An Ant looking for food

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Introduction

An ant leaves its ant hill to look for food. The ant walks at speed of $10cm$ per 1 second and it moves randomly towards north, south, east and weat with equal probability.

Question 1

The food is located $20cm$ away from the ant hill. In this case, the ant walks towards one of the four directions randomly at each step, and it starts exactly $20cm$ away from the food. This process is a random walk with $|10|cm$ per second. Each step randomly moves to one of the four directions with equal probability.

```
Walk_Q1 <- function(t){ # t is the second/step

  walks <- 0  #starts from 20cm outside the center
  #walks <- runif(n = 1, min = 0.01, max = 10.01) #start on the line of (10cm,0cm) and (0cm,10cm)

  for (s in 1:t){

  walks <- c(walks, walks[length(walks)] + sample(c(10,-10, 10,-10), size = 1, replace = TRUE))

}

return(walks)


}
```

```
# run this process many times
t = 100
outcomes_Q1 <- replicate(n = 500, Walk_Q1(t))

#the first occurrence at 20cm or -20cm means the ant successfully foraged the food

simu_timeQ1 <- apply(outcomes_Q1, 2, function(v){which(abs(v) == 20)[1]})

mean(simu_timeQ1) # the average time (seconds) an ant spent to forage food outside 20cm away from ant h
```

```
## [1] 4.876
```

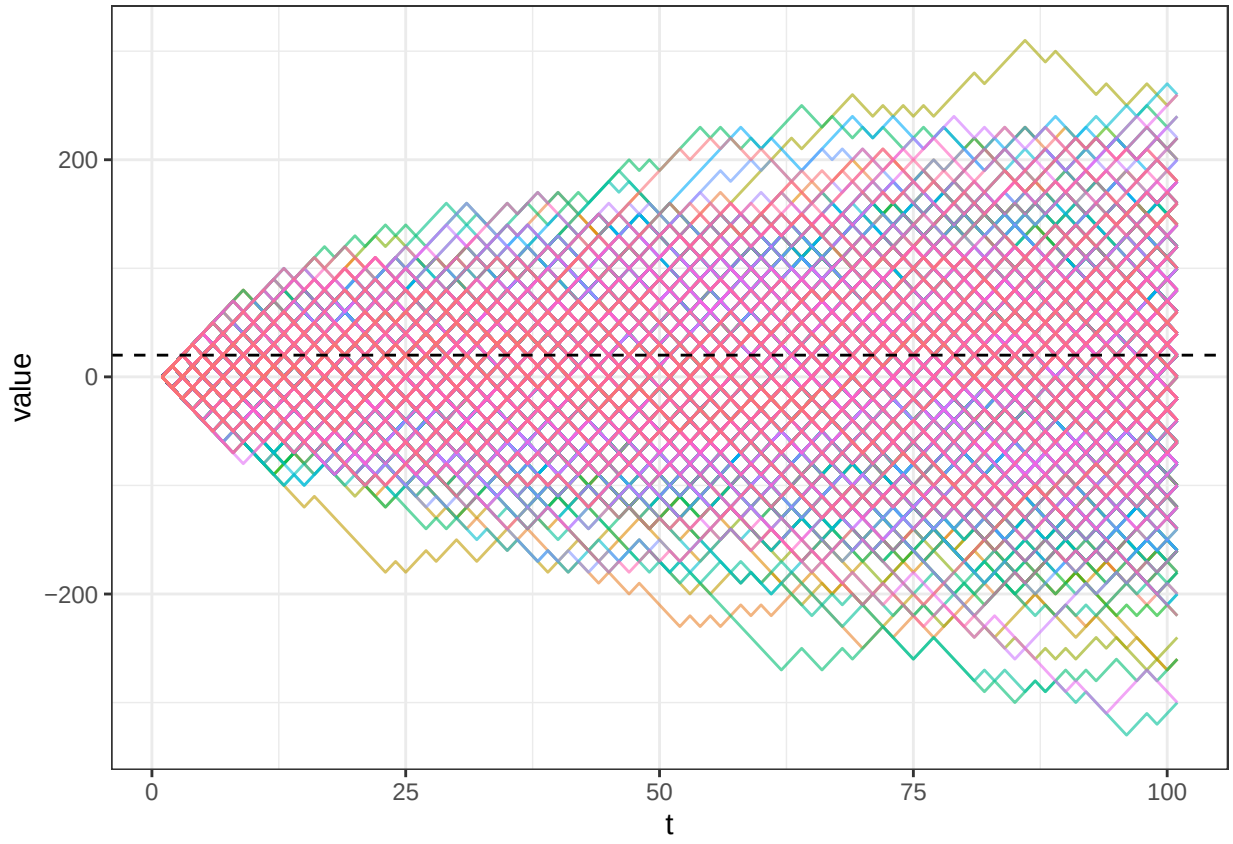
```r
sd(simu_timeQ1)
```

```
## [1] 2.524554
```

```r
dt1 <- data.table(t = 1:(t+1),
                  outcomes_Q1)


dt1 <- melt(dt1, id.vars = "t")


ggplot(dt1, aes(x = t, y = value, col = variable)) +
  geom_line(alpha = 0.6) +
  theme_bw() + theme(legend.position = "none") +
  geom_hline(yintercept = 20, linetype = "dashed")
```



