

# Statistical Inference Course Project - simulation exercise

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*February 27, 2016*

[Link to project on GitHub](#)

## Overview

In this project we are going to investigate the exponential distribution in R and compare it with the Central Limit Theorem.

The exponential distribution can be simulated in R with `rexp(n, lambda)` where `lambda` is the rate parameter. The mean of exponential distribution is  $1/\lambda$  and the standard deviation is also  $1/\lambda$ . We will set  $\lambda = 0.2$  for all of the simulations. Also we will investigate the distribution of averages of 40 exponentials. We will do a thousand simulations.

## 1. Simulations

```
# loading necessary libraries
library(ggplot2)

## Warning: package 'ggplot2' was built under R version 3.2.3

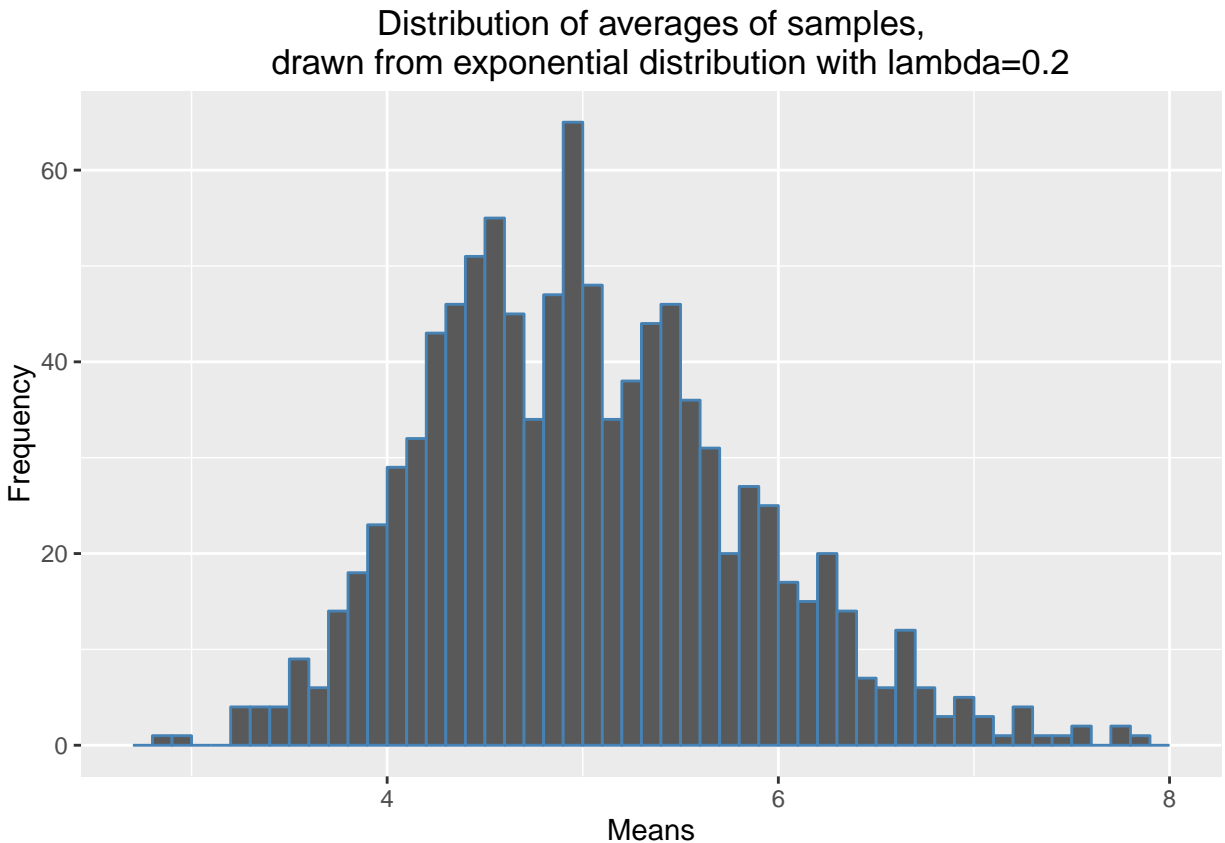
# set constants
lambda <- 0.2 # rate parameter for exponential distribution
n <- 40 # number of exponentials
numberOfSimulations <- 1000 # number of simulations

# set the seed to create reproducibility
set.seed(123456)

# creating matrix with observations
exponentialDistributions <- matrix(data=rexp(n * numberOfSimulations,
                                             lambda),
                                  nrow=numberOfSimulations)

# creating data frame with means of rows in the matrix
exponentialDistributionMeans <- data.frame(means=apply(exponentialDistributions, 1, mean))

# plotting the means
ggplot(data = exponentialDistributionMeans, aes(x = means)) +
  geom_histogram(binwidth=0.1, color = "steelblue") +
  labs(title = "Distribution of averages of samples,
drawn from exponential distribution with lambda=0.2") +
  labs(x = "Means") +
  labs(y = "Frequency")
```



