DA 2

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```
library(nycflights13)

## Warning: package 'nycflights13' was built under R version 4.3.3

library(dplyr)

##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union

library(tidyr)
library(mice)

## Warning: package 'mice' was built under R version 4.3.3

##
## Attaching package: 'mice'

## The following object is masked from 'package:stats':
##
##     filter

## The following objects are masked from 'package:base':
##
##     cbind, rbind

library(VIM)

## Warning: package 'VIM' was built under R version 4.3.3

## Loading required package: colorspace

## Loading required package: grid
## VIM is ready to use.
```

```
## Suggestions and bug-reports can be submitted at: https://github.com/statis
tikat/VIM/issues
```

```
##
## Attaching package: 'VIM'
```

```
## The following object is masked from 'package:datasets':
##
##     sleep
```

```r
# Load the flights dataset
data("flights")

# View the structure of the dataset
str(flights)
```

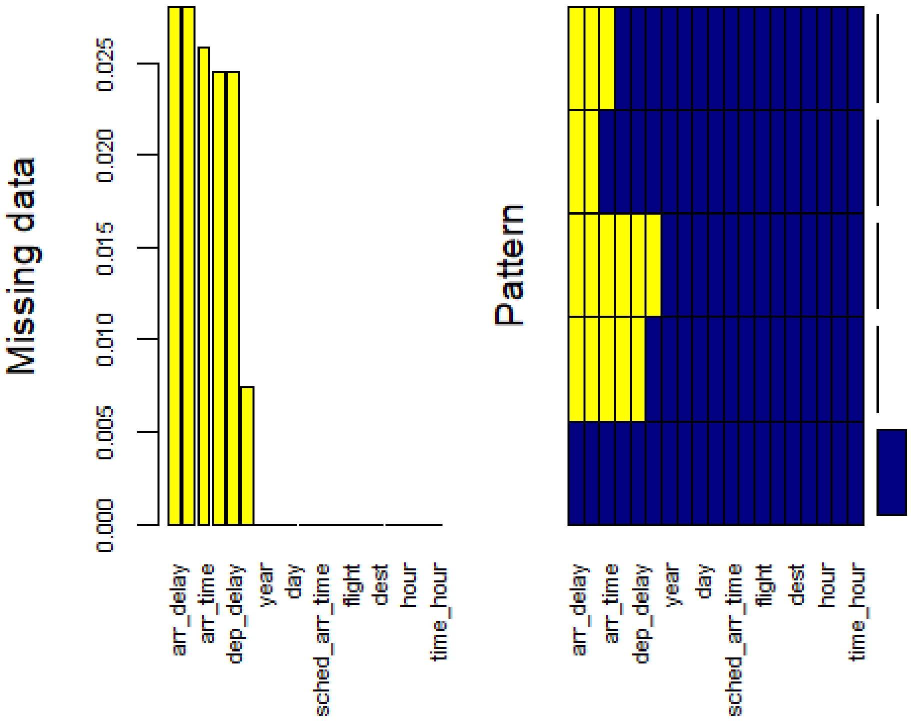
```
## tibble [336,776 × 19] (S3: tbl_df/tbl/data.frame)
##  $ year          : int [1:336776] 2013 2013 2013 2013 2013 2013 2013 2013
2013 2013 ...
##  $ month         : int [1:336776] 1 1 1 1 1 1 1 1 1 1 ...
##  $ day           : int [1:336776] 1 1 1 1 1 1 1 1 1 1 ...
##  $ dep_time      : int [1:336776] 517 533 542 544 554 554 555 557 557 558
...
##  $ sched_dep_time: int [1:336776] 515 529 540 545 600 558 600 600 600 600
...
##  $ dep_delay     : num [1:336776] 2 4 2 -1 -6 -4 -5 -3 -3 -2 ...
##  $ arr_time      : int [1:336776] 830 850 923 1004 812 740 913 709 838 753
...
##  $ sched_arr_time: int [1:336776] 819 830 850 1022 837 728 854 723 846 745
...
##  $ arr_delay     : num [1:336776] 11 20 33 -18 -25 12 19 -14 -8 8 ...
##  $ carrier       : chr [1:336776] "UA" "UA" "AA" "B6" ...
##  $ flight        : int [1:336776] 1545 1714 1141 725 461 1696 507 5708 79
301 ...
##  $ tailnum       : chr [1:336776] "N14228" "N24211" "N619AA" "N804JB" ...
##  $ origin        : chr [1:336776] "EWR" "LGA" "JFK" "JFK" ...
##  $ dest          : chr [1:336776] "IAH" "IAH" "MIA" "BQN" ...
##  $ air_time      : num [1:336776] 227 227 160 183 116 150 158 53 140 138 .
..
##  $ distance      : num [1:336776] 1400 1416 1089 1576 762 ...
##  $ hour          : num [1:336776] 5 5 5 5 6 5 6 6 6 6 ...
##  $ minute        : num [1:336776] 15 29 40 45 0 58 0 0 0 0 ...
##  $ time_hour     : POSIXct[1:336776], format: "2013-01-01 05:00:00" "2013-
01-01 05:00:00" ...
```

