Human Gait Analysis

Exploratory Project of
Second Year IDD.
by
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Process

- Accelerometer is started [Start] and subject walks with phone in his/her pocket.
- Subject stops and presses the [Stop] button. Recorded accelerometer readings is then saved in Internal/External storage.
- Subject presses [Compare] button.
- Recorded data is read from the storage.
- Data is the then passed to the low-pass filter.
- Moving average algorithm is then used to smooth time series data and remove sudden spikes.

Process (Cont.)

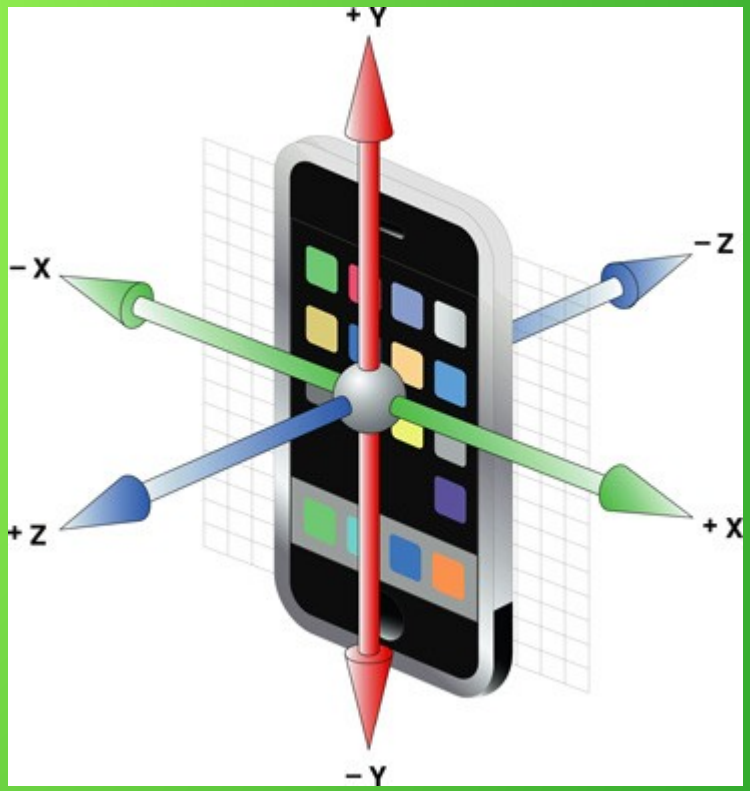
- Data is then normalized.
- Local maximal points are found out in the time series data.
- Points(maximal) which are less than a threshold value is discarded.
- Gait cycle template is extracted.
- The gait cycle template of both legs is calculate and the resemblance score is reported.

Recording Accelerometer Data

- Smartphone is kept in trouser in proper orientation. As shown in the figure.
- With +z axis pointing forward and -z axis passing through the legs.
- -X and +X axis pointing right

  and left respectively.
- +Y and -Y axis pointing top and

  down respectively.