## 2. Sample Mean versus Theoretical Mean

The theoretical mean  $\mu$  of an exponential distribution of rate  $\lambda$  is

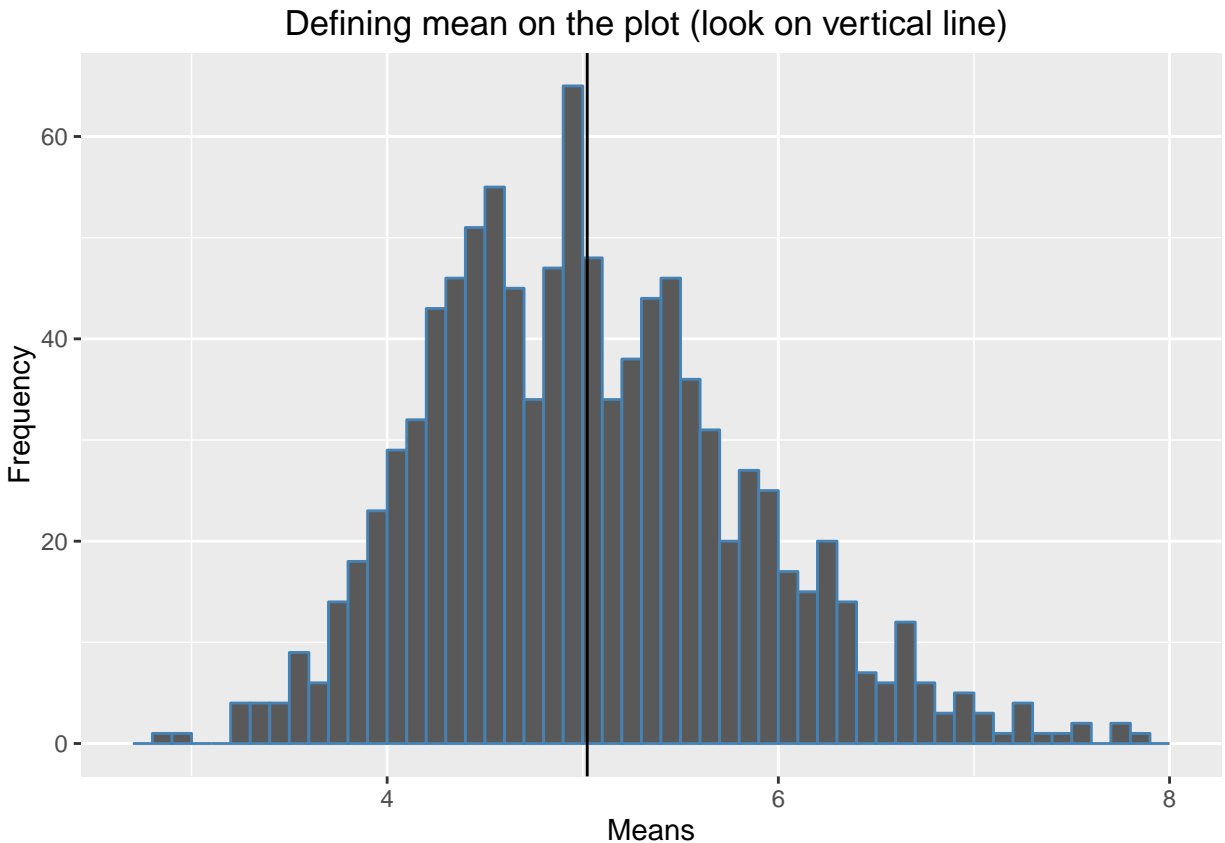
$\mu = \frac{1}{\lambda}$ , then  $\mu$  for  $\lambda = 0.2$  equal:

```
## [1] 5
```

Lets define sample mean and compare it with theoretical:

```
# calculating sample mean
SampleMean <- mean(exponentialDistributionMeans$means)
SampleMean
```

```
## [1] 5.022915
```



**Infer:** So, as you can see the theoretical mean (5) and sample mean (5.0229151) are very close.

### 3. Sample Variance versus Theoretical Variance

The theoretical standard deviation  $\sigma$  of a exponential distribution of rate  $\lambda$  is:  $\sigma = \frac{1/\lambda}{\sqrt{n}}$ , then  $\sigma$  for  $\lambda=.2$  and  $n=40$  equal:

```
## [1] 0.7905694
```