```r
# Summarize missing data
summary(flights)
```

```
##       year          month             day           dep_time    sched_dep_
time
##  Min.   :2013   Min.   : 1.000   Min.   : 1.00   Min.   :   1   Min.   : 1
06
##  1st Qu.:2013   1st Qu.: 4.000   1st Qu.: 8.00   1st Qu.: 907   1st Qu.: 9
06
##  Median :2013   Median : 7.000   Median :16.00   Median :1401   Median :13
59
##  Mean   :2013   Mean   : 6.549   Mean   :15.71   Mean   :1349   Mean   :13
44
##  3rd Qu.:2013   3rd Qu.:10.000   3rd Qu.:23.00   3rd Qu.:1744   3rd Qu.:17
29
##  Max.   :2013   Max.   :12.000   Max.   :31.00   Max.   :2400   Max.   :23
59
##                                                  NA's   :8255
##    dep_delay          arr_time    sched_arr_time   arr_delay
##  Min.   : -43.00   Min.   :   1   Min.   :   1   Min.   : -86.000
##  1st Qu.:  -5.00   1st Qu.:1104   1st Qu.:1124   1st Qu.: -17.000
##  Median :  -2.00   Median :1535   Median :1556   Median :  -5.000
##  Mean   :  12.64   Mean   :1502   Mean   :1536   Mean   :   6.895
##  3rd Qu.:  11.00   3rd Qu.:1940   3rd Qu.:1945   3rd Qu.:  14.000
##  Max.   :1301.00   Max.   :2400   Max.   :2359   Max.   :1272.000
##  NA's   :8255      NA's   :8713                  NA's   :9430
##    carrier              flight       tailnum             origin
##  Length:336776      Min.   :   1   Length:336776      Length:336776
##  Class :character   1st Qu.: 553   Class :character   Class :character
##  Mode  :character   Median :1496   Mode  :character   Mode  :character
##                     Mean   :1972
##                     3rd Qu.:3465
##                     Max.   :8500
##
##      dest              air_time        distance         hour
##  Length:336776      Min.   : 20.0   Min.   :  17   Min.   : 1.00
##  Class :character   1st Qu.: 82.0   1st Qu.: 502   1st Qu.: 9.00
##  Mode  :character   Median :129.0   Median : 872   Median :13.00
##                     Mean   :150.7   Mean   :1040   Mean   :13.18
##                     3rd Qu.:192.0   3rd Qu.:1389   3rd Qu.:17.00
##                     Max.   :695.0   Max.   :4983   Max.   :23.00
##                     NA's   :9430
##      minute        time_hour
##  Min.   : 0.00   Min.   :2013-01-01 05:00:00.00
##  1st Qu.: 8.00   1st Qu.:2013-04-04 13:00:00.00
##  Median :29.00   Median :2013-07-03 10:00:00.00
##  Mean   :26.23   Mean   :2013-07-03 05:22:54.64
##  3rd Qu.:44.00   3rd Qu.:2013-10-01 07:00:00.00
##  Max.   :59.00   Max.   :2013-12-31 23:00:00.00
##