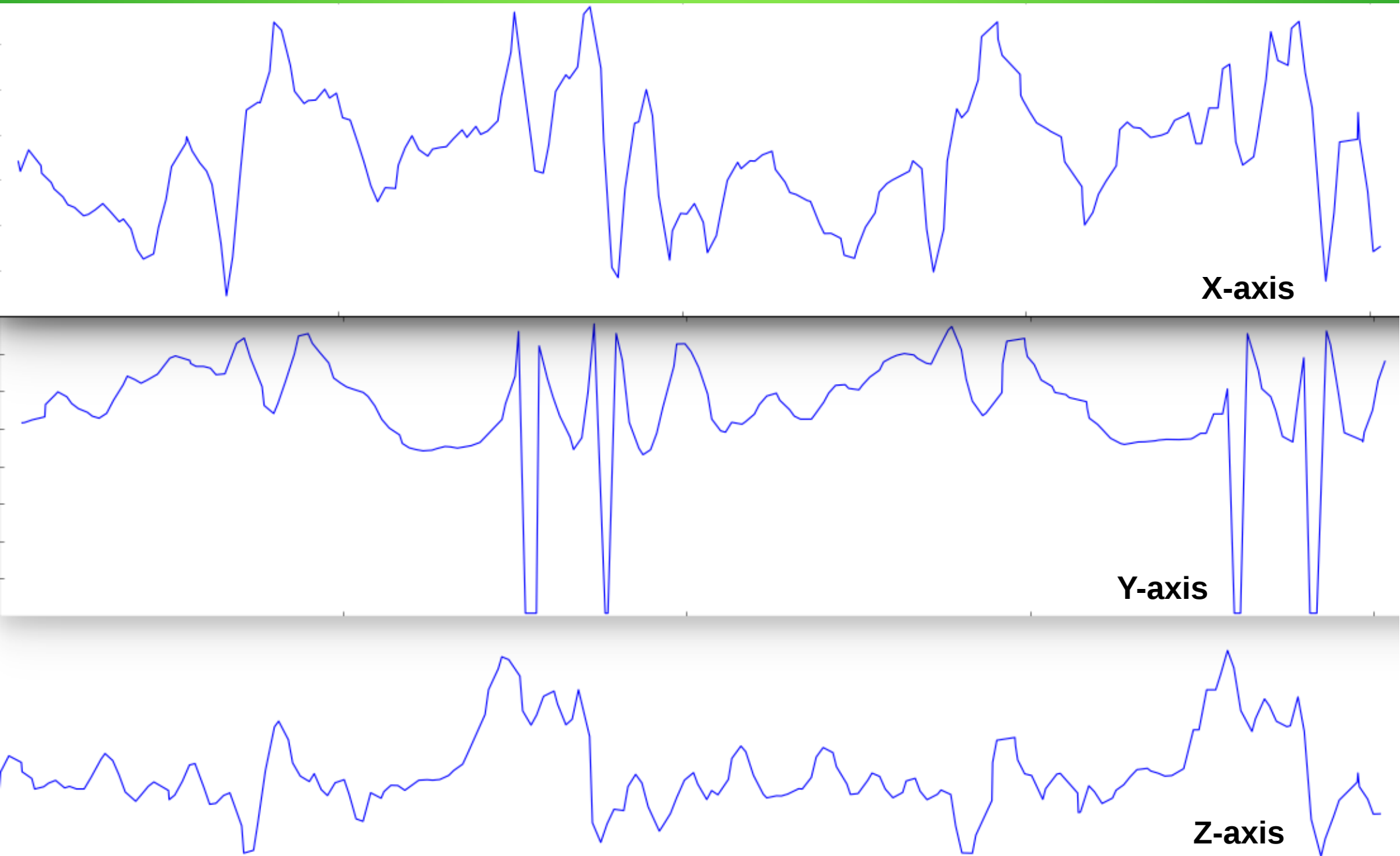


Inage Source:http://stackoverflow.com/questions/11175599/how-to-measure-the-tilt-of-the-phone-in-xy-plane-using-accelerometer-in-android

Cont..

- In this orientation both Y-axis and Z-axis reading can be used for effective time series analysis.
- Z-axis is used here for further analysis.
- Z & Y axis give reading of same orientation where as X axis reading are mirror image of each other.

X Y Z axis raw readings



Data Logging

- Either internal or external storage option can be used for logging accelerometer data.
- Recorded data is saved in txt format.
- This app can also be used as standalone accelerometer data logger.
- First column: “time” in milli’s.

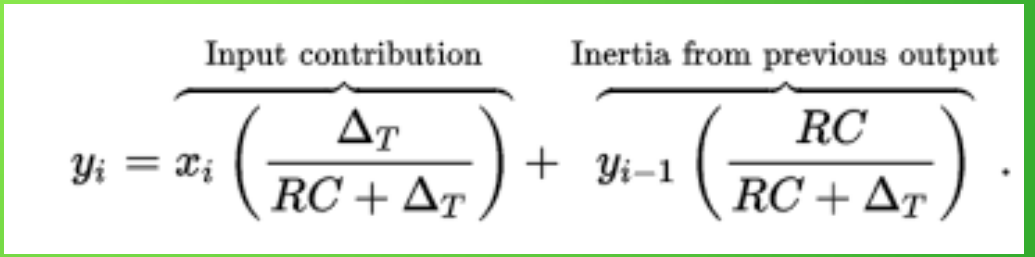
  2nd,3rd,4th column are X,Y,Z axis reading respectively.
- SENSOR_DELAY_FASTEST is used for recording accelerometer data.
- Storage Location:

  sdcard/AcceleroData/*

1016	-2.2146366	11.829751	0.9911995
1032	-2.1308396	11.346122	1.0486604
1036	-1.7262194	11.020511	0.93134445
1055	-0.78769237	10.630256	0.59376204
1076	-1.4628572	10.311827	0.34955344
1077	-2.255338	9.792285	0.6488287
1078	-1.5490485	10.156203	0.92895025
1086	-2.753332	8.719683	0.8523358
1097	-2.918532	8.966286	1.2497733

Low-pass filter

- Holt exponential smoother is used[1].
- This filter removes the high frequency element from the time series data and its extent is set by the value of alpha i.e., the weight given to the previous data point.



