Laplace sanitizer

DATA PRIVACY AND ANONYMIZATION IN R

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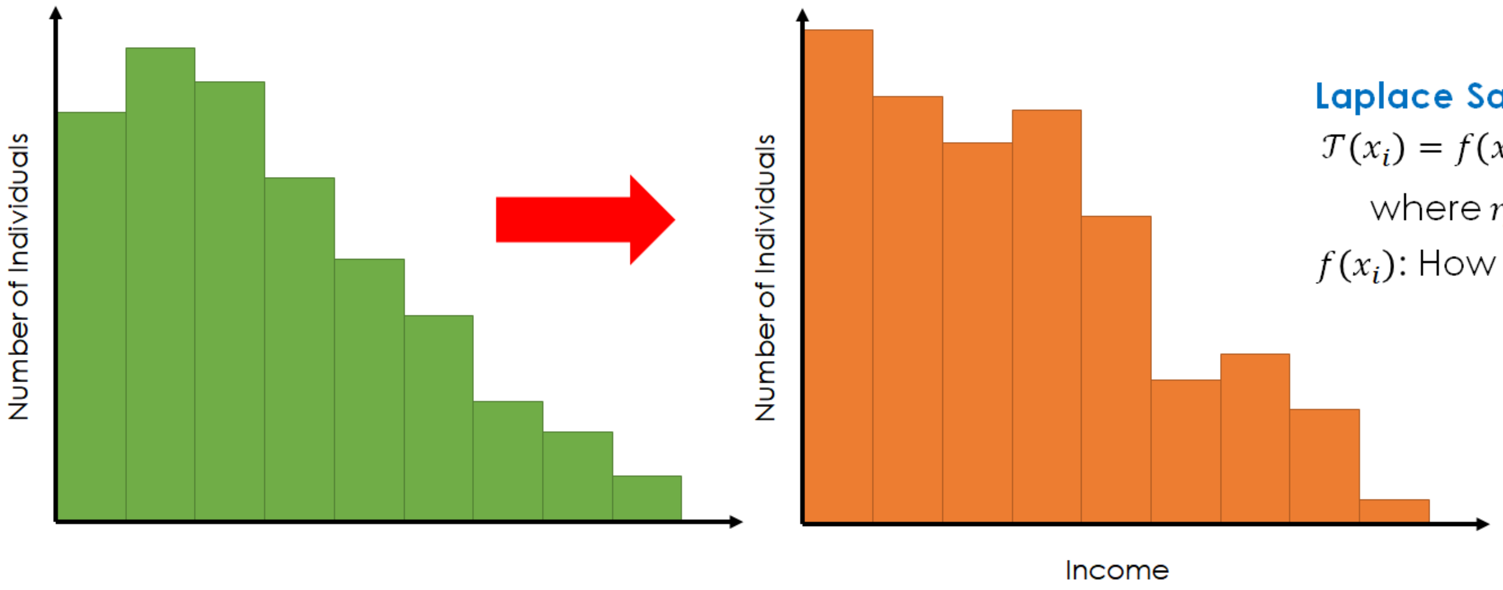
Laplace sanitizer



Laplace Sanitizer

$\mathcal{T}(x_i) = f(x_i) + r_i$

where r_i are drawn i.i.d. from $Lap\left(\frac{S(f)}{\epsilon}\right)$

$f(x_i)$: How many counts?

```r
fertility %>%
   count(High_Fevers)
```

```
# A tibble: 3 x 2
  High_Fevers Count
        <int> <int>
1          -1     9
2           0    63
3           1    28
```

```r
# Old: Set Value of Epsilon
eps <- 0.01 / 2
# GS of Counts
gs.count <- 1
# Set Value of Epsilon
eps <- 0.01
```

Male fertility data: apply the Laplace mechanism

```r
# Apply the Laplace mechanism and set.seed(42)
set.seed(42)
fever1 <- rdoublex(1, 9, gs.count / eps) %>%
  max(0)
fever2 <- rdoublex(1, 63, gs.count / eps) %>%
  max(0)
fever3 <- rdoublex(1, 28, gs.count / eps) %>%
  max(0)
fever <- c(fever1, fever2, fever3)
# Normalize noise
normalized <- (fever/sum(fever)) * (nrow(fertility))
# Round the values
round(normalized)
```

```
24 76  0
```

Male fertility data: generating synthetic data

```
rep(-1, 24) %>%
  head()
```

```
-1 -1 -1 -1 -1 -1
```

```
rep(0, 76) %>%
  head()
```

```
0 0 0 0 0 0
```

Let's practice!