# Mean imputation for numeric columns
flights_imputed <- flights %>%
```

```r
  mutate(
    dep_time = ifelse(is.na(dep_time), mean(dep_time, na.rm = TRUE), dep_time
),
    arr_time = ifelse(is.na(arr_time), mean(arr_time, na.rm = TRUE), arr_time
)
  )

# Median imputation (another global method)
flights_imputed <- flights %>%
  mutate(
    dep_delay = ifelse(is.na(dep_delay), median(dep_delay, na.rm = TRUE), dep
_delay),
    arr_delay = ifelse(is.na(arr_delay), median(arr_delay, na.rm = TRUE), arr
_delay)
  )


# Impute missing values by grouping by the carrier (class-based method)
flights_imputed <- flights %>%
  group_by(carrier) %>%
  mutate(
    dep_time = ifelse(is.na(dep_time), mean(dep_time, na.rm = TRUE), dep_time
),
    arr_time = ifelse(is.na(arr_time), mean(arr_time, na.rm = TRUE), arr_time
)
  ) %>%
  ungroup()


# Visualize missing data
aggr(flights, col = c('navyblue', 'yellow'), numbers = TRUE, sortVars = TRUE,
labels = names(flights), cex.axis = .7, gap = 3, ylab = c("Missing data", "Pa
ttern"))
```

```
## Warning in plot.aggr(res, ...): not enough horizontal space to display
## frequencies
```



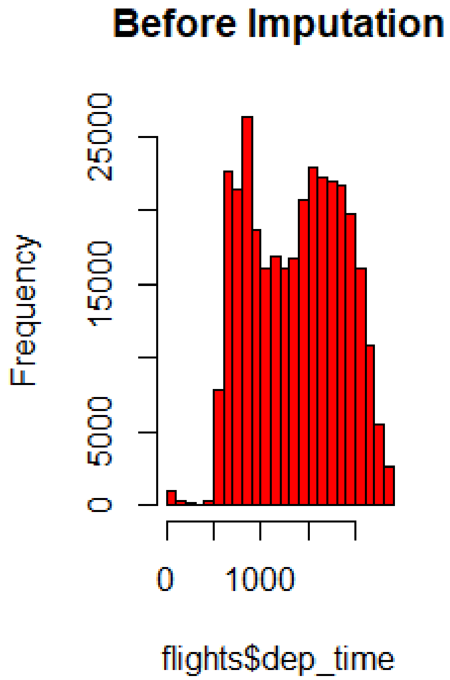
```
##
##  Variables sorted by number of missings:
##        Variable       Count
##       arr_delay 0.028000808
##        air_time 0.028000808
##        arr_time 0.025871796
##        dep_time 0.024511842
##       dep_delay 0.024511842
##         tailnum 0.007458964
##            year 0.000000000
##           month 0.000000000
##             day 0.000000000
##  sched_dep_time 0.000000000
##  sched_arr_time 0.000000000
##         carrier 0.000000000
##          flight 0.000000000
##          origin 0.000000000
##            dest 0.000000000
##        distance 0.000000000
##            hour 0.000000000
##          minute 0.000000000
##       time_hour 0.000000000

# Compare distributions before and after imputation
par(mfrow = c(1, 2))
hist(flights$dep_time, main = "Before Imputation", col = "red")
```

```r
## COVARIANCE AND CORRELATION
calculate_covariance <- function(x, y) {

  if(length(x) != length(y)) {
    stop("X and Y must have the same length.")
  }


  x_mean <- mean(x)
  y_mean <- mean(y)


  covariance <- sum((x - x_mean) * (y - y_mean)) / (length(x) - 1)

  return(covariance)
}


calculate_correlation <- function(x, y) {

  if(length(x) != length(y)) {
    stop("X and Y must have the same length.")
  }


  covariance <- calculate_covariance(x, y)


  x_sd <- sd(x)
  y_sd <- sd(y)


  correlation <- covariance / (x_sd * y_sd)

  return(correlation)
}


x <- flights$dep_delay
y <- flights$arr_delay


valid_indices <- !is.na(x) & !is.na(y)
x_clean <- x[valid_indices]
y_clean <- y[valid_indices]


