HW5_567

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```r
library(ggplot2)
```

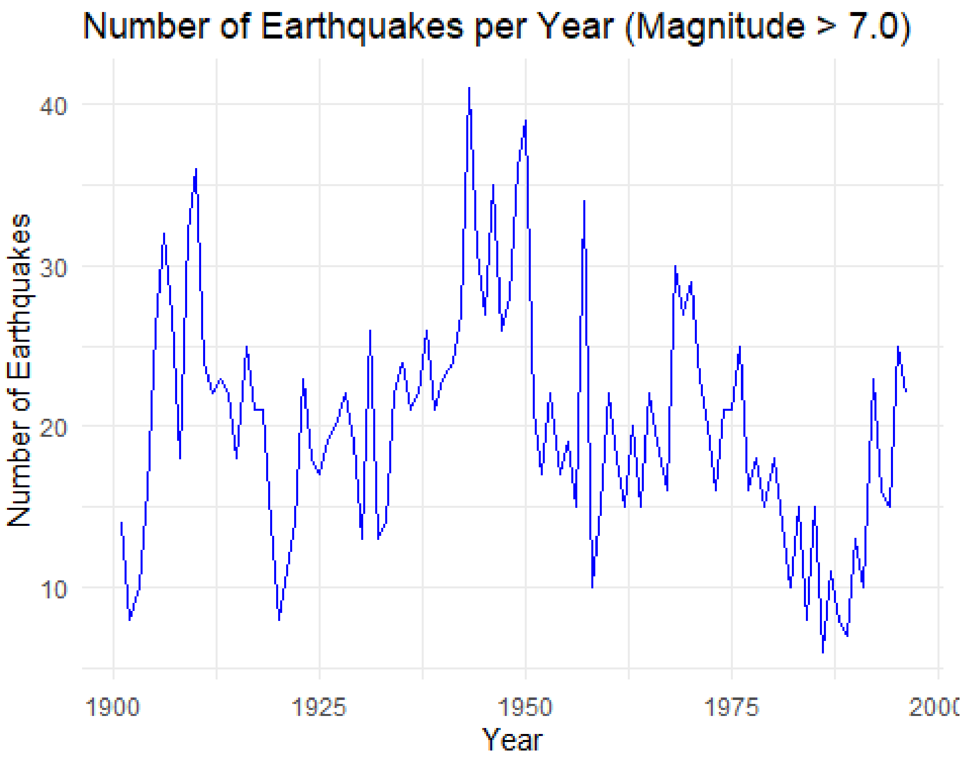
#Question 1

```r
earthquakes <- read.csv("Data/earthquakes.csv")
head(earthquakes)
```

```
##   year quakes
## 1 1901     14
## 2 1902      8
## 3 1903     10
## 4 1904     16
## 5 1905     26
## 6 1906     32
```

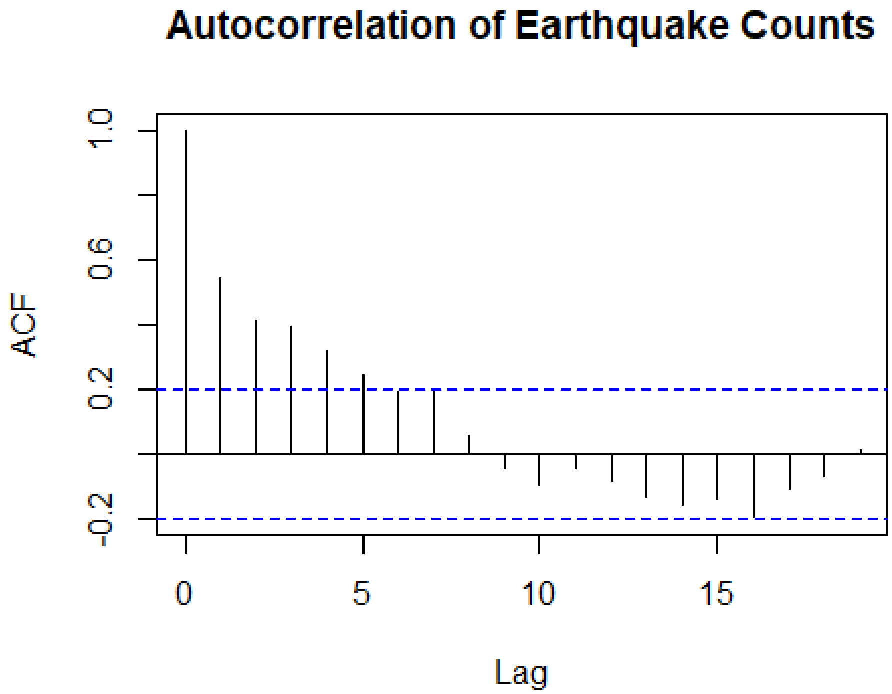
##a Create summary plots of the data. Specifically, create a (line) plot of number of earthquakes per year. Also use acf() to create an autocorrelation plot.

