

Exploratory Data Analysis on los_angeles_11.csv

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Data Loading

```
# load data file
if (!exists("LA11.raw")) {
  LA11.raw <- read.csv("./los_angeles_11.csv")
}
print(nrow(LA11.raw))
```

```
## [1] 955
```

Data Cleaning & Exploratory Analysis

Data Cleaning & Exploratory Analysis are iterative, starting at next page.

Epoch 1: Display of Vertical Acceleration with Natural Gravity

Date: the time stamp of a data point

Latitude:

Longitude:

Speed: traveling speed of the vehicle

speedbump: whether this data point is a speedbump

****forw_accel:** forward acceleration (front and back) of the vehicle

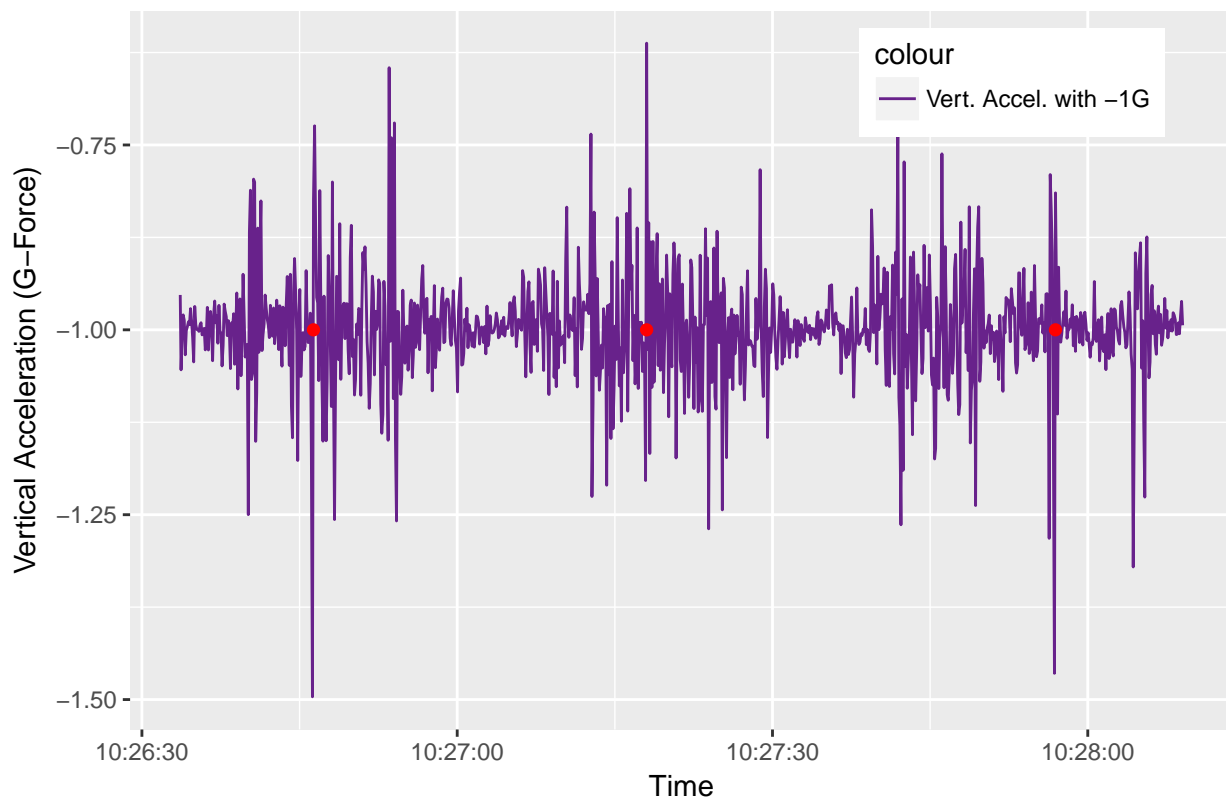
hori_accel: horizontal acceleration (left and right) of the vehicle

vert_accel_G:** vertical acceleration (up and down) of the vehicle with natural gravity (-1G)

```
LA11.valid = LA11.raw[, c("Date", "Latitude", "Longitude", "Speed", "speedbump")]
# validate DateTime format
LA11.valid$Date <- as.POSIXct(LA11.valid$Date, format="%Y-%m-%d %H:%M:%OS")
# specify orientation of accelration
LA11.valid$forw_accel = LA11.raw$X
LA11.valid$hori_accel = LA11.raw$Y
LA11.valid$vert_accel_G = LA11.raw$Z
```

```
## Loading required package: ggplot2
```