1.http://folk.uib.no/ngbnk/kurs/notes/node107.html

ImageSource:https://en.wikipedia.org/wiki/Low-pass_filter

Low-pass filtered data.

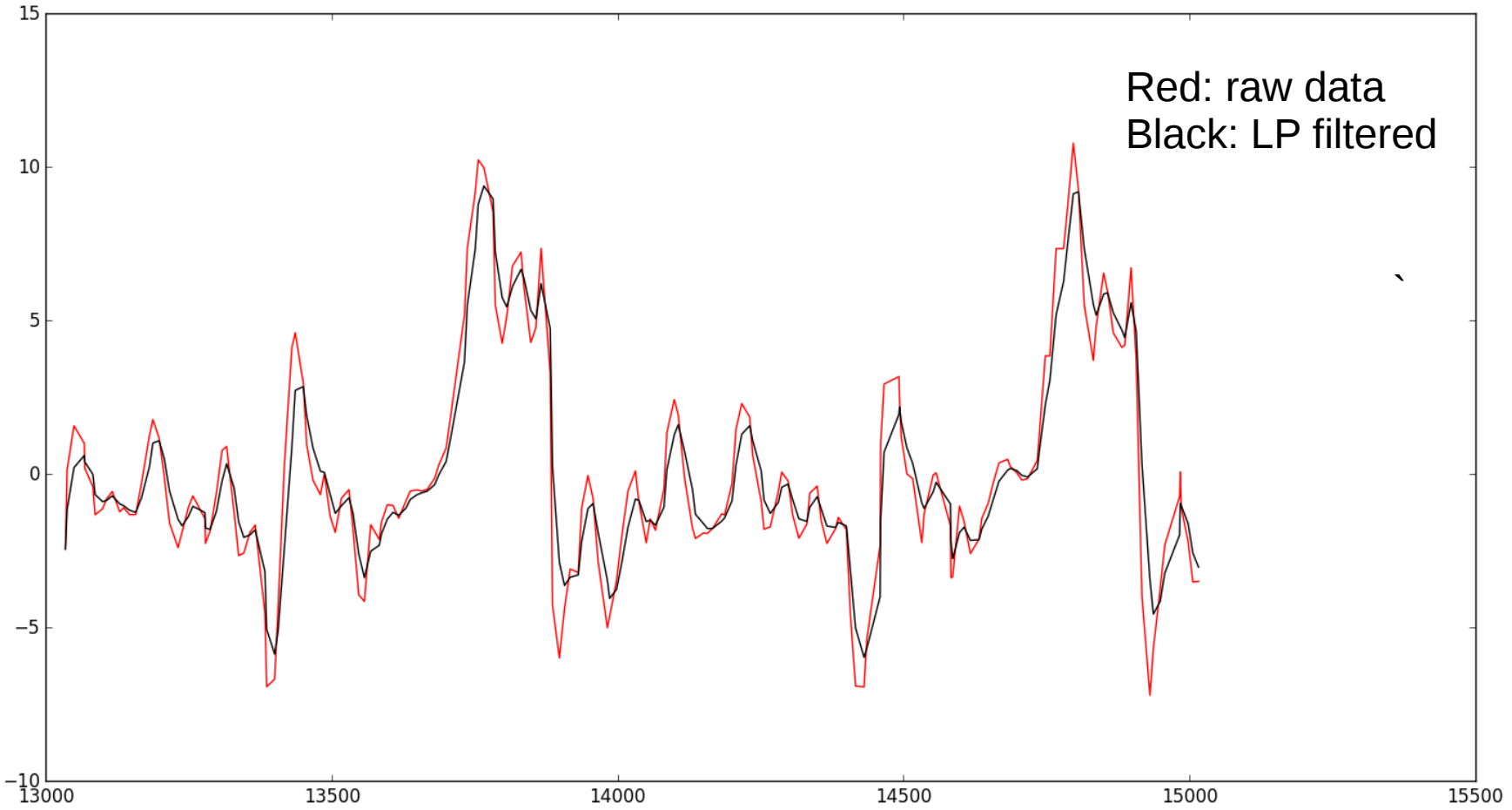


Fig: Low-pass filtered Z-axis data with alpha=0.5

Moving Average

$$\frac{1}{q}\sum_{k=-q/2}^{q/2} x_{t+k}$$

- A smoothing technique used for time series analysis.
- The average over q data is set as the value of the median element.
- Here equal weight is given to every element over summation.

