Reproducible Research: Peer Assessment 1

Contents

Assignment background

Devices marketed by vendors such as Nike and others are able to collect personal activity data such as the number of steps taken each day. The dataset for this assignment is the record of walking activity collected from an anonymous user of one of these devices. It contains the number of steps taken during each 5 minute period in the months of October and November, 2012.

The assignment seeks to extract some basic features of the data such as the distribution of daily step totals, the average number of steps taken during each 5-minute time period within a day, and other features.

Load packages

These packages are required to repeat the results of this analysis:

```r
library(dplyr)
library(ggplot2)
library(knitr)  # For simple html tables.
```

Define helper functions

The raw data describing the 5 minute time interval is actually a concatenation of hours and minutes represented as an integer. The functions defined here are used to transform the raw `interval` variable into forms that are more approriate for this analysis.

```r
# Convert raw interval variable into decimal hours.
to.hour <- function(interval){
    interval.char <- sprintf("%04d", interval)
    as.numeric(substr(interval.char, 1, 2)) + as.integer(substr(interval.char, 3, 4)) / 60.0
}

# Convert raw interval variable into character hh:mm display.
to.hhmm <- function(interval){
    interval.char <- sprintf("%04d", interval)
    paste0(substr(interval.char, 1, 2), ":", substr(interval.char, 3, 4))
}
```

Read raw data

The data for this assignment can be found here. It was downloaded and unzipped into the current working directory. The structure of the raw dataset appears below. For `interval` the big jump in values bewteen `55` and `100` is a clue that there is a problem with this variable.

```r
rawData <- read.csv("activity/activity.csv", header = TRUE, sep = ",",
                    col.names = c("steps", "date", "interval"),
                    colClasses = c("integer", "Date", "integer")) %>% tbl_df %>%
            mutate(weekday = weekdays(date), hour = to.hour(interval), hhmm = to.hhmm(interval))
glimpse(rawData)
```

```
## Observations: 17,568
## Variables: 6
## $ steps    (int) NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, N...
## $ date     (date) 2012-10-01, 2012-10-01, 2012-10-01, 2012-10-01, 2012...
## $ interval (int) 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 100, 10...
## $ weekday  (chr) "Monday", "Monday", "Monday", "Monday", "Monday", "Mo...
## $ hour     (dbl) 0.00000000, 0.08333333, 0.16666667, 0.25000000, 0.333...
## $ hhmm     (chr) "00:00", "00:05", "00:10", "00:15", "00:20", "00:25",...
```