The theoretical variance  $Var$  of standard deviation  $\sigma$  is

$$Var = \sigma^2$$

```
## [1] 0.625
```

Lets define the sample variance ( $Var_x$ ) and the sample standard deviation  $\sigma_x$ .

```
sd_x <- sd(exponentialDistributionMeans$means)
sd_x
```

```
## [1] 0.8097816
```

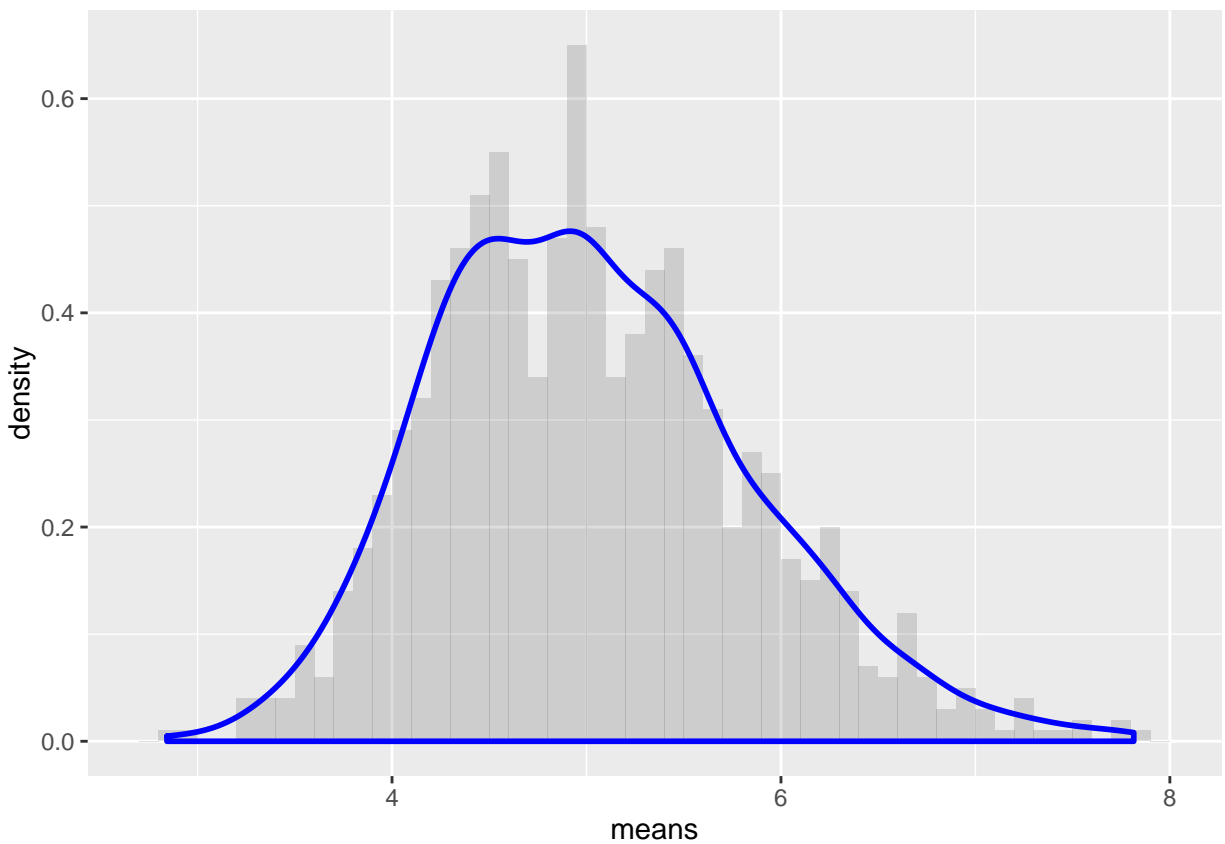
```
Var_x <- var(exponentialDistributionMeans$means)
Var_x
```

```
## [1] 0.6557463
```

**Infer:** As you can see standard deviation and variance in theory (0.7905694 and 0.625) and sample (0.8097816 and 0.6557463) are pretty close.

## 4. Distribution

Due to the Central Limit Theorem, the averages of samples should follow a normal distribution. Lets show it.



**Infer:** As shown in the graph, the calculated distribution of means of random sampled exponential distributions overlaps with the normal distribution, due to the Central Limit Theorem. The more samples we would get (now 1000), the closer will the density distribution be to the normal distribution bell curve.