ImageSource:http://folk.uib.no/ngbnk/kurs/notes/img342.gif

Moving Averaged data

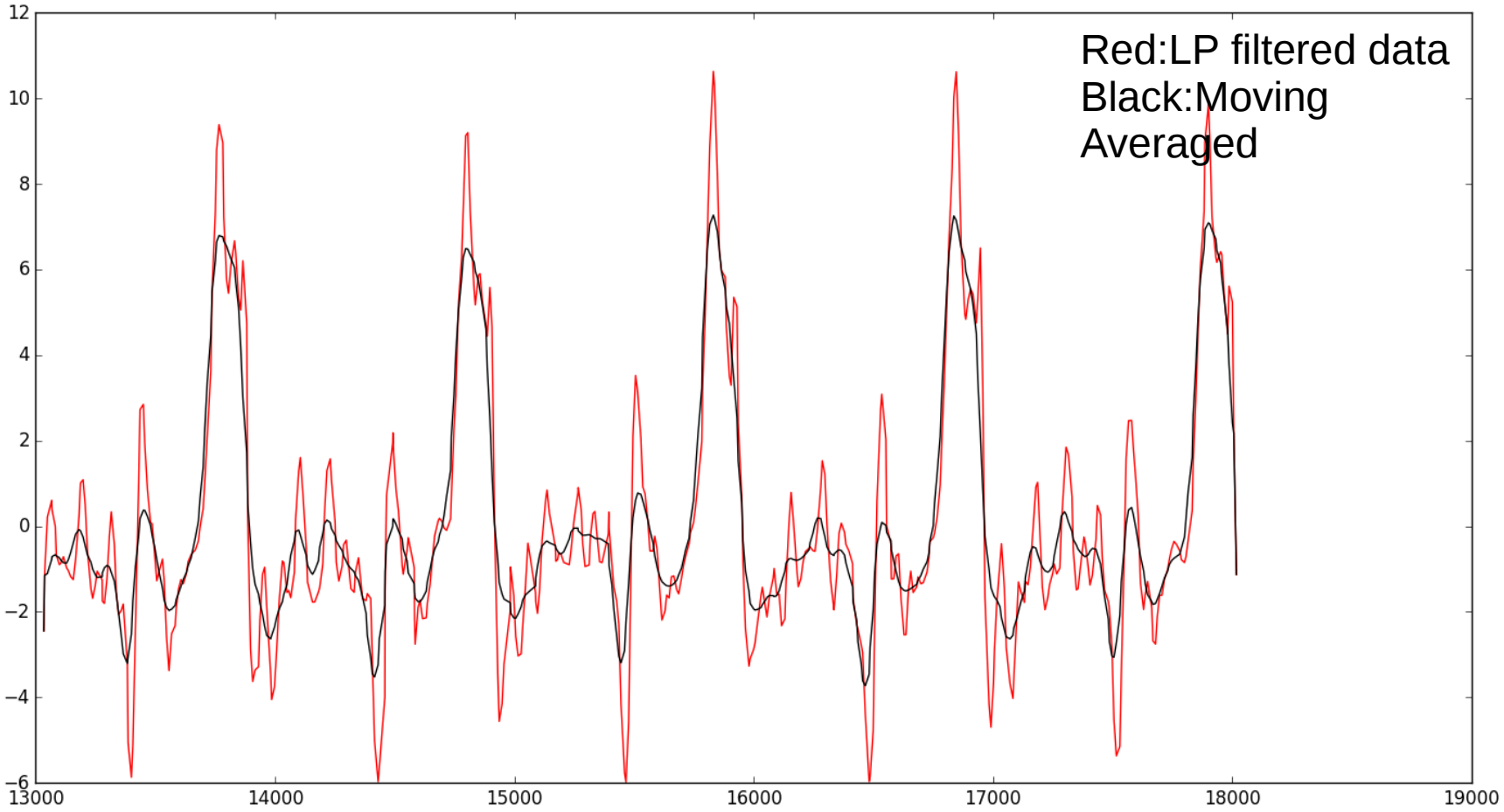


Fig: Moving average applied on LP filtered data. Window size=5, with moving average applied three times.