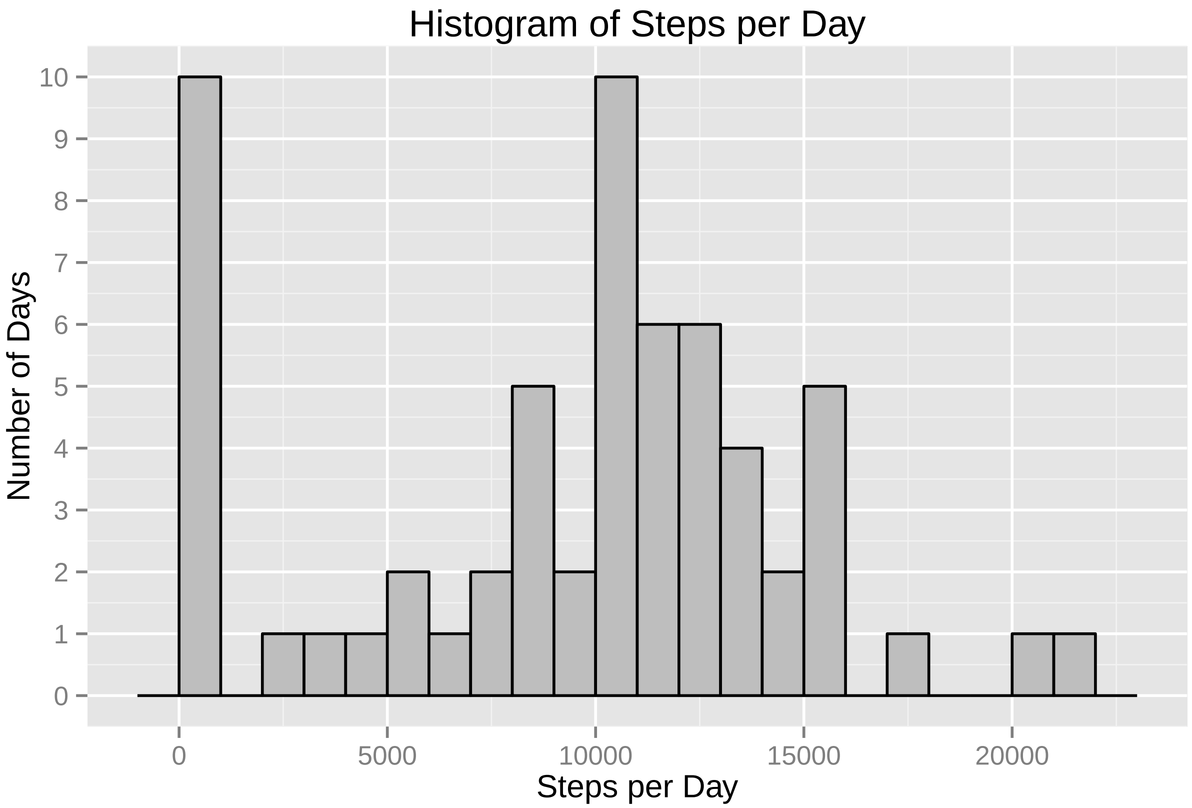
Mean steps per day

What is the mean total number of steps taken per day?

Group the raw data by day, and compute the sum across all time periods of the number of steps taken each day. Ignore for now any periods where the data are missing. Generate a histogram of daily step totals to see their distribution.

```r
stepsPerDay <- rawData %>%
    group_by(date) %>% summarise(totalSteps = sum(steps, na.rm = TRUE))

ggplot(stepsPerDay) +
    geom_histogram(aes(x = totalSteps),
                   binwidth = 1000, colour = "black", fill = "gray") +
    xlab("Steps per Day") + ylab("Number of Days") +
    scale_y_continuous(breaks = seq(0, 10, 1)) +
    ggtitle("Histogram of Steps per Day")
```



Daily step totals are concetrated between 10,000 and 15,000 but there is a tall bar on the far left of the histogram. In particular there are 8 days with a step total equal to zero. Missing values are driving this feature.

Compute the mean and median steps per day.

```
statsPerDay <- data.frame("Statistic" = c("Mean", "Median"),
                          "Value" = c(mean(stepsPerDay$totalSteps),
                                      quantile(stepsPerDay$totalSteps, prob = 0.5)),
                          row.names = NULL)

# A knitr function for printing html tables.
kable(statsPerDay, digits = 1, align = c("l", "l"),
      caption = "Steps per Day", format.args = list(decimal.mark = ".", big.mark = ","))
```

Table 1: Steps per Day

Statistic	Value
Mean	9,354.2
Median	10,395.0

With Mean < Median and given the histogram we can see that the raw daily step totals are slightly skwewed to the left.