```r
ggplot(data = earthquakes, aes(x = year, y = quakes)) +
  geom_line(color = "blue") +
  labs(title = "Number of Earthquakes per Year (Magnitude > 7.0)",
       x = "Year",
       y = "Number of Earthquakes") +
  theme_minimal()
```



Number of Earthquakes per Year (Magnitude > 7.0)

```
acf(earthquakes$quakes, main = "Autocorrelation of Earthquake Counts")
```



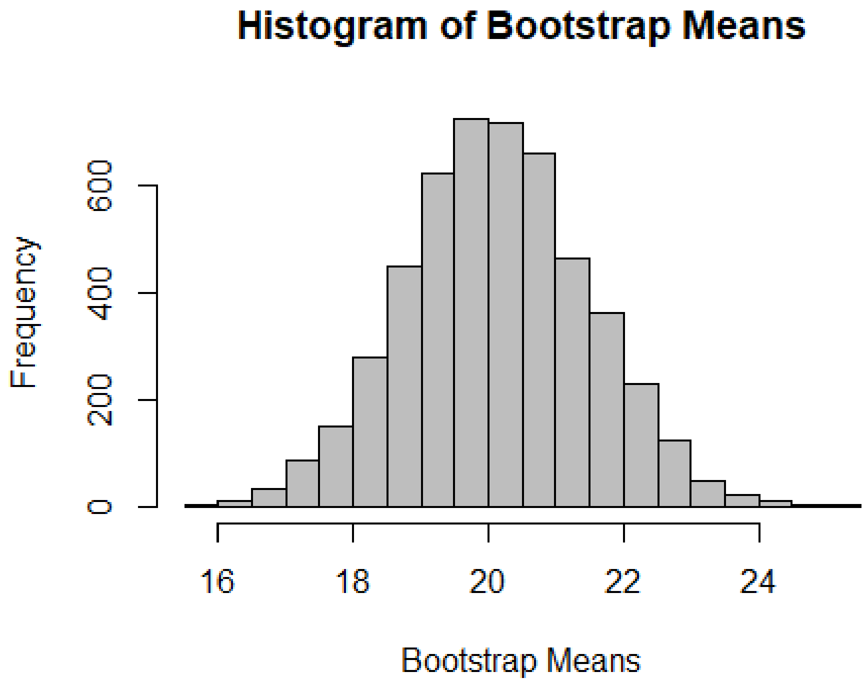
Autocorrelation of Earthquake Counts

##b Provide the estimated mean and simple t-based confidence interval for the mean. We will use this naive approach for purposes of comparison only!

```
n <- nrow(earthquakes)
mean_eq <- mean(earthquakes$quakes)
sd_eq <- sd(earthquakes$quakes)

df <- n - 1


se_eq <- sd_eq / sqrt(n)

# t-value for 95% confidence interval
alpha <- 0.05
t_value <- qt(1 - alpha/2, df)

lower_bound <- mean_eq - t_value * se_eq
upper_bound <- mean_eq + t_value * se_eq

cat("Estimated Mean:", mean_eq, "\n")

## Estimated Mean: 20.13542

cat("95% t-based Confidence Interval: [", lower_bound, ",", upper_bound,
"]\n")

## 95% t-based Confidence Interval: [ 18.65037 , 21.62047 ]
```

##c Now perform a non-moving block bootstrap with a block length of 8 and R = 5000. Write a function to do this. Show the 12 blocks and the histogram of the resulting bootstrap means

```
set.seed(420)  # For reproducibility

block_length <- 8
num_blocks <- floor(n / block_length)

# Create blocks
blocks <- split(earthquakes$quakes, rep(1:num_blocks, each = block_length))


non_moving_block_bootstrap <- function(data, block_length, R) {
  n <- length(data)
  num_blocks <- floor(n / block_length)
  blocks <- split(data, rep(1:num_blocks, each = block_length))

  bootstrap_means <- numeric(R)

  for (i in 1:R) {
    # Sample blocks with replacement
    sampled_blocks <- sample(blocks, size = num_blocks, replace = TRUE)
    # Concatenate sampled blocks
    sampled_data <- unlist(sampled_blocks)
    # Calculate mean
    bootstrap_means[i] <- mean(sampled_data)
  }
  return(bootstrap_means)
}

# Perform bootstrap
R <- 5000
bootstrap_means <- non_moving_block_bootstrap(earthquakes$quakes,
block_length, R)
hist(bootstrap_means, breaks = 30, main = "Histogram of Bootstrap Means",
     xlab = "Bootstrap Means", col = "grey", border = "black")
```



##d Using your boostrap results, construct a 95% confidence interval using the percentile method.

