Pothole Detection Report

Contents

1. Pre Processing

Data acquired from a mobile device which is there in file data.csv, column X represent the linear acceleration towards the right side of the vehicle, column Y represent linear acceleration towards the front side of the vehicle and column Z represent linear acceleration towards an upward direction. When pothole experienced by the mobile device 3D accelerometer sensor, it is expected to change the amplitude level in sensor's X, Y and Z axis. To get combined acceleration data points, RMS value (R) of X, Y and Z axis is computed. Pothole detection analysis is performed over R instated of any individual acceleration data direction either of X, Y or Z to make system or algorithm independent of data acquisition system or mobile phone independent of orientation.

$$R = \sqrt{X^2 + Y^2 + Z^2}$$

The fourth column, t, represents time ms. The average time gap between two samples is 5 ms. It assumed that sampling frequency of the accelerometer to be 200 Hz.

2. Low pass/High pass filter design

The accelerometer data provided in data.csv encompass High-frequency oscillations from the device and ambient atmosphere. In order to remove this noise, mean RMS R acceleration data need to processes from a low pass band filter to remove the noise to acquire the clear signal.

Because of flat nature in the pass band, Butterworth Low Pass IIR filter is selected with the order of 2.

To select the best low pass filter cuff off frequency from the range of frequencies from 0.01*FS to 0.5*FS, SNR of filtered and inputted signal is computed. And it is observed that for given signal ideal low pass cut off frequency filter is 2Hz.