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Differential privacy (DP) parametric approaches

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Male fertility data

```r
library(dplyr)
library(smoothmest)
fertility
```

```
# A tibble: 100 x 10
   Season   Age Child_Disease Accident_Trauma Surgical_Intervention
    <dbl> <dbl>         <int>           <int>                 <int>
 1  -0.33  0.69             0               1                     1
 2  -0.33  0.94             1               0                     1
 3  -0.33  0.50             1               0                     0
 4  -0.33  0.75             0               1                     1
 5  -0.33  0.67             1               1                     0
 6  -0.33  0.67             1               0
# ... with 94 more rows, and 5 more variables: High_Fevers <int>,
#   Alcohol_Freq <dbl>, Smoking <int>, Hours_Sitting <dbl>, Diagnosis <int>
```

Generating DP synthetic data part 1

Sampling from a Binomial Distribution

```r
fertility %>%
    summarize_at(vars(Child_Disease), mean)
```

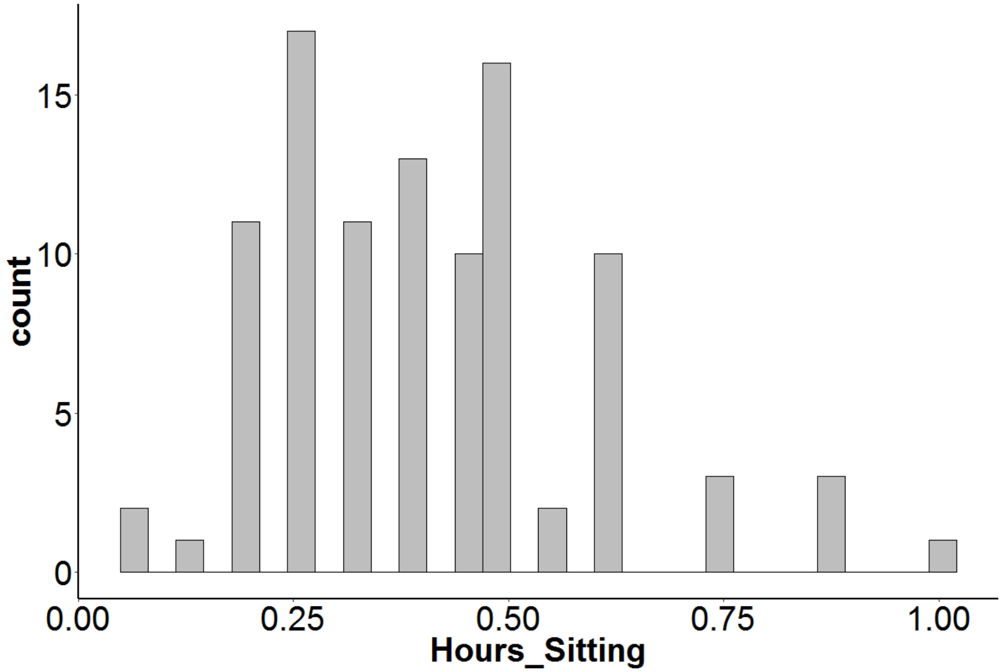
```
# A tibble: 1 x 1
  Child_Disease
          <dbl>
1          0.87
```