```
# Calculate the 2.5th and 97.5th percentiles
ci_lower <- quantile(bootstrap_means, 0.025)
ci_upper <- quantile(bootstrap_means, 0.975)

# Output the bootstrap confidence interval
cat("95% Bootstrap Confidence Interval (Percentile Method): [", ci_lower,
",", ci_upper, "]\n")
```

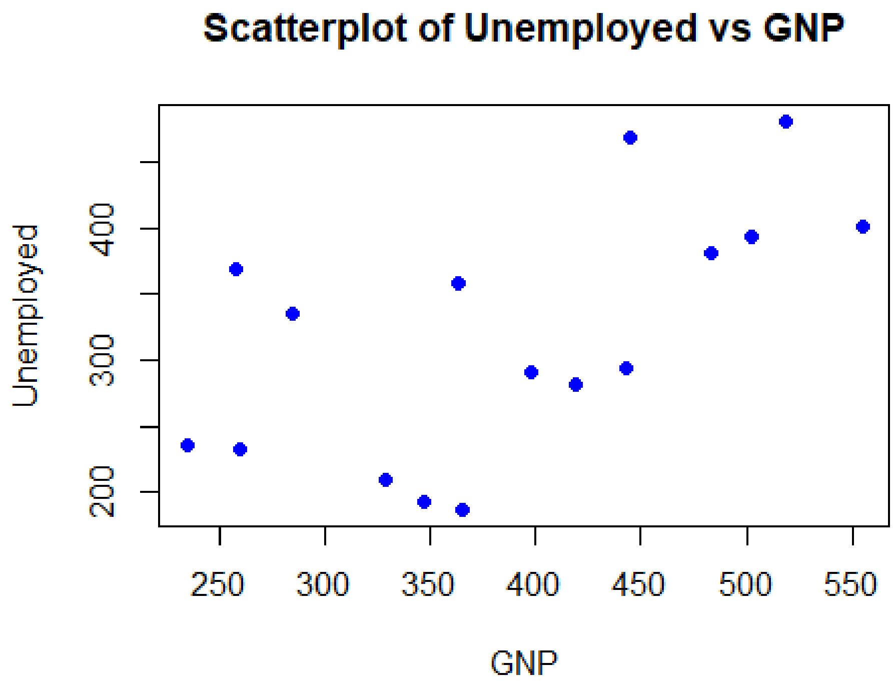
```
## 95% Bootstrap Confidence Interval (Percentile Method): [ 17.46875 ,
22.80208 ]
```

##e Compare your bootstrap confidence interval to the simple t-based confidence interval.Which is wider? Briefly explain why this is the case. Our bootstrap Confidence interval is wider because it accounts for the autocorrelation in the data.The t based method assumes independent samples which is often not the case with time series data.

#Question 2

##a Create a scatterplot of Unemployed (y) vs GNP (x).

```
data(longley)
plot(longley$GNP, longley$Unemployed,
     main = "Scatterplot of Unemployed vs GNP",
     xlab = "GNP",
     ylab = "Unemployed",
     pch = 19, col = "blue")
```



##b Use cor.test() to calculate (default) Pearson correlation, p-value and 95% confidence interval. You can just print the output

```
pearson_result <- cor.test(longley$Unemployed, longley$GNP)
print(pearson_result)

##
##  Pearson's product-moment correlation
##
```

```
## data:  longley$Unemployed and longley$GNP
## t = 2.8376, df = 14, p-value = 0.01317
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.1549766 0.8464304
## sample estimates:
##       cor
## 0.6042609
```

##c Use cor.test() again but this time with method = ”spearman” and print the result. Note that a confidence interval is NOT provided.

```
spearman_result <- cor.test(longley$Unemployed, longley$GNP, method =
"spearman")
print(spearman_result)
```

```
##
##  Spearman's rank correlation rho
##
## data:  longley$Unemployed and longley$GNP
## S = 246, p-value = 0.009375
## alternative hypothesis: true rho is not equal to 0
## sample estimates:
##       rho
## 0.6382353
```

##d Use bootstrap() to perform case resampling bootrap for correlation with R = 5000.Provide a 95% confidence interval using the percentile method.

```
# I was having issues with the bootstrap() function so i swapped to this one.
library(boot)
```

```
## Warning: package 'boot' was built under R version 4.4.2
```

```
data_longley <- longley[, c("Unemployed", "GNP")]
correlation_stat <- function(data, indices) {
  resampled_data <- data[indices, ]
  return(cor(resampled_data$Unemployed, resampled_data$GNP))
}

# Perform bootstrapping
R <- 5000
boot_results <- boot(data_longley, statistic = correlation_stat, R = R)
bootstrap_estimates <- boot_results$t


# Calculate the 95% confidence interval using the percentile method
ci_lower <- quantile(bootstrap_estimates, 0.025)
ci_upper <- quantile(bootstrap_estimates, 0.975)
```

```
cat("95% Bootstrap Confidence Interval: [", ci_lower, ",", ci_upper, "]\n")

## 95% Bootstrap Confidence Interval: [ 0.2564638 , 0.8303361 ]
```

##e Finally, implement a permutation test of H0 : ρ = 0 where ρ is the population correlation. Perform 5000 permutations and report your permutation based p-value (twosided).

```
obs_cor <- cor(longley$Unemployed, longley$GNP, method='spearman')

n_perm <- 5000
perm_cor <- numeric(n_perm)

for (i in 1:n_perm) {
  permuted_gnp <- sample(longley$GNP)
  perm_cor[i] <- cor(longley$Unemployed, permuted_gnp,  method='spearman')
}

# two-sided p-value
p_value <- (sum(abs(perm_cor) >= abs(obs_cor)) + 1) / (n_perm + 1)
cat("Permutation p-value:", p_value)

## Permutation p-value: 0.00859828
```