Average daily activity

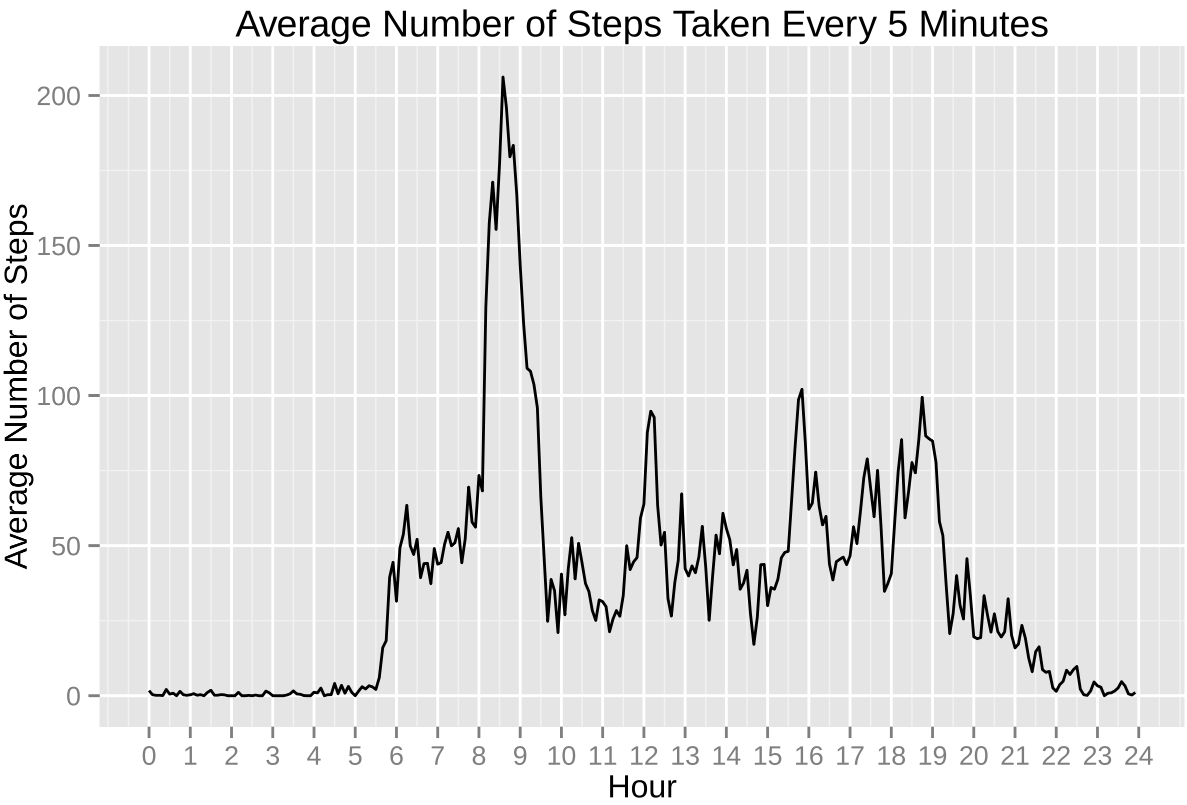
What is the average daily activity pattern?

Re-group the raw data by 5-minute time period and compute the average across all days of the number of steps taken in each period. Ignore missing values and plot the average step counts by time period.

Note: The `interval` variable is a concatenation of hours and minutes stored as an integer and is not a proper representation of time. For plotting I chose to convert the original `interval` variable to an equivalent `hour` variable. There will be 12 data points plotted every hour.

```r
stepsPerTimePeriod <- rawData %>%
    group_by(hour, hhmm) %>% summarize(meanSteps = mean(steps, na.rm = TRUE))

ggplot(stepsPerTimePeriod) +
    geom_line(aes(x = hour, y = meanSteps)) + scale_x_continuous(breaks = seq(0, 24, 1)) +
    xlab("Hour") + ylab("Average Number of Steps") + ggtitle("Average Number of Steps Taken Every 5 Minu
```



With data at this level we can find the beginning of the 5-minute time period with the maximum average number of steps taken.

```r
maxTimePeriod <- stepsPerTimePeriod %>% ungroup %>%
    arrange(desc(meanSteps)) %>% slice(1) %>% select(hhmm, meanSteps)
colnames(maxTimePeriod) <- c("Time of Day", "Average Number of Steps")
kable(maxTimePeriod, digits = c(0, 1), align = c("c", "c"),
      caption = "Most Active Time Period", format.args = list(decimal.mark = ".", big.mark = ","))
```

Table 2: Most Active Time Period

Time of Day	Average Number of Steps
08:35	206.2

Imputing missing values

The number of 5-minute time periods with missing step counts is shown below.

```r
numberMissing <- sum(is.na(rawData$steps))
names(numberMissing) <- "Periods with missing step counts"
print(numberMissing)
```

```
## Periods with missing step counts
##                             2304
```