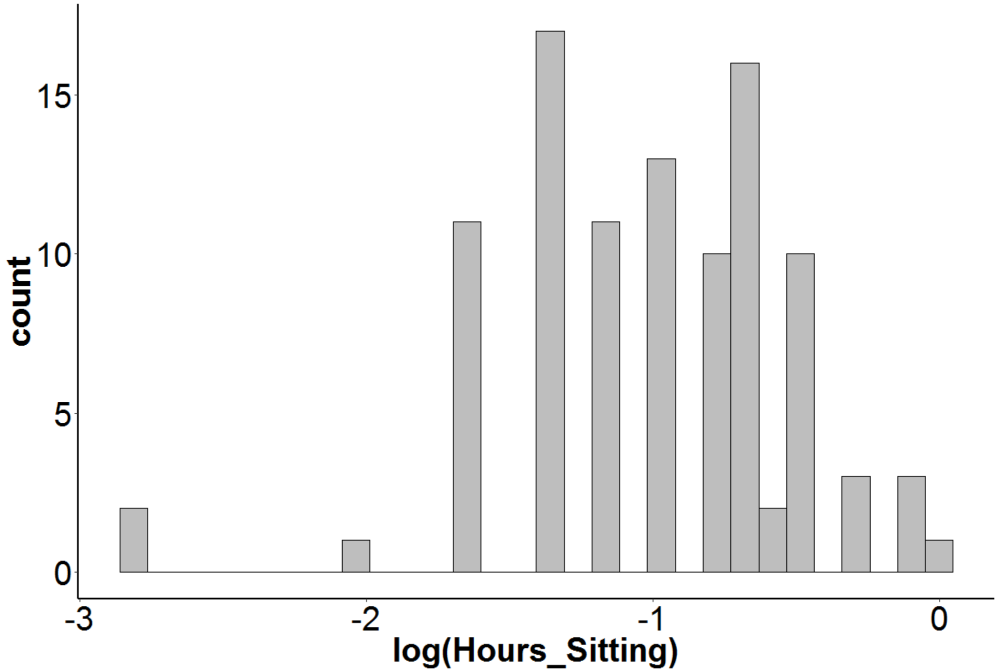
```r
set.seed(42)
rdoublex(1, 0.87, (1 / 100) / 0.1)
set.seed(42)
child.disease <- rbinom(100, 1, 0.89)
sum(child.disease)
```

```
0.8898337
```

```
84
```

Examining the data





Generating DP synthetic data part 2

Sampling from a Normal Distribution

```
fertility %>%
    mutate(Hours_Sitting = log(Hours_Sitting)) %>%
    summarize_at(vars(Hours_Sitting), funs(mean, var))
```

```
# A tibble: 1 x 2
       mean       var
      <dbl>     <dbl>
1 -1.012244 0.2548017
```

```
set.seed(42)
rdoublex(1, -1.01, (1 / 100) / 0.01 / 2)
rdoublex(1, 0.25, (1 / 100)^2 / 0.01 / 2)
```

```
-0.9108316
```

```
0.2514175
```

Generating DP synthetic data part 3

Sampling from a Normal Distribution

```r
set.seed(42)
hours.sit <- rnorm(100, -0.91, sqrt(0.25))
hours.sit <- exp(hours.sit)
hours.sit[hours.sit < 0] <- 0
hours.sit[hours.sit > 1] <- 1
hours.sit %>%
  head()
```

```
0.3115892 1.0000000 0.6662523 0.4659892 0.3625910 1.0000000
```

Let's practice!

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Wrap-up

DATA PRIVACY AND ANONYMIZATION IN R

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Chapter 1: Introduction to data privacy

- Removing Identifiers
- Generalization
- Top and Bottom coding
- Generating Synthetic Data

Chapter 2: Introduction to differential privacy

- Privacy Budget
- Global Sensitivity
- Laplace mechanism

Chapter 3: Differentially private properties

- Sequential Composition
- Parallel Composition
- Post-processing
- Impossible and Inconsistent Answers

Chapter 4: Differentially private data synthesis

- Laplace sanitizer
- Parametric approaches

More on data privacy

Issues

- Complex solutions for complex data
- Biasing inferences

Other Topics

- Other versions of differential privacy
- Differential privacy methods for specific data types or analyses

Thank you!

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