Time-Indexed Vertical Acceleration with Natural Gravity

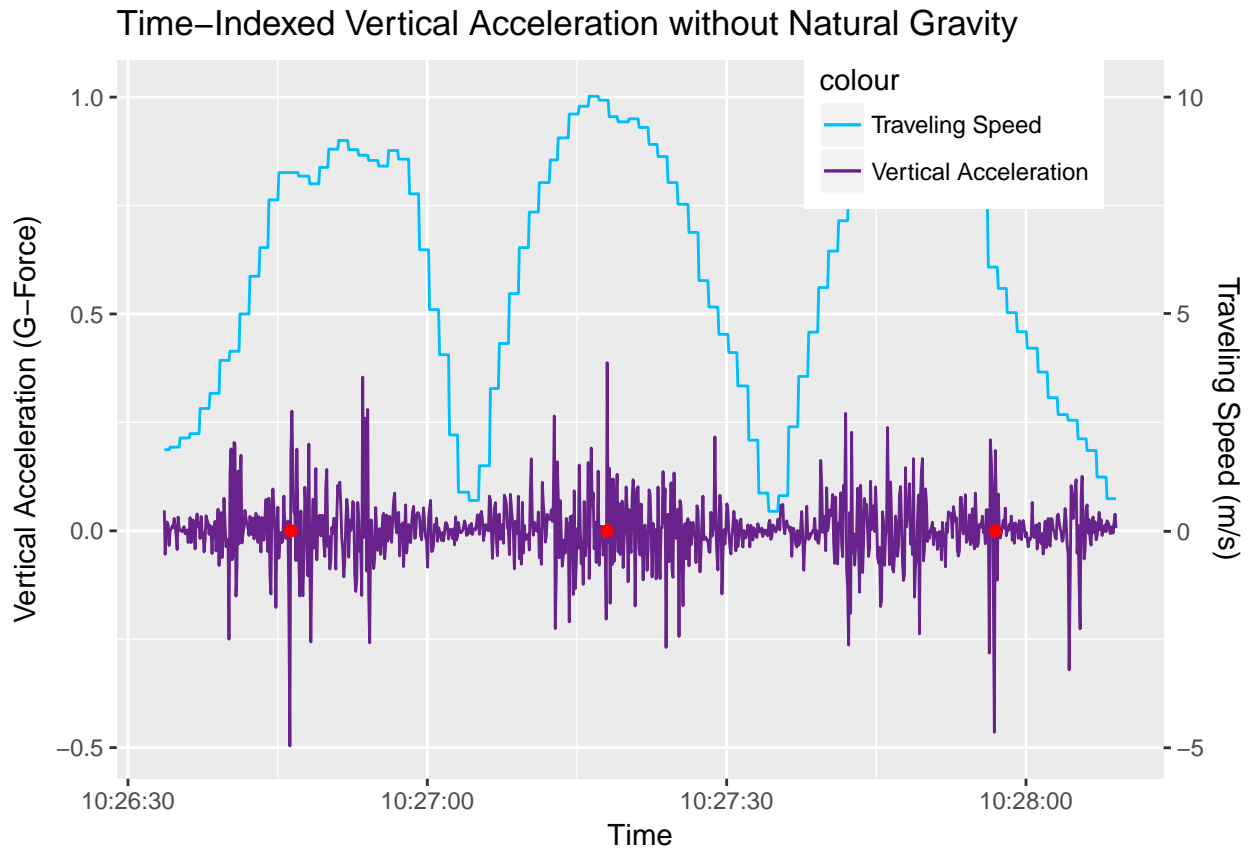


Note: Speed bumps are labeled as *red* points on the graph.

Epoch 2: Display of Vertical Acceleration without Natural Gravity

vert_accel: vertical acceleration (up and down) of the vehicle without natural gravity

```
# remove natural gravity in vertical acceleration  
LA11.valid$vert_accel = LA11.valid$vert_accel_G + 1
```