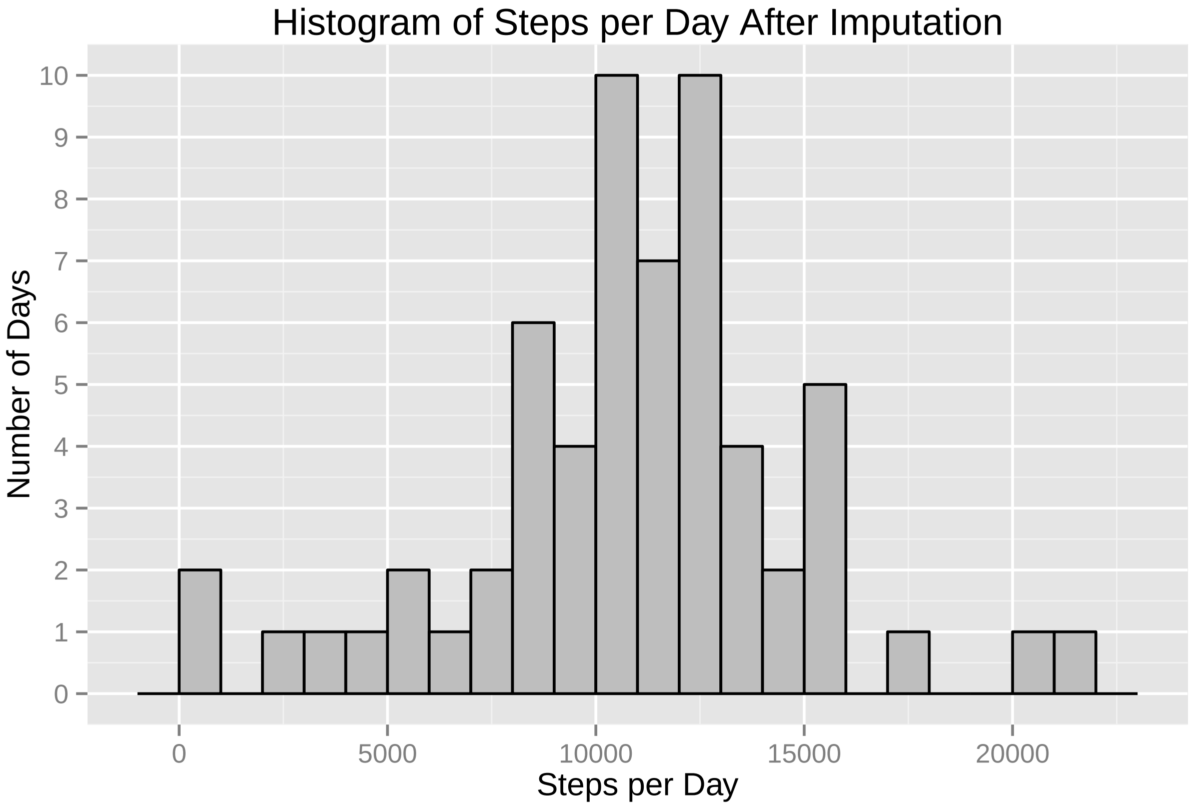
My imputation scheme is to replace each missing value with the average number of steps taken for the corresponding day of week and time of day combination. Copy the raw data and replace the NAs for `interval` with imputed values.

```r
meanDayTime <- rawData %>% group_by(weekday, hour) %>%
                summarize(meanSteps = mean(steps, na.rm = TRUE))
impData <- rawData %>% inner_join(meanDayTime, by = c("weekday", "hour"))
impData$steps[is.na(impData$steps)] <- impData$meanSteps[is.na(impData$steps)]
```

Summarize the post-imputation data by day and plot the distribution of daily step totals.

```r
impStepsPerDay <- impData %>%
    group_by(date) %>% summarise(totalSteps = sum(steps))

ggplot(impStepsPerDay) +
    geom_histogram(aes(x = totalSteps),
                   binwidth = 1000, colour = "black", fill = "gray") +
    xlab("Steps per Day") + ylab("Number of Days") +
    scale_y_continuous(breaks = seq(0, 10, 1)) +
    ggtitle("Histogram of Steps per Day After Imputation")
```



After imputation the overall distibution of steps per day has shifted to the right with an increased number of days with step counts above 10,000. The number of days with a zero step count has been reduced from 8 to 0.

The mean and median steps per day after imputation are shown below.

```r
impStatsPerDay <- data.frame("Statistic" = c("Mean", "Median"),
                             "Value" = c(mean(impStepsPerDay$totalSteps),
                                         quantile(impStepsPerDay$totalSteps, prob = 0.5)),
                             row.names = NULL)

kable(impStatsPerDay, digits = 1, align = c("l", "l"),
      caption = "Total Steps per Day", format.args = list(decimal.mark = ".", big.mark = ","))
```

Table 3: Total Steps per Day

Statistic	Value
Mean	10,821.2
Median	11,015.0

These give further evidence that imputation has shifted the data to the right, with an increase in the mean by 1466.98 steps per day, and an increase in the median by 620 steps per day.

Weekday vs. weekend activity patterns

Are there differences in activity patterns between weekdays and weekends?