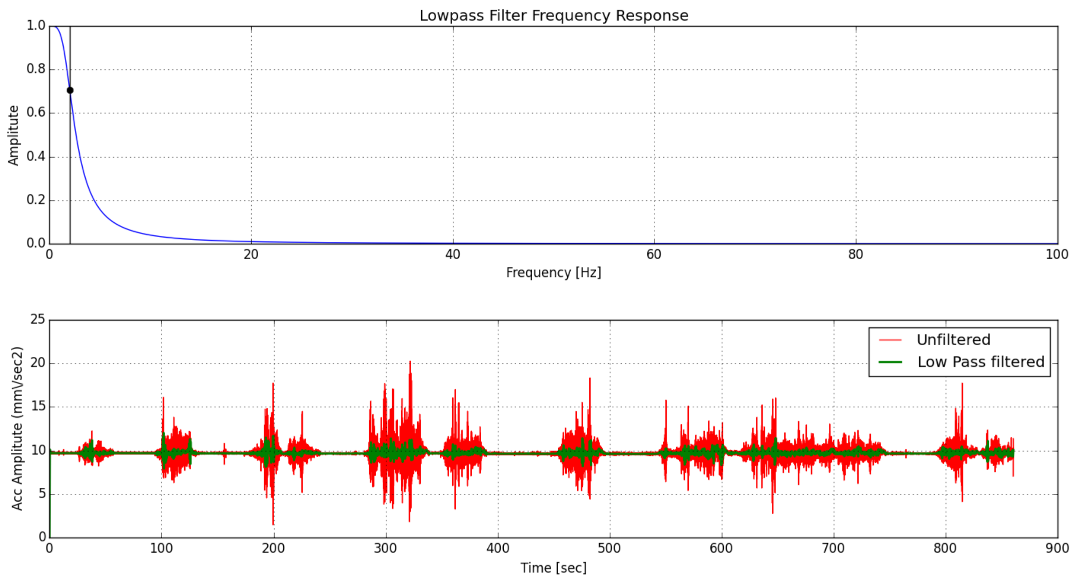

Figure 1: Low pass Filter Frequency Response and its Signal Filtering

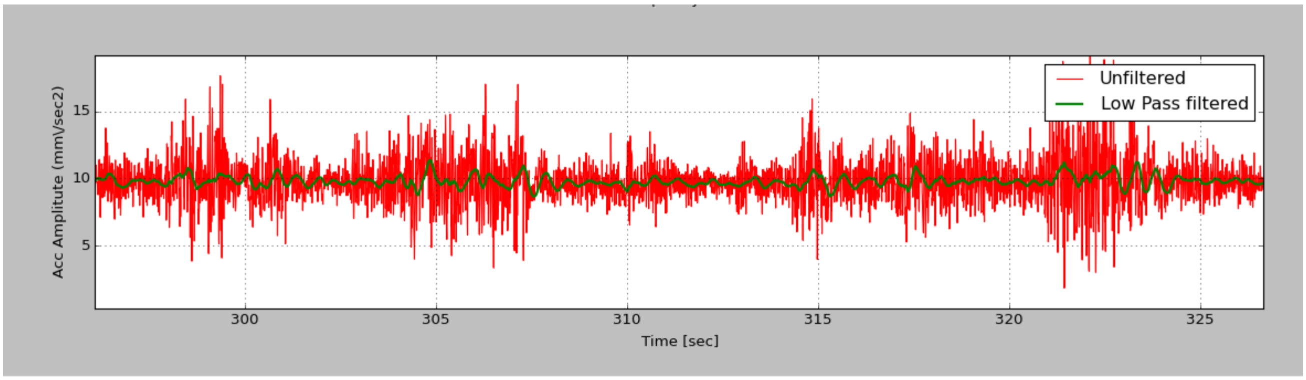

Figure 2: Input Signal Vs Low pass filtered Signal

Since we wanted to preserve peaks which represent sudden jerks at every sampling, the Higher cut off frequency set to 0.5*FS – T*LpCutOff frequency. Where T is a threshold, which is programmable and it can be tuned depending on peskiness required in the signal.

