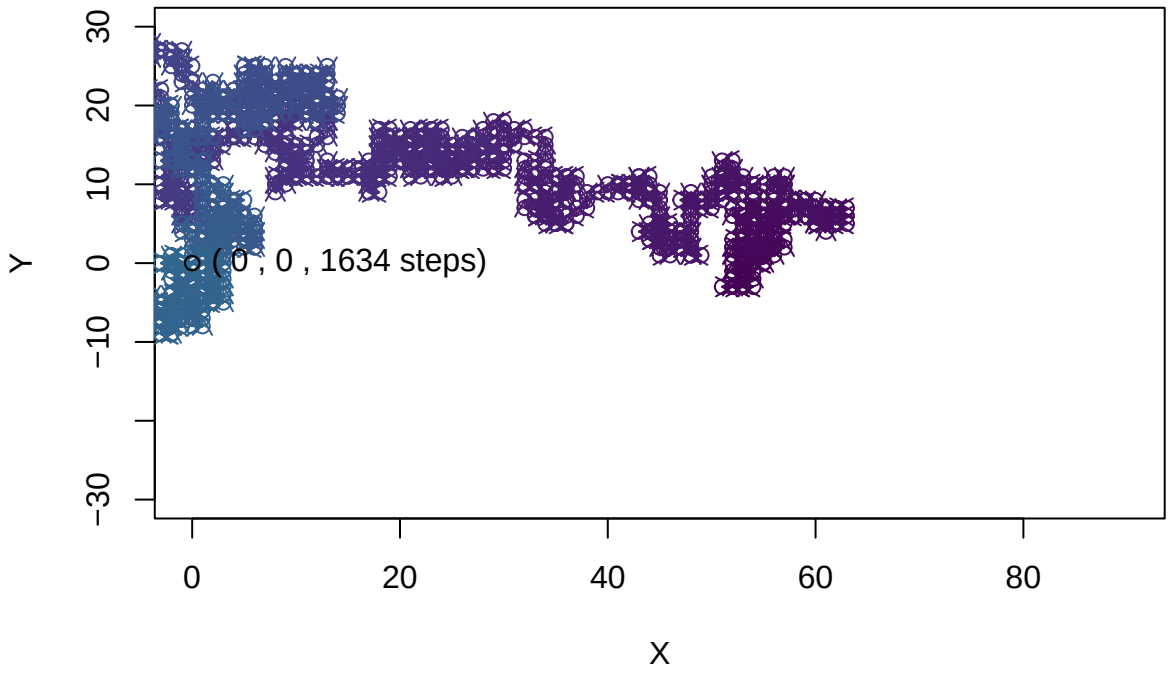
```
library(viridisLite)
rw = function() {
  x = 55
  y = 0
  plot(x, y, xlim = c(0, 90), ylim = c(-30, 30), xlab = "X", ylab = "Y")
  set.seed(109)
  A = runif(5000, -1, 1)
  B = runif(5000, -1, 1)
  colors = viridis(5000)

  for (i in 1:5000){
    x_1 = x + (-1 + (-1)^(floor(A[i])))/2*(-1)^(floor(B[i]))
    y_1 = y + (-1 + (-1)^(1 - floor(A[i])))/2*(-1)^(floor(B[i]))
    arrows(x, y, x_1, y_1, length=0.1, col = colors[i])
    points(x_1, y_1, col = colors[i])

    if (x ==0 && y ==0){
      points(x, y)
      text(x, y, paste("(", round(x, 2), ",", round(y, 2), ",", i, "steps)"), pos = 4)
      break;
    }

    x = x_1
    y = y_1
  }
}

rw()
```


o (0 , 0 , 1634 steps)
Y
X
30
20
10
0
−10
−30
0
20
40
60
80