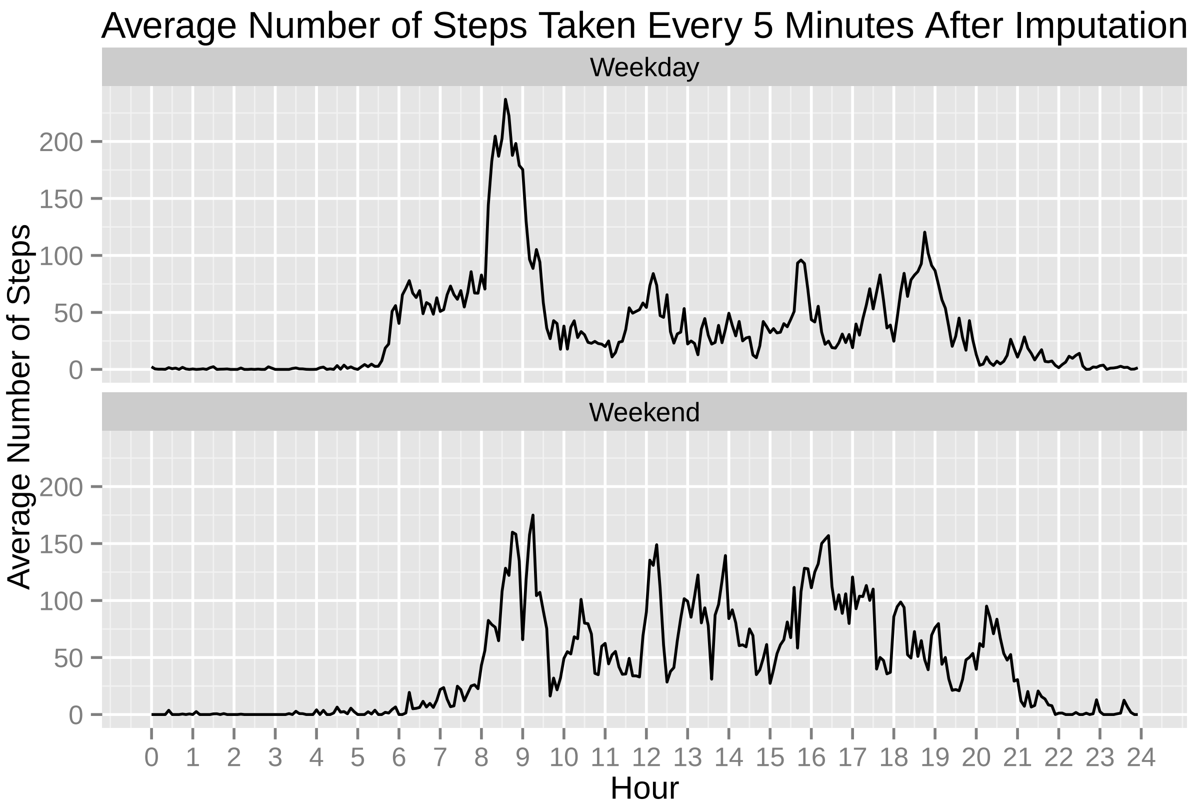
Add a factor to the post-imputation data indicating whether or not a given date falls on a weekday or weekend.

```
impData2 <- impData %>%
    mutate(weekendInd = factor(weekdays(date) %in% c("Saturday", "Sunday"),
                               labels = c("Weekday", "Weekend")))
```

Plot of the average number of steps taken per time period, faceted by this new factor to contrast the step patterns for weekdays and weekends.

```
stepsPerTimePeriod2 <- impData2 %>%
    group_by(weekendInd, hour, hhmm) %>% summarize(meanSteps = mean(steps, na.rm = TRUE))

ggplot(stepsPerTimePeriod2) +
    geom_line(aes(x = hour, y = meanSteps)) + scale_x_continuous(breaks = seq(0, 24, 1)) +
    facet_wrap(~weekendInd, ncol = 1) +
    xlab("Hour") + ylab("Average Number of Steps") +
    ggtitle("Average Number of Steps Taken Every 5 Minutes After Imputation")
```



We can see that step intensity is spread more uniformly throughout the day on weekends and is more concentrated in the early hours on weekdays. It also appears that more late-evening steps are taken on weekends compared to weekdays.

Summary

Weekday and weekend step patterns vary with a more uniform pattern throughout the day on weekends and more early steps taking place in the early hours of weekdays. Walking intensity is concentrated between 10K and 15K steps per day but is affected by the quality of the raw data. An imputation strategy to replace NAs in the raw data with average values results in a slight shift to the right of the original dataset.