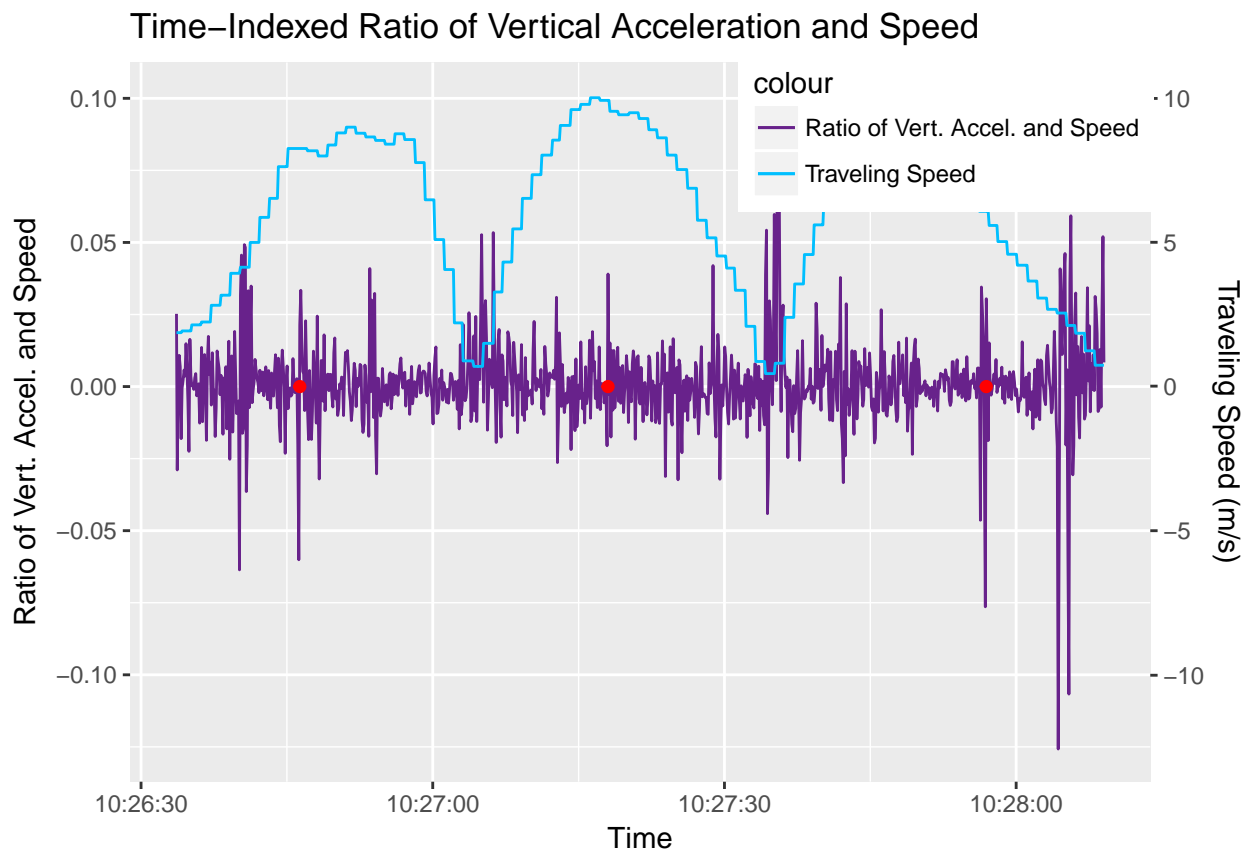


Note: Speed bumps are labeled as *red* points on the graph.

Epoch 3: Display of Ratio between Vertical Acceleration (w/o Natural G) and Speed

`vert_accel_ratio_speed`: the ratio between vertical acceleration (without natural gravity) and traveling speed

```
# calculate ratio between vertical acceleration and speed
for (i in 1:nrow(LA11.valid)) {
  if (LA11.valid$Speed[i] == 0) {
    LA11.valid$vert_accel_ratio_speed[i] = 0
  }
  else {
    LA11.valid$vert_accel_ratio_speed[i] = LA11.valid$vert_accel[i] / LA11.valid$Speed[i]
  }
}
```

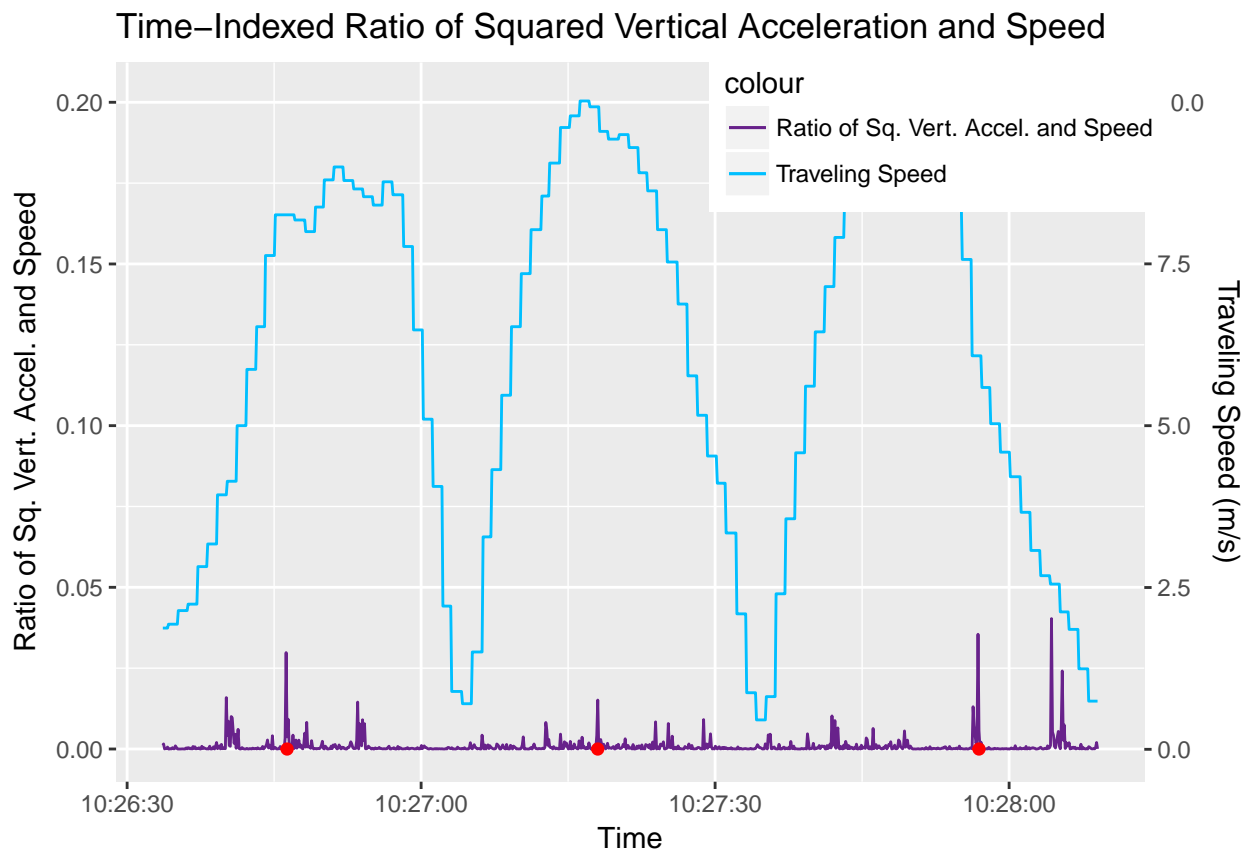


Note: Speed bumps are labeled as *red* points on the graph.

