Placement

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Note: the github repo for this work is: https://github.com/sheny2/Placement

Q1

Task 1: Read the data Scrape the wikipedia page on natural disasters

```r
url <- "https://en.wikipedia.org/wiki/List_of_natural_disasters_by_death_toll"

webpage <- read_html(url)

tables <- webpage %>% html_nodes("table.wikitable")

# 20th and 21st century data are the 2nd and 3rd table of this page
table_20th <- tables[[2]] %>% html_table(fill = TRUE)
table_21st <- tables[[3]] %>% html_table(fill = TRUE)

disasters <- rbind(table_20th, table_21st) %>% as_tibble()

head(disasters)
```

```
## # A tibble: 6 x 6
##    Year ‘Death toll‘ Event                         ‘Countries affected‘ Type  Date
##   <int> <chr>        <chr>                         <chr>                <chr> <chr>
## 1  1900 6,000-12,000 1900 Galveston hurricane     United States        Trop~ Sept~
## 2  1901 9,500        1901 eastern United State~  United States        Heat~ June~
## 3  1902 29,000       1902 eruption of Mount Pe~  Martinique           Volc~ Apri~
## 4  1903 3,500        1903 Manzikert earthquake    Turkey               Eart~ Apri~
## 5  1904 400          1904 Sichuan earthquake      China                Eart~ Augu~
## 6  1905 20,000+      1905 Kangra earthquake       India                Eart~ Apri~
```

Task 2: Clean the data Convert the death toll to numbers using the midpoints when a range is given and the bound when an upper or lower bound is given.

```r
disasters_clean = disasters

disasters_clean$`Death toll` = disasters$`Death toll` %>%
                                          str_remove_all(",") %>%
                                          str_remove_all("\\[.*?\\]") %>%
                                          str_remove_all("\\(.*?\\)") %>%
                                          str_remove_all("[a-zA-Z]") %>%
                                          str_trim()
```

```r
# which entries need special attention to clean
list_of_clean = is.na(as.numeric(gsub("," ,"", disasters_clean$`Death toll`)))
disasters$`Death toll`[list_of_clean]
```

```
##  [1] "6,000-12,000"      "20,000+"           "12,000-15,000"    
##  [4] "75,000-82,000"     "6,000-8,000"       "50,000-220,000"   
##  [7] "942-1,900"         "29,978-32,610"     "2,000-10,000"     
## [10] "258,707-273,407"   "50,000-100,000+"   "105,385-142,800"  
## [13] "4,112+"            "3,257-3,800"       "2,000-8,000"      
## [16] "422,499-4,000,000" "3,103+"            "6,865-9,300"      
## [19] "10,700-12,000"     "5,000+"            "715+"             
## [22] "32,700-32,968"     "2,824-5,000"       "10,000-110,000"   
## [25] "1,023+"            "300,000-500,000"   "2,175-2,204"      
## [28] "8,210+"            "26,000-240,000"    "242,419-655,000"  
## [31] "10,000-50,000"     "15,000-25,000"     "2,633-5,000"      
## [34] "25,000-50,000"     "35,000-45,000"     "17,126-18,373"    
## [37] "700-800"           "13,805-20,023"     "86,000-87,351"    
## [40] "5,749-5,778"       "100,000-316,000"   "3,951+"           
## [43] "59,259-62,013"     "320-600(estimate)"
```

```r
# use regular expression here
convert_death_toll <- function(toll) {
  if (str_detect(toll, "\\d+\\s*-\\s*\\d+")) {
    nums <- str_extract_all(toll, "\\d+")[[1]] %>% as.numeric()
    return(mean(nums))
  } else if (str_detect(toll, "\\d+\\s*-\\s*\\d+")) {
    nums <- str_extract_all(toll, "\\d+")[[1]] %>% as.numeric()
    return(mean(nums))
  } else if (str_detect(toll, ">\\s*\\d+")) {
    return(as.numeric(str_extract(toll, "\\d+")))
  } else if (str_detect(toll, "\\d+")) {
    return(as.numeric(str_extract(toll, "\\d+")))
  }
}

death_toll_clean = round(sapply(disasters_clean$`Death toll`, convert_death_toll))
death_toll_clean[list_of_clean] # check the results of those irregular ones
```

```
##     6000-12000         20000+    12000-15000    75000-82000      6000-8000 
##           9000          20000          13500          78500           7000 
##   50000-220000       942-1900    29978-32610     2000-10000  258707-273407 
##         135000           1421          31294           6000         266057 
##  50000-100000+  105385-142800          4112+      3257-3800      2000-8000 
##          75000         124092           4112           3528           5000 
## 422499-4000000          3103+      6865-9300    10700-12000          5000+ 
##        2211250           3103           8082          11350           5000 
##           715+    32700-32968      2824-5000   10000-110000          1023+ 
##            715          32834           3912          60000           1023 
##  300000-500000      2175-2204          8210+   26000-240000  242419-655000 
##         400000           2190           8210         133000         448710 
##    10000-50000    15000-25000      2633-5000    25000-50000    35000-45000 
##          30000          20000           3816          37500          40000 
##    17126-18373        700-800    13805-20023    86000-87351      5749-5778 
##          17750            750           16914           86676           5764
##  100000-316000          3951+     59259-62013         320-600
##         208000           3951           60636             460
```