covariance_value <- calculate_covariance(x_clean, y_clean)
```

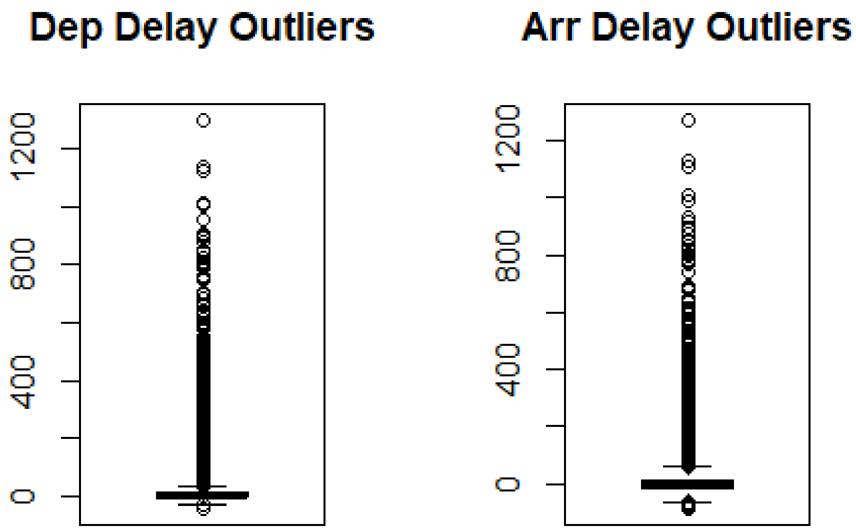
```
correlation_value <- calculate_correlation(x_clean, y_clean)

cat("Covariance between dep_delay and arr_delay:", covariance_value, "\n")

## Covariance between dep_delay and arr_delay: 1635.908

cat("Correlation between dep_delay and arr_delay:", correlation_value, "\n")

## Correlation between dep_delay and arr_delay: 0.9148028

## OUTLIER DETECTION
detect_outliers_zscore <- function(x, threshold = 3) {
  z_scores <- (x - mean(x, na.rm = TRUE)) / sd(x, na.rm = TRUE)
  return(which(abs(z_scores) > threshold))
}

dep_delay_clean <- flights$dep_delay[!is.na(flights$dep_delay)]
arr_delay_clean <- flights$arr_delay[!is.na(flights$arr_delay)]

dep_delay_outliers_z <- detect_outliers_zscore(dep_delay_clean)
arr_delay_outliers_z <- detect_outliers_zscore(arr_delay_clean)

cat("Number of outliers in dep_delay (Z-score):", length(dep_delay_outliers_z
), "\n")

## Number of outliers in dep_delay (Z-score): 7928

cat("Number of outliers in arr_delay (Z-score):", length(arr_delay_outliers_z
), "\n")

## Number of outliers in arr_delay (Z-score): 7285

detect_outliers_iqr <- function(x) {
  Q1 <- quantile(x, 0.25, na.rm = TRUE)
  Q3 <- quantile(x, 0.75, na.rm = TRUE)
  IQR <- Q3 - Q1
  lower_bound <- Q1 - 1.5 * IQR
  upper_bound <- Q3 + 1.5 * IQR
  return(which(x < lower_bound | x > upper_bound))
}

dep_delay_outliers_iqr <- detect_outliers_iqr(dep_delay_clean)
arr_delay_outliers_iqr <- detect_outliers_iqr(arr_delay_clean)

cat("Number of outliers in dep_delay (IQR):", length(dep_delay_outliers_iqr),
"\n")

## Number of outliers in dep_delay (IQR): 43216

cat("Number of outliers in arr_delay (IQR):", length(arr_delay_outliers_iqr),
"\n")
```

```
## Number of outliers in arr_delay (IQR): 27880
```

```
# Boxplot to visualize outliers
par(mfrow = c(1, 2))
```



```
boxplot(dep_delay_clean, main = "Dep Delay Outliers", col = "lightblue")
boxplot(arr_delay_clean, main = "Arr Delay Outliers", col = "lightgreen")
```


Dep Delay Outliers
0
400
800
1200
Arr Delay Outliers
0
400
800
1200