Epoch 4: Display of Ratio between Vertical Acceleration (w/o Natural G) and Speed

sq_vert_accel_ratio_speed: the ratio between squared vertical acceleration (without natural gravity) and traveling speed

```
# calculate ratio between vertical acceleration and speed
for (i in 1:nrow(LA11.valid)) {
  if (LA11.valid$Speed[i] == 0) {
    LA11.valid$sq_vert_accel_ratio_speed[i] = 0
  }
  else {
    LA11.valid$sq_vert_accel_ratio_speed[i] = (LA11.valid$vert_accel[i] * LA11.valid$vert_accel[i]) /
    LA11.valid$Speed[i]
  }
}
```

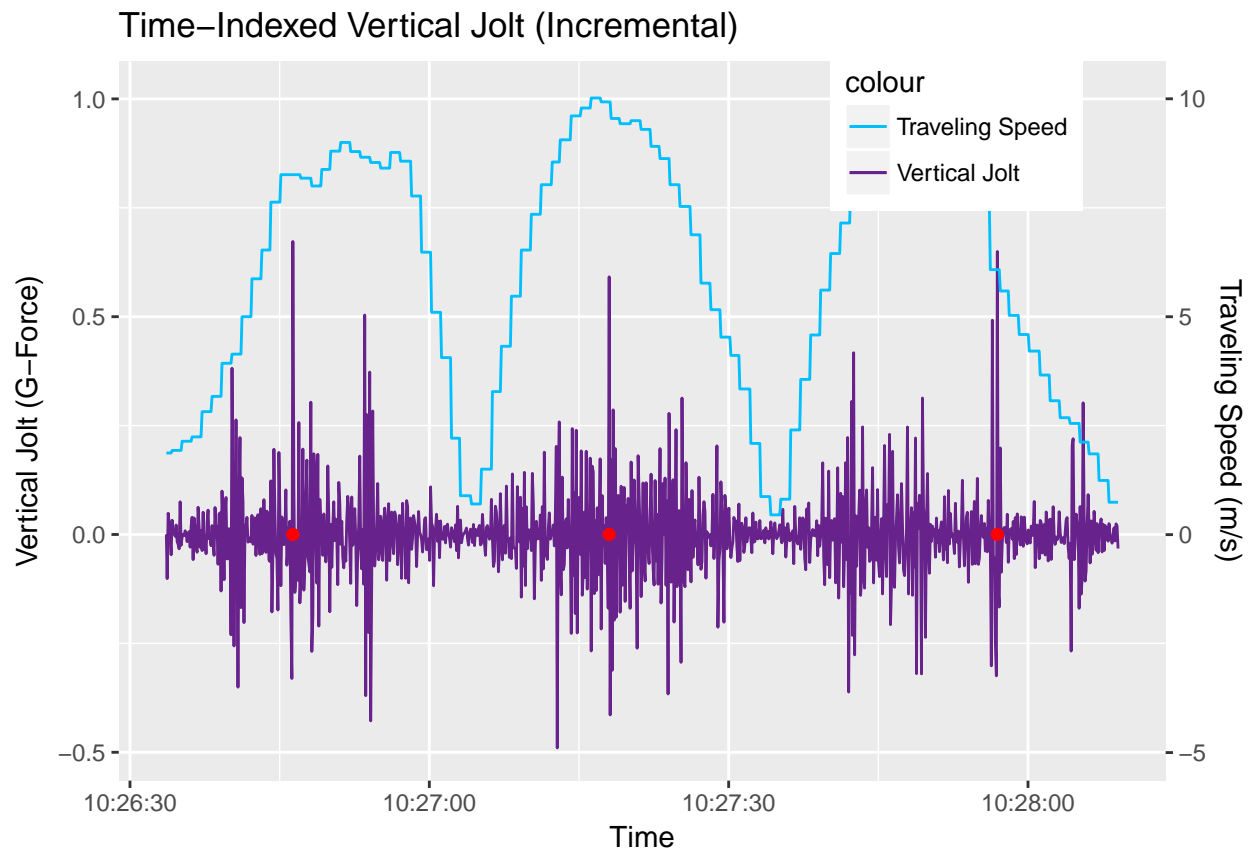


Note: Speed bumps are labeled as *red* points on the graph.

Epoch 5: Display of Vertical Jolt (Incremental Change of Vert. Accel.)

`vert_jolt`: vertical jolt of the vehicle (incremental change of vertical acceleration)

```
# calculate vertical jolt
for (i in 1:nrow(LA11.valid)) {
  if (i == 1) {
    LA11.valid$vert_jolt[i] = 0
  }
  else {
    LA11.valid$vert_jolt[i] = LA11.valid$vert_accel[i] - LA11.valid$vert_accel[i - 1]
  }
}
```