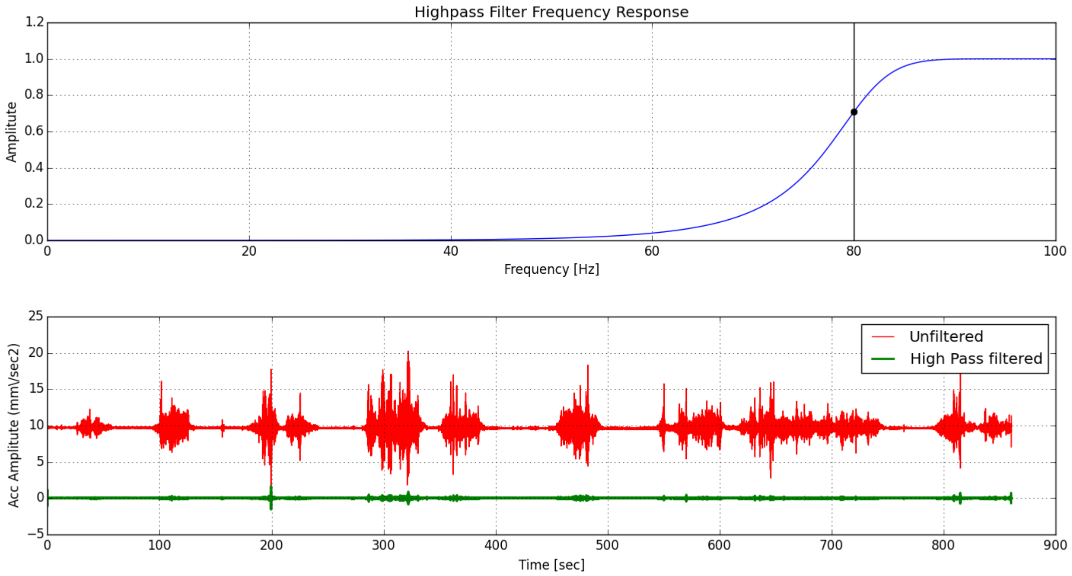

Figure 3: High Pass Filter Frequency Response and its Signal Filtering

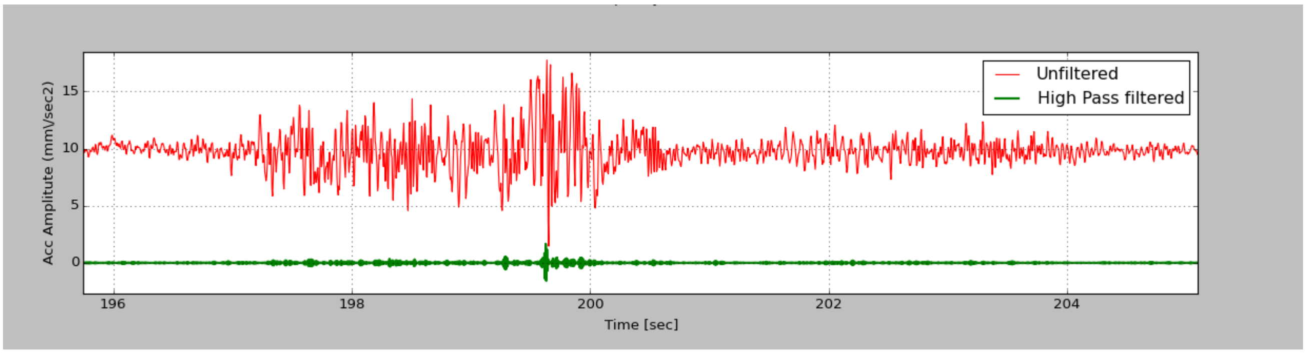

Figure 4: Input Signal Vs High Pass filtered Signal

Now, Band Pass = Low Pass + High pass,

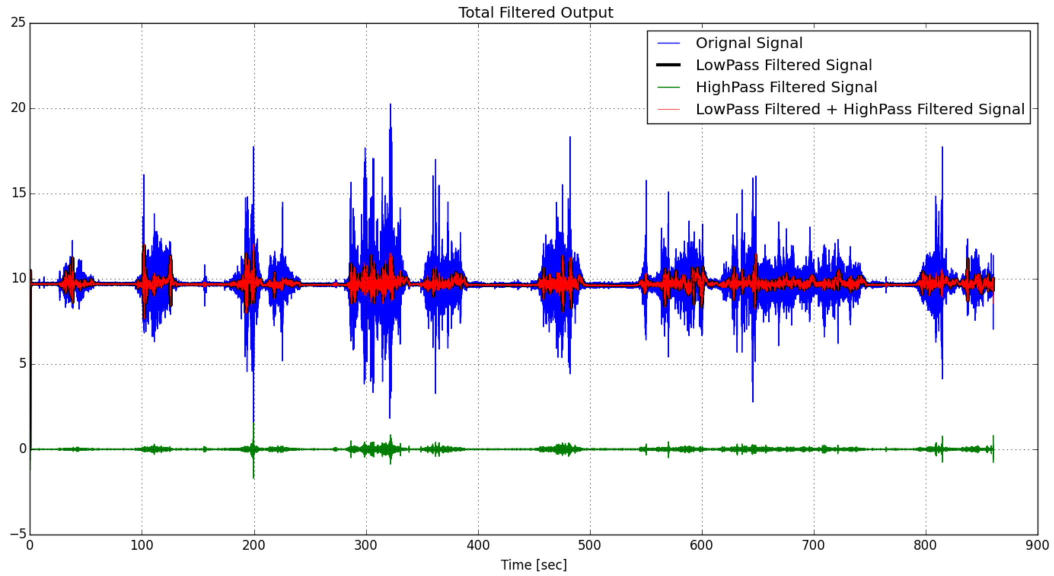

Figure 5: Band Pass (Low pass Filter + High Pass) Filtered Output

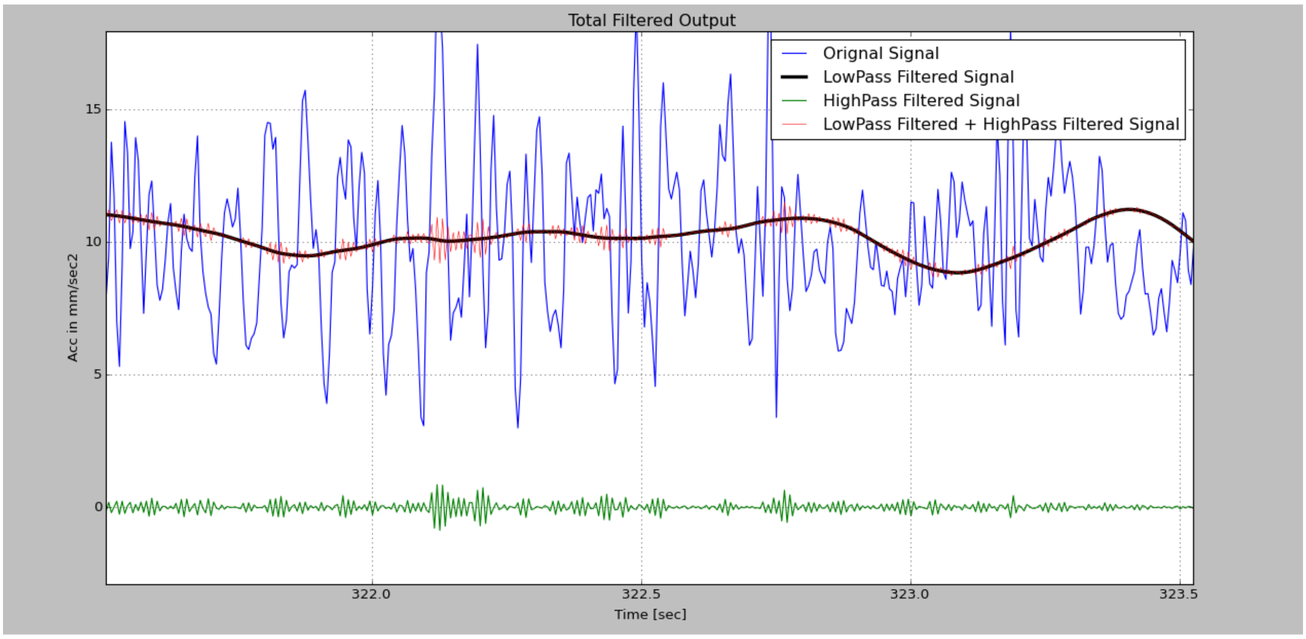

Figure 6: Band Pass (Low pass Filter + High Pass) Filtered Output

3. Pothole detection Approach

The objective of the algorithm is to broadly identify the start time stamp and end stamp of and the filtered signal. The approach adopted in this algorithm to find out the transition experienced by the accelerometer above the zero level. Ideally, when there is this zero level of the accelerometer does have 9.8g value when there is no movement in either of the direction. However, whenever the car is moving this zero level can be changed due to implicit jerks due to not only due to the moving car but also the relative movement of the mobile phone.

To nullify the jerks experienced by the implicit movement the zero level is optimally defined as

zero level = mean(Filtered Signal) + S*SD(Filtered Signal)

Where SD is standard deviation and S is scaling factor

Here, the value of S used is 1. However, the value of the zero level can be tuned by experimenting on large data set.