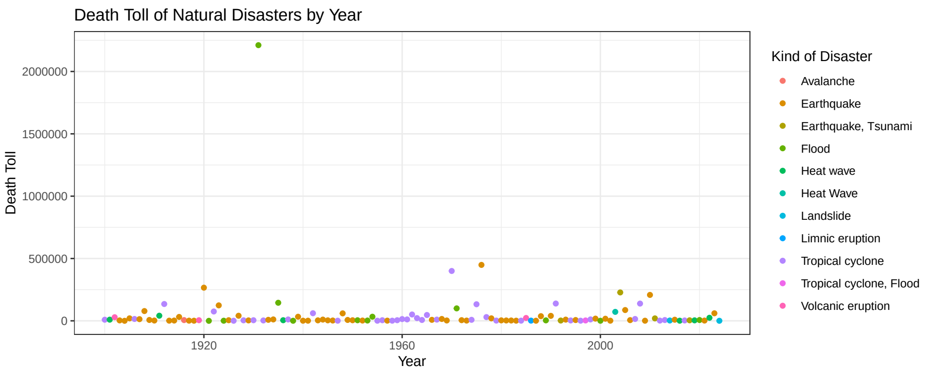
```r
disasters_clean$`Death toll` = death_toll_clean
disasters_clean
```

```
## # A tibble: 125 x 6
##     Year ‘Death toll‘ Event                     ‘Countries affected‘ Type  Date 
##    <int>        <dbl> <chr>                     <chr>                <chr> <chr>
##  1  1900         9000 1900 Galveston hurricane  United States        Trop~ Sept~
##  2  1901         9500 1901 eastern United Stat~ United States        Heat~ June~
##  3  1902        29000 1902 eruption of Mount P~ Martinique           Volc~ Apri~
##  4  1903         3500 1903 Manzikert earthquake Turkey               Eart~ Apri~
##  5  1904          400 1904 Sichuan earthquake   China                Eart~ Augu~
##  6  1905        20000 1905 Kangra earthquake    India                Eart~ Apri~
##  7  1906        15000 1906 Hong Kong typhoon    Hong Kong,China      Trop~ Sept~
##  8  1907        13500 1907 Qaratog earthquake   Uzbekistan           Eart~ Octo~
##  9  1908        78500 1908 Messina earthquake   Italy                Eart~ Dece~
## 10  1909         7000 1909 Borujerd earthquake  Iran                 Eart~ Janu~
## # i 115 more rows
```

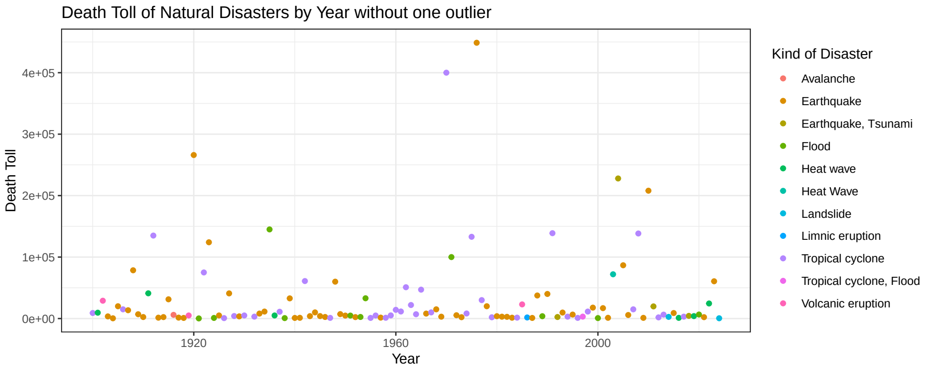
Task 3: Plot the data

```r
# Convert the year to numeric
disasters_clean <- disasters_clean %>%
  mutate(Year = as.numeric(gsub("[^0-9]", "", `Year`)))

# Plot the death toll by year, color-coded by kind of disaster
ggplot(disasters_clean, aes(x = Year, y = `Death toll`, color = Type)) +
  geom_point() +
  labs(title = "Death Toll of Natural Disasters by Year",
       x = "Year",
       y = "Death Toll",
       color = "Kind of Disaster")
```



```r
ggplot(disasters_clean %>% filter(Event != "1931 China floods"),
       aes(x = Year, y = `Death toll`, color = Type)) +
  geom_point() +
  labs(title = "Death Toll of Natural Disasters by Year without one outlier",
       x = "Year",
       y = "Death Toll",
       color = "Kind of Disaster")
```