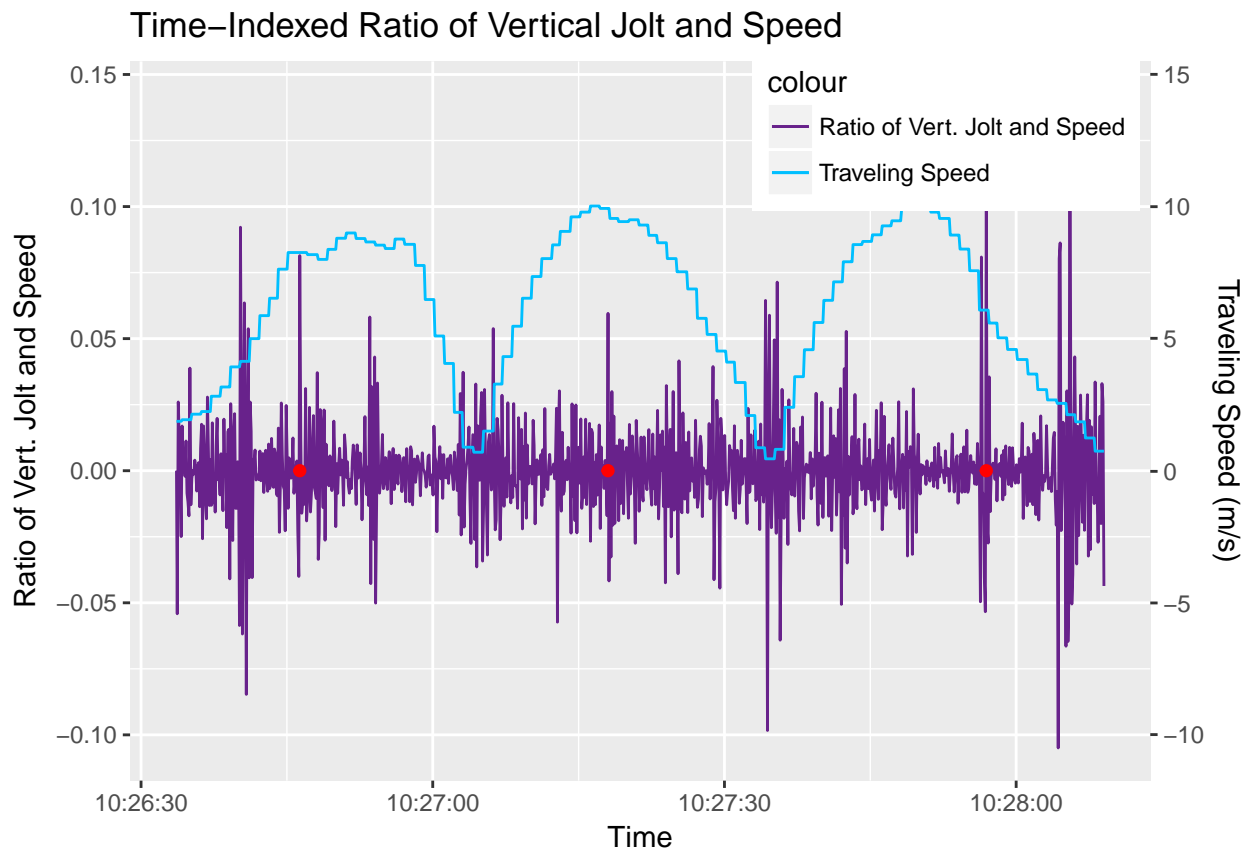


Note: Speed bumps are labeled as *red* points on the graph.

Epoch 6: Display of Ratio between Vertical Jolt and Speed

`vert_jolt_ratio_speed`: the ratio between vertical jolt and traveling speed

```
# calculate ratio between vertical jolt and speed
for (i in 1:nrow(LA11.valid)) {
  if (LA11.valid$Speed[i] == 0) {
    LA11.valid$vert_jolt_ratio_speed[i] = 0
  }
  else {
    LA11.valid$vert_jolt_ratio_speed[i] = LA11.valid$vert_jolt[i] / LA11.valid$Speed[i]
  }
}
```