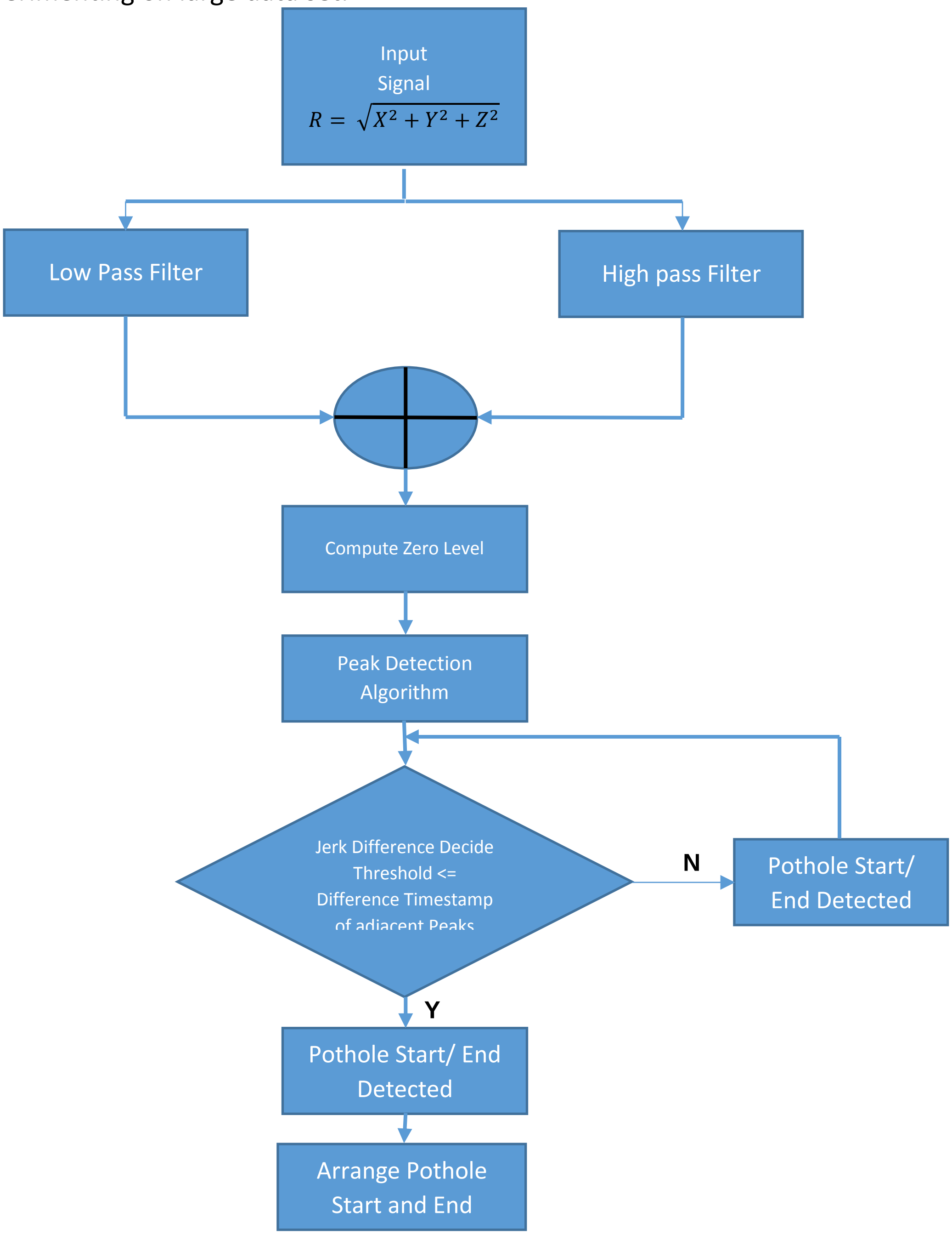

Figure 7: Flowchart for Detecting Pothole

Figure 7 represents the overall flow for detecting pothole start and end timestamp.

Peak search algorithm works as below:

1. Define zero level as mean of R data, initialize present state and previous state to none
2. This Zero level is level above which if find any values we are categorizing it as peak region values
3. If there is no positive transition from previous value to present value then ignore the present value else if there is a positive transition, categorize the previous value as a peak if last detected peak is less than zero level.