Question 2

The food is still at the same location, but the ant can only start moving at the coordinates of $(10cm, 0)$ and $(0, 10cm)$. In this case, the starting point for an ant is uniformly distributed within the range of 0 and 10.

```r
Walk_Q2 <- function(t2){ # t is the second/step
```

```
  walks <- runif(n = 1, min = 0, max = 10) #start on the line of (10cm,0cm) and (0cm,10cm)

  for (s in 1:t2){

  walks <- c(walks, walks[length(walks)] + sample(c(10,-10, 10,-10), size = 1, replace = TRUE))

}

return(walks)


}
```

```
# run this process many times
t2 = 100
outcomes_Q2 <- replicate(n = 500, Walk_Q2(t2))

#the first occurrence at 20cm or -20cm means the ant successfully foraged the food

simu_timeQ2 <- apply(outcomes_Q2, 2, function(v){which(abs(v) == 20)[1]})

mean(simu_timeQ2) # the average time (seconds) an ant spent to forage food outside 20cm away from ant h
```

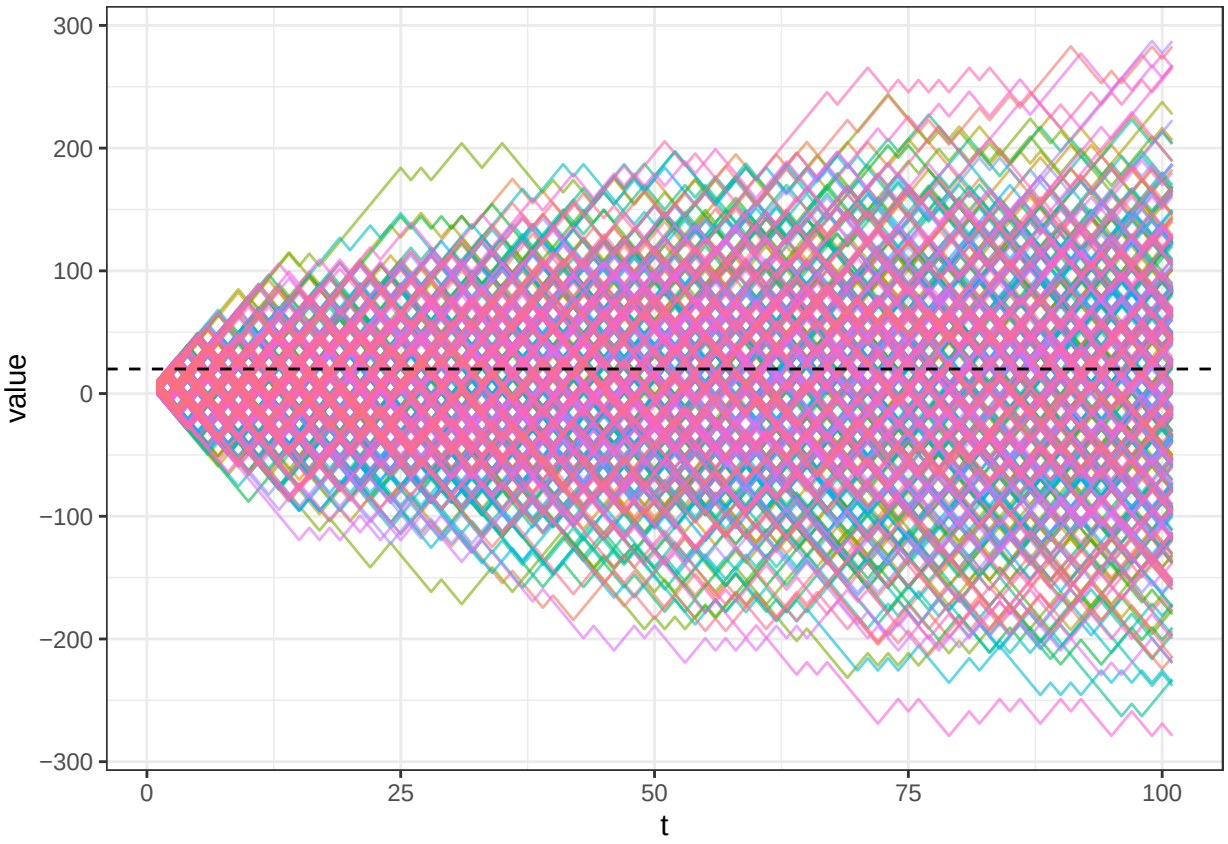
```
## [1] NA
```

```
# The average time for foraging the food is "NA", which means non converging. Thus, the ant cannot reac
```

```
dt2 <- data.table(t = 1:(t2 + 1), outcomes_Q2)

dt2 <- melt(dt2, id.vars = "t")