Q2

First we derive the form of gradient by computing the derivative:

$$\frac{\partial||y-bx||^2}{\partial b} = 2(\frac{\partial\sum(y_i-bx_i)}{\partial b}) = 2(\frac{-x_i\sum(y_i-bx_i)}{n})$$

```
# write the gradient descent function
gradient_descent <- function(x, y, learning_rate, num_iter) {
  b <- 0
  n <- length(x)

  for (i in 1:num_iter) {
    gradient <- -2 * sum(x * (y - b * x)) / n # compute gradient
    b <- b - learning_rate * gradient # update here
  }

  return(b)
}

# Test the function using randomly generated normal vectors
set.seed(8848)
n <- 100
x <- rnorm(n)
b <- 2
y <- b * x + rnorm(n)

S <- 1000

b_estimated <- gradient_descent(x, y, learning_rate = 0.01, num_iter = S)

# Compare
b
```

```
## [1] 2
```

```
b_estimated
```

```
## [1] 2.015827
```

```
b_est_all = c()

# To test different learning rates
test_learning_rates <- function(x, y, b, learning_rates, num_iter) {
  results <- data.frame(learning_rate = c(), estimated_b = c())

  for (lr in learning_rates) {
    b_est <- gradient_descent(x, y, lr, num_iter)
    # error <- abs(b - b_est)
    results <- rbind(results, data.frame(learning_rate = lr, estimated_b = b_est))
  }

  return(results)
}
```

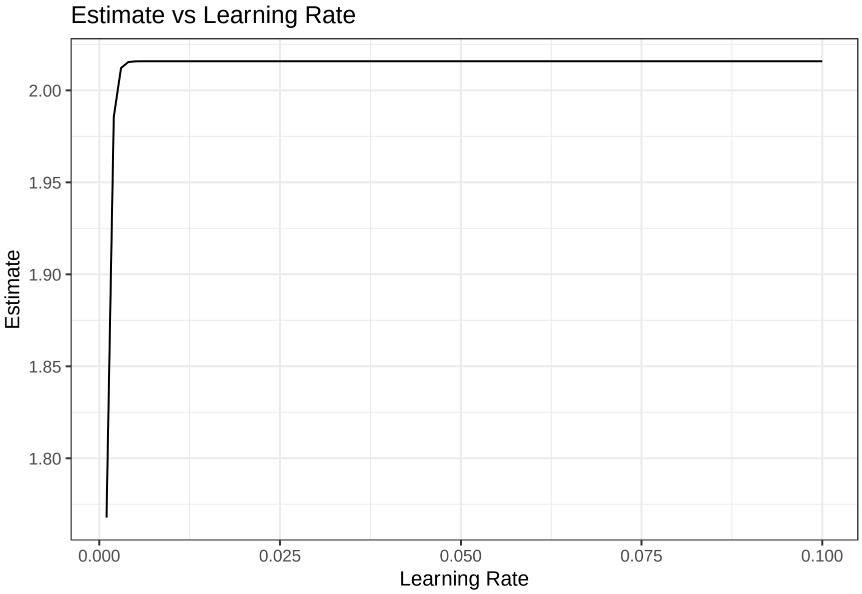
Findings: The algorithm can perform well as long as we choose a reasonable value for the learning rate.

We can see from below that the learning rate should not be too small. A too-small step size can make it inefficient for the algorithm to explore and reach convergence or get stuck at a local min instead of global mean.

Meanwhile, we also do not want the step size to be too large at each update, which could cause our estimate to oscillate too much and miss the optimal point.

```
learning_rates <- seq(0.001, 0.1, by = 0.001)
results <- test_learning_rates(x, y, b_true, learning_rates, num_iter = S)

# Plot the results
ggplot(results, aes(x = learning_rate, y = estimated_b)) +
  geom_line() +
  labs(title = "Estimate vs Learning Rate", x = "Learning Rate", y = "Estimate")
```


Estimate vs Learning Rate
Estimate
Learning Rate