The filtered signal is processed for detecting peaks above the zero level as shown in Figure 8

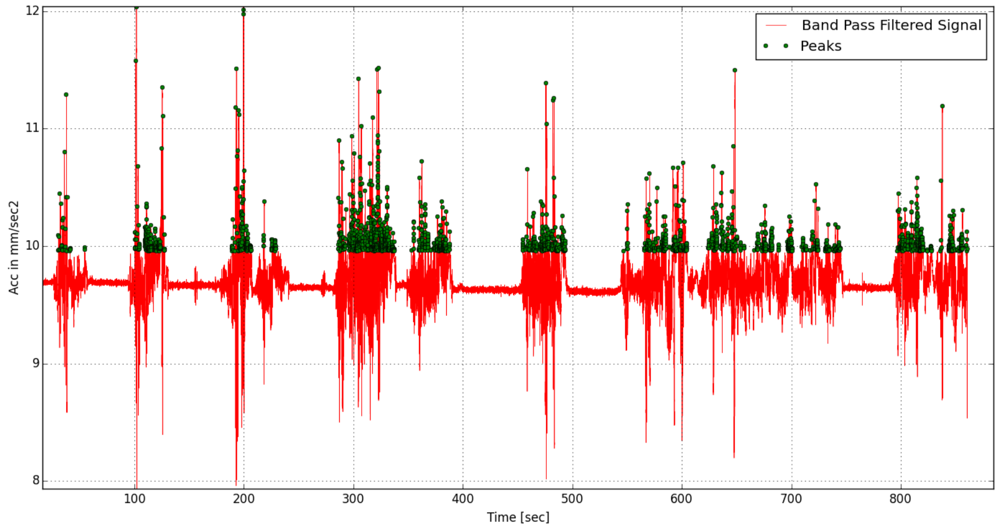

Figure 8: Peaks Detected in Band Pass Filtered Signal

After detecting peaks the next step is to find out the start and end time stamps. If the adjacent peaks time stamps difference is greater than or equal to Jerk Difference Decide Threshold (JDDT) then that time stamp corresponding peaks is to be noted as pothole Start or End. From start and stop Vector the even instances are classified as Start point and Odd instances at classified as End point of the pothole

4. Results

From Figure 9 it can be observed that algorithm accurately detects the starting instances of the pot holes which is marked by black dots and from Figure 10, the algorithm detects the end point instances which is marked by yellow dots. Combined start and end instances are shown in Figure 11