ggplot(dt2, aes(x = t, y = value, col = variable)) +
  geom_line(alpha = 0.6) +
  theme_bw() + theme(legend.position = "none") +
  geom_hline(yintercept = 20, linetype = "dashed")
```



Question 3

The ant hill is located at $x = 0cm$, $y = 0cm$, and the food is located at a closed boundary $(\frac{x-2.5cm}{30cm})^2 + (\frac{y-2.5cm}{40})^2 < 1$.

```
Walk_Q3 <- function(t3){

  x_cor <- 0
  y_cor <- 0

  for (i in 1:t3)
  {
    #if walk along x coordinate
    x_cor <- c(x_cor, x_cor[length(x_cor)] + sample(c(10,-10), size = 1, replace = TRUE))

    #if walk alone y coordinate
    y_cor <- c(y_cor, y_cor[length(y_cor)] + sample(c(10,-10), size = 1, replace = TRUE))
  }


  boundary = ((x_cor - 2.5)/30)^2 + ((y_cor - 2.5)/40)^2 < 1

  return(boundary)
}
```

```r
# run this process many times
t3 = 100
outcomes_Q3 <- replicate(n = 1000, Walk_Q3(t3))

#the first occurrence at 20cm or -20cm means the ant successfully foraged the food

simu_timeQ3 <- apply(outcomes_Q3, 2, function(v){which(v == FALSE)[1]}) # the first occurence of FALSE

mean(simu_timeQ3)
```

```
## [1] 9.118
```

```r
sd(simu_timeQ3)
```

```
## [1] 5.868604
```