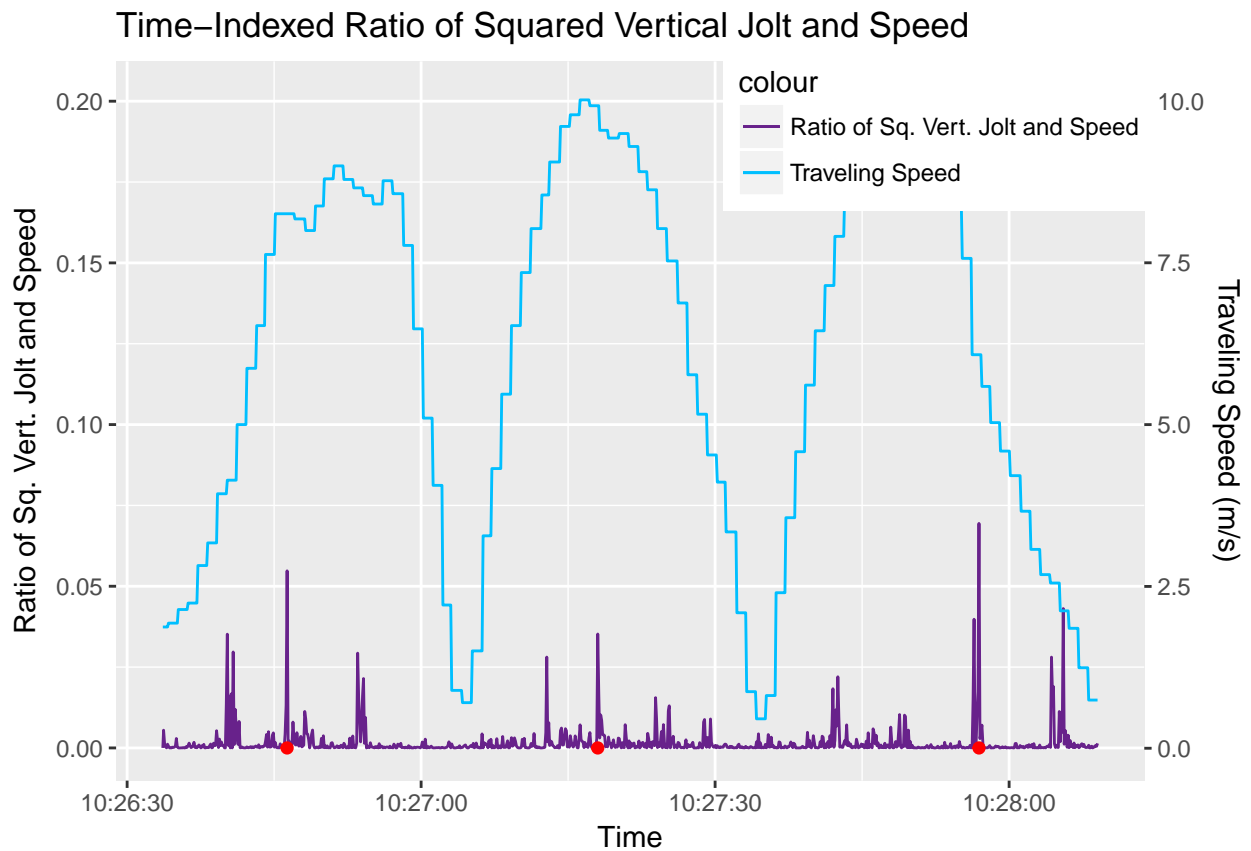


Note: Speed bumps are labeled as *red* points on the graph.

Epoch 7: Display of Ratio between Squared Vertical Jolt and Speed

`sq_vert_jolt_ratio_speed`: the ratio between squared vertical jolt and traveling speed

```
# calculate ratio between vertical jolt and speed
for (i in 1:nrow(LA11.valid)) {
  if (LA11.valid$Speed[i] == 0) {
    LA11.valid$sq_vert_jolt_ratio_speed[i] = 0
  }
  else {
    LA11.valid$sq_vert_jolt_ratio_speed[i] = (LA11.valid$vert_jolt[i] * LA11.valid$vert_jolt[i]) / LA11.valid$Speed[i]
  }
}
```



Note: Speed bumps are labeled as *red* points on the graph.