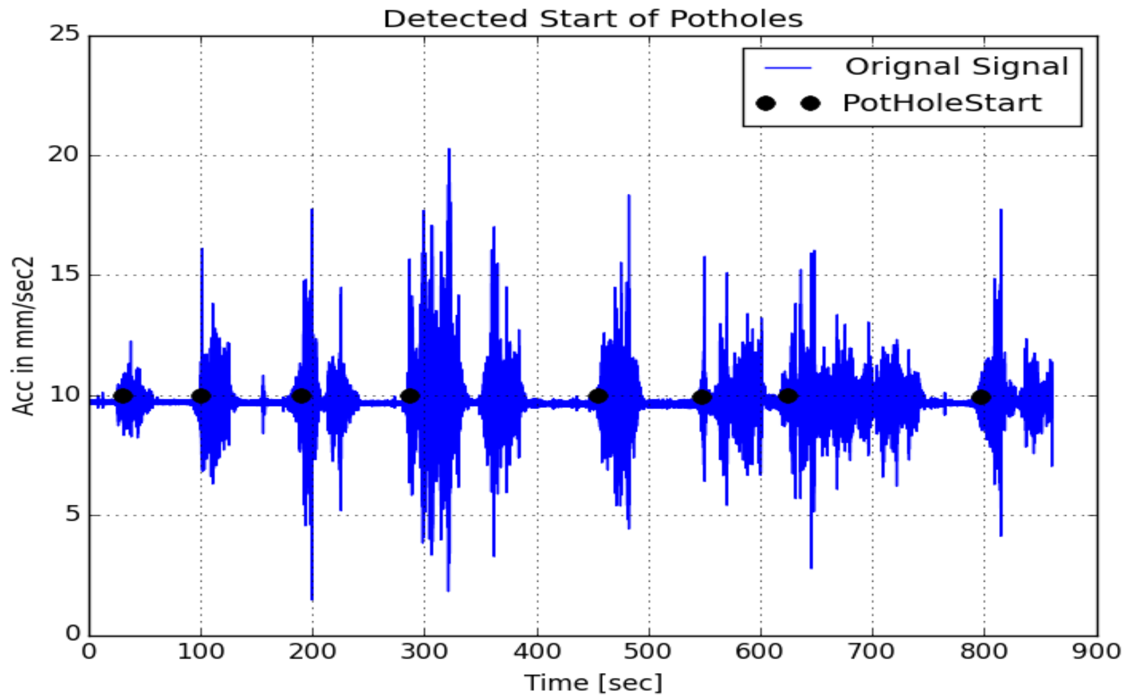

Figure 9: Detected Starting time point of the Pothole

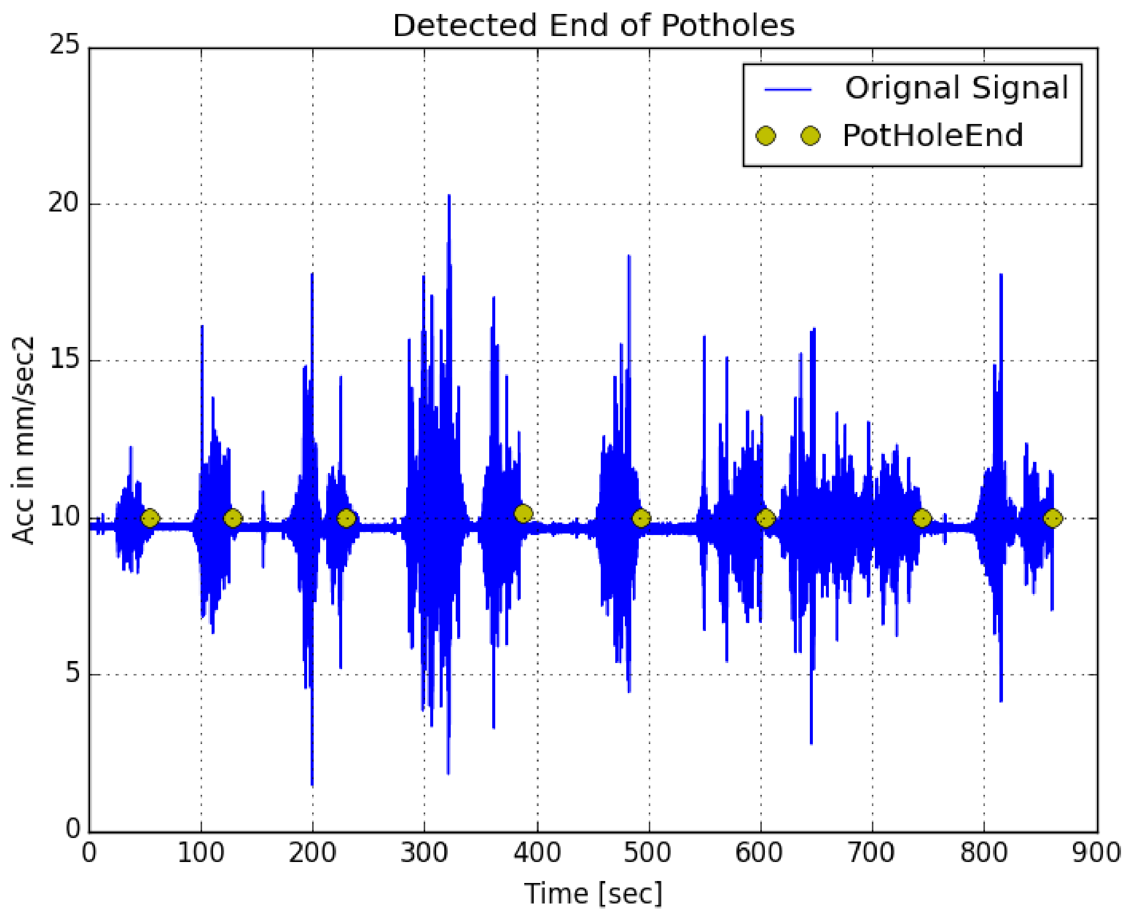

Figure 10: Detected End time point of Pothole

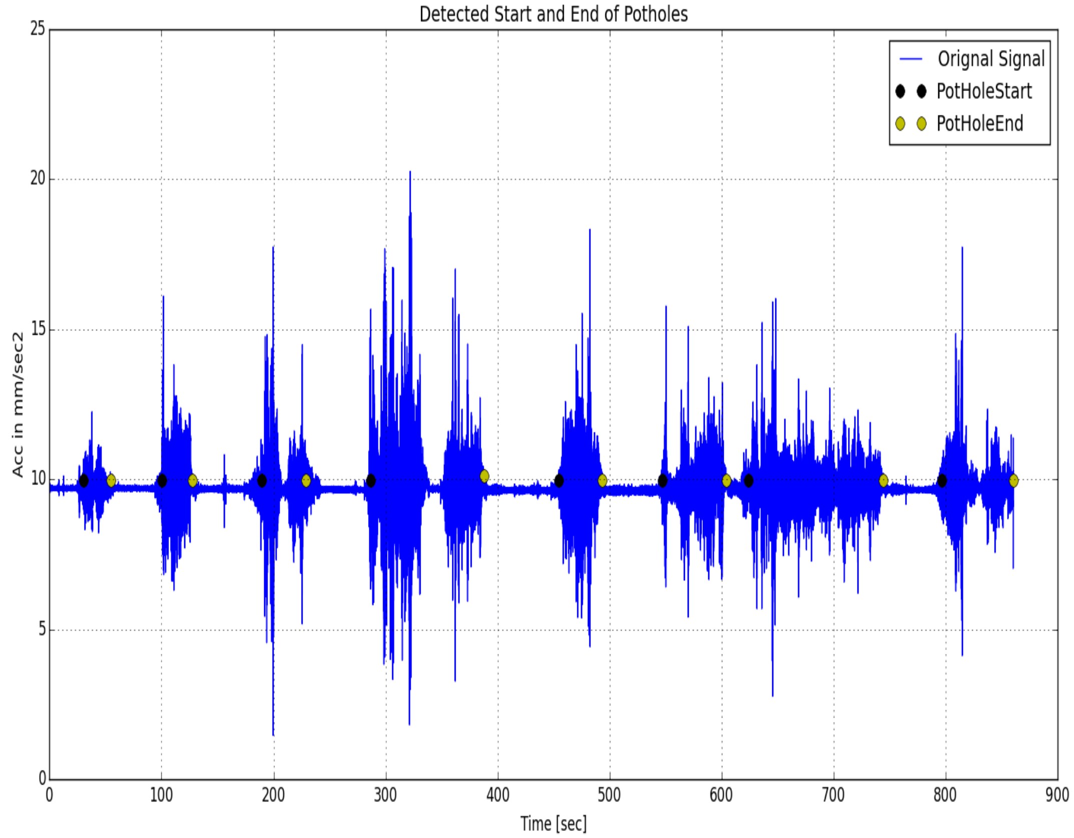

Figure 11: Detected Start and End Time Point of Pothole

5. Conclusion

The proposed algorithm is time domain based method which detects the start and end point of the jerks. Also, the proposed algorithm does processing only a signal data which mean of all 3 axis data of accelerometer. Hence the algorithm is a computationally efficient and can be implemented in the mobile phones easily.

However, zero level, Low pass cut off frequency, High pass cut off frequency and Jerk Difference Decide Threshold (JDDT) can be tuned easily tuned for referring more variant data set of the pothole. Moreover, the more accurate adaptive peak detection algorithm can be tuned to avoid miss classification of potholes from manholes, curbs, railroad crossings, and expansion joints.