Epoch 8: Display of Sliding-Window Statistics of Vertical Jolt

vert_jolt_mean: 5-sliding-window mean of vertical jolt

vert_jolt_sd: 5-sliding-window standard deviation of vertical jolt

vert_jolt_min: 5-sliding-window minimum of vertical jolt

vert_jolt_max: 5-sliding-window maximum of vertical jolt

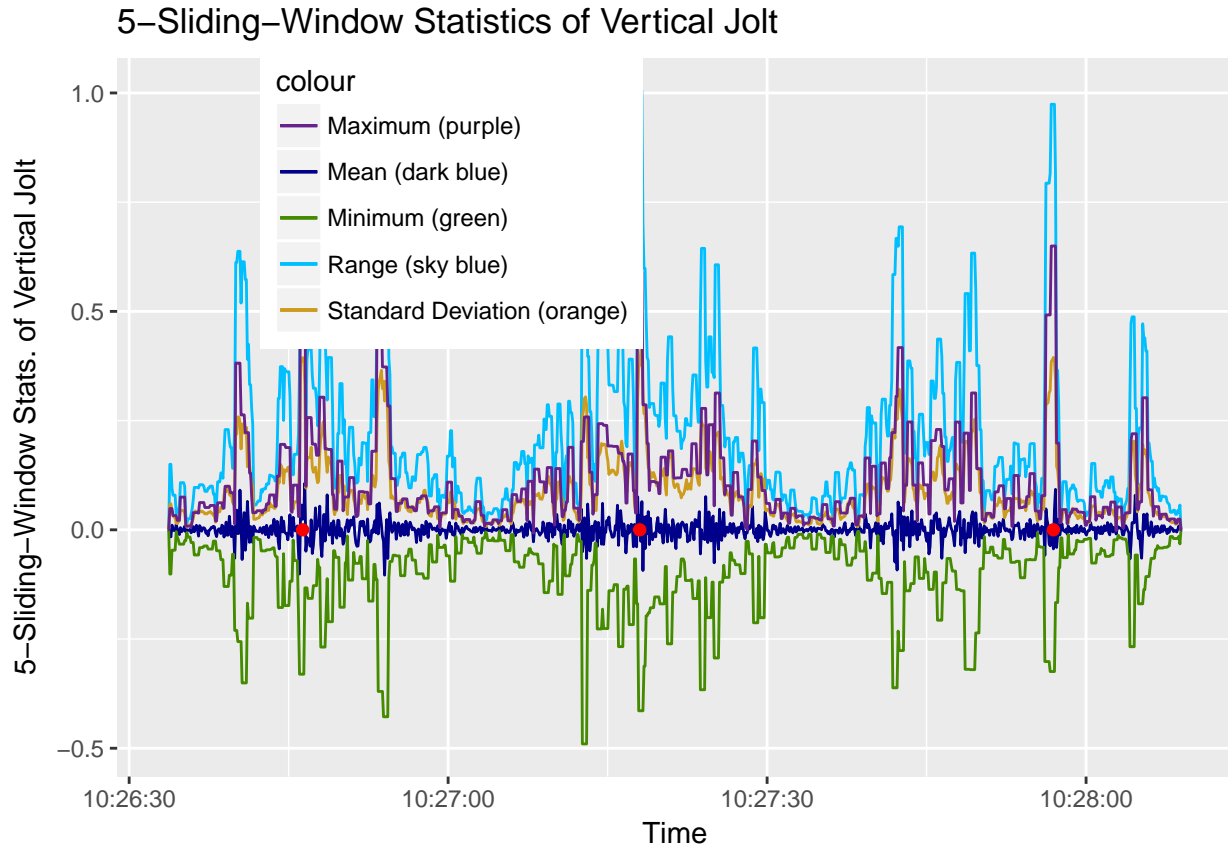
vert_jolt_range: 5-sliding-window range of vertical jolt

```
# calculate 5-sliding-window mean of vertical jolt
for (i in 3:nrow(LA11.valid)-2) {
  LA11.valid$vert_jolt_mean[i] = mean(c(LA11.valid$vert_jolt[i-2],
                                       LA11.valid$vert_jolt[i-1],
                                       LA11.valid$vert_jolt[i],
                                       LA11.valid$vert_jolt[i+1],
                                       LA11.valid$vert_jolt[i+2]))
}
LA11.valid$vert_jolt_mean[1] = 0
LA11.valid$vert_jolt_mean[2] = 0
LA11.valid$vert_jolt_mean[nrow(LA11.valid) - 1] = 0
LA11.valid$vert_jolt_mean[nrow(LA11.valid)] = 0
# calculate 5-sliding-window standard deviation of vertical jolt
for (i in 3:nrow(LA11.valid)-2) {
  LA11.valid$vert_jolt_sd[i] = sd(c(LA11.valid$vert_jolt[i-2],
                                   LA11.valid$vert_jolt[i-1],
                                   LA11.valid$vert_jolt[i],
                                   LA11.valid$vert_jolt[i+1],
                                   LA11.valid$vert_jolt[i+2]))
}
LA11.valid$vert_jolt_sd[1] = 0
LA11.valid$vert_jolt_sd[2] = 0
LA11.valid$vert_jolt_sd[nrow(LA11.valid) - 1] = 0
LA11.valid$vert_jolt_sd[nrow(LA11.valid)] = 0
# calculate 5-sliding-window minimum of vertical jolt
for (i in 3:nrow(LA11.valid)-2) {
  LA11.valid$vert_jolt_min[i] = min(c(LA11.valid$vert_jolt[i-2],
                                      LA11.valid$vert_jolt[i-1],
                                      LA11.valid$vert_jolt[i],
                                      LA11.valid$vert_jolt[i+1],
                                      LA11.valid$vert_jolt[i+2]))
}
LA11.valid$vert_jolt_min[1] = 0
LA11.valid$vert_jolt_min[2] = 0
LA11.valid$vert_jolt_min[nrow(LA11.valid) - 1] = 0
LA11.valid$vert_jolt_min[nrow(LA11.valid)] = 0
# calculate 5-sliding-window maximum of vertical jolt
for (i in 3:nrow(LA11.valid)-2) {
  LA11.valid$vert_jolt_max[i] = max(c(LA11.valid$vert_jolt[i-2],
                                      LA11.valid$vert_jolt[i-1],
                                      LA11.valid$vert_jolt[i],
                                      LA11.valid$vert_jolt[i+1],
                                      LA11.valid$vert_jolt[i+2]))
}
LA11.valid$vert_jolt_max[1] = 0
```

```

LA11.valid$vert_jolt_max[2] = 0
LA11.valid$vert_jolt_max[nrow(LA11.valid) - 1] = 0
LA11.valid$vert_jolt_max[nrow(LA11.valid)] = 0
# calculate 5-sliding-window range of vertical jolt
LA11.valid$vert_jolt_range = LA11.valid$vert_jolt_max - LA11.valid$vert_jolt_min

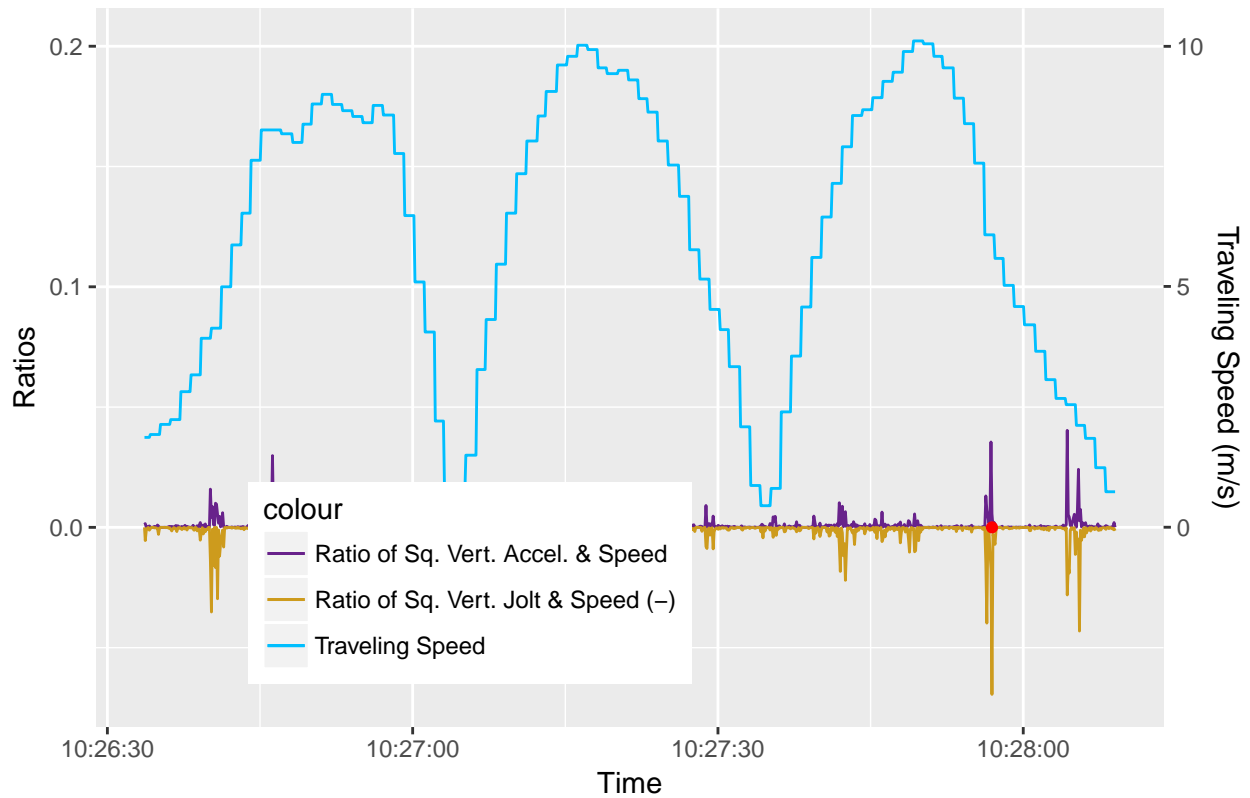
```



Note: Speed bumps are labeled as *red* points on the graph.

Epoch 9: Comparative Display of Two Most Promising Factors

Comparison of Two Most Promising Factors



Note: Ratio of Sq. Vert. Jolt & Speed is negatively flipped for visualization purpose.

Note: Speed bumps are labeled as *red* points on the graph.

Data Writing

Date: the time stamp of a data point

Latitude:

Longitude:

Speed: traveling speed of the vehicle

speedbump: whether this data point is a speedbump

forw_accel: forward acceleration (front and back) of the vehicle

hori_accel: horizontal acceleration (left and right) of the vehicle

vert_accel_G: vertical acceleration (up and down) of the vehicle with natural gravity (-1G)

vert_accel: vertical acceleration (up and down) of the vehicle without natural gravity

vert_accel_ratio_speed: the ratio between vertical acceleration (without natural gravity) and traveling speed

sq_vert_accel_ratio_speed: the ratio between squared vertical acceleration (without natural gravity) and traveling speed

vert_jolt: vertical jolt of the vehicle (incremental change of vertical acceleration)

vert_jolt_ratio_speed: the ratio between vertical jolt and traveling speed

sq_vert_jolt_ratio_speed: the ratio between squared vertical jolt and traveling speed

vert_jolt_mean: 5-sliding-window mean of vertical jolt

vert_jolt_sd: 5-sliding-window standard deviation of vertical jolt

vert_jolt_min: 5-sliding-window minimum of vertical jolt

vert_jolt_max: 5-sliding-window maximum of vertical jolt

vert_jolt_range: 5-sliding-window range of vertical jolt

```
jpeg("./Epoch1_LA11.vert_accel_G.plot.jpeg", width = 1200, height = 750, units = "px")
print(LA11.vert_accel_G.plot)
dev.off()
```

```
## pdf
## 2
```

```
jpeg("./Epoch2_LA11.vert_accel.plot.jpeg", width = 1200, height = 750, units = "px")
print(LA11.vert_accel.plot)
dev.off()
```

```
## pdf
## 2
```

```
jpeg("./Epoch3_LA11.vert_accel_ratio_speed.plot.jpeg", width = 1200, height = 750, units = "px")
print(LA11.vert_accel_ratio_speed.plot)
dev.off()
```

```
## pdf
## 2
```

```
jpeg("./Epoch4_LA11.sq_vert_accel_ratio_speed.plot.jpeg", width = 1200, height = 750, units = "px")
print(LA11.sq_vert_accel_ratio_speed.plot)
dev.off()
```

```
## pdf
## 2
```

```
jpeg("./Epoch5_LA11.vert_jolt.plot.jpeg", width = 1200, height = 750, units = "px")
print(LA11.vert_jolt.plot)
dev.off()
```

```
## pdf
```

```

## 2
jpeg("./Epoch6_LA11.vert_jolt_ratio_speed.plot.jpeg", width = 1200, height = 750, units = "px")
print(LA11.vert_jolt_ratio_speed.plot)
dev.off()

## pdf
## 2
jpeg("./Epoch7_LA11.sq_vert_jolt_ratio_speed.plot.jpeg", width = 1200, height = 750, units = "px")
print(LA11.sq_vert_jolt_ratio_speed.plot)
dev.off()

## pdf
## 2
jpeg("./Epoch8_LA11.vert_jolt_5.plot.jpeg", width = 1200, height = 750, units = "px")
print(LA11.vert_jolt_5.plot)
dev.off()

## pdf
## 2
jpeg("./Epoch9_LA11.comparative.plot.jpeg", width = 1200, height = 750, units = "px")
print(LA11.comparative.plot)
dev.off()

## pdf
## 2
write.csv(LA11.valid, "./los_angeles_11_labeled.csv")

```