Normalization

- y[i] = (x[i] - min) / (max – min)[1].
- Where y’s are the normalized data and x’s are the data to be normalized.
- Helps in calculating Average Gait Cycle effectively.

1.http://machinelearningmastery.com/normalize-standardize-time-series-data-python/

Normalized Data

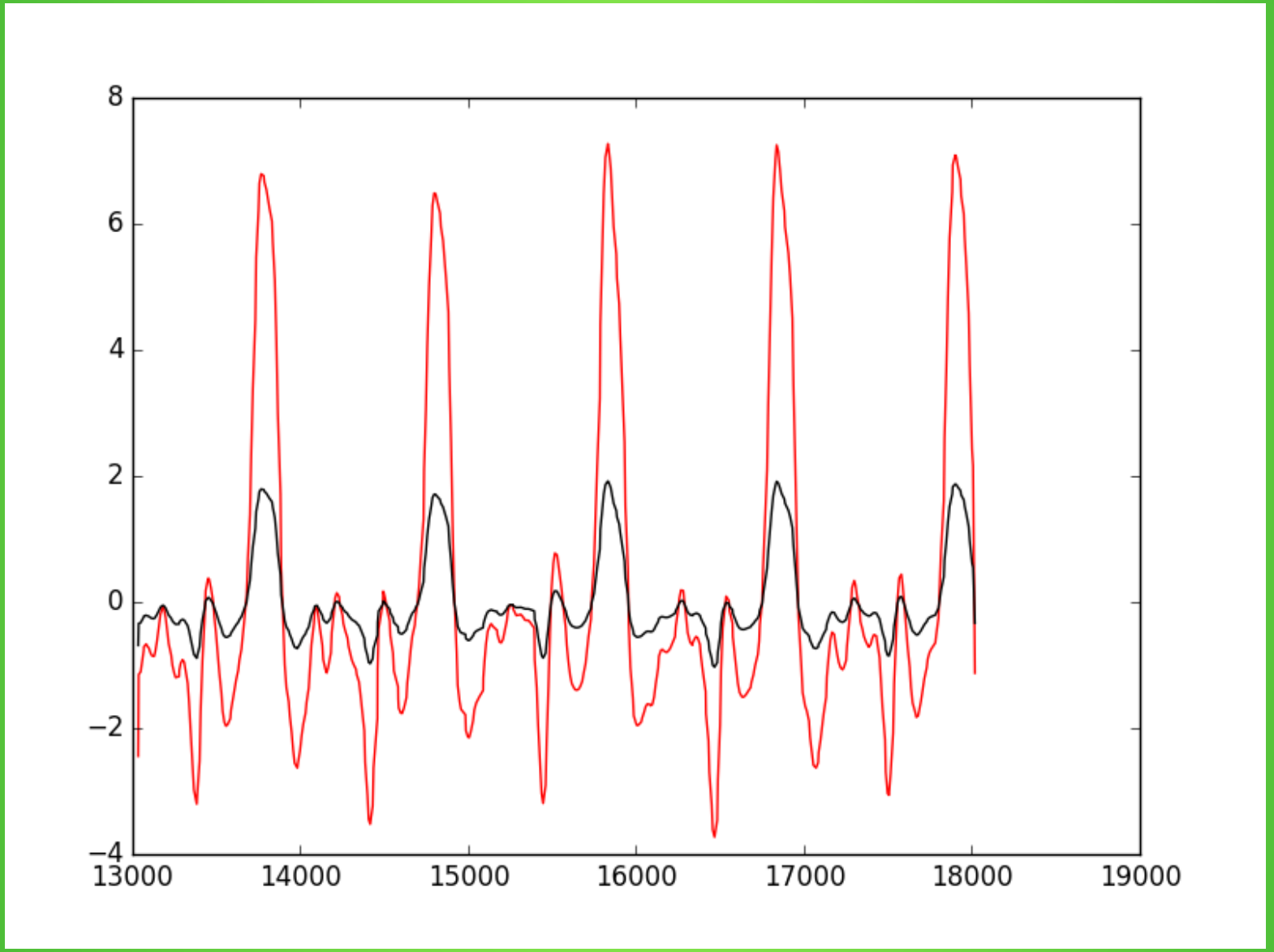


Fig: Normalized data after being passed through moving average filter.

Maximal Points

- First local maximal points are extracted. Points which are greater than its previous and next value.
- Among these, points which has value[i] < threshold is discarded.
- The threshold is calculated with th=mean+sd*k; the value of k is tuned according to the data set.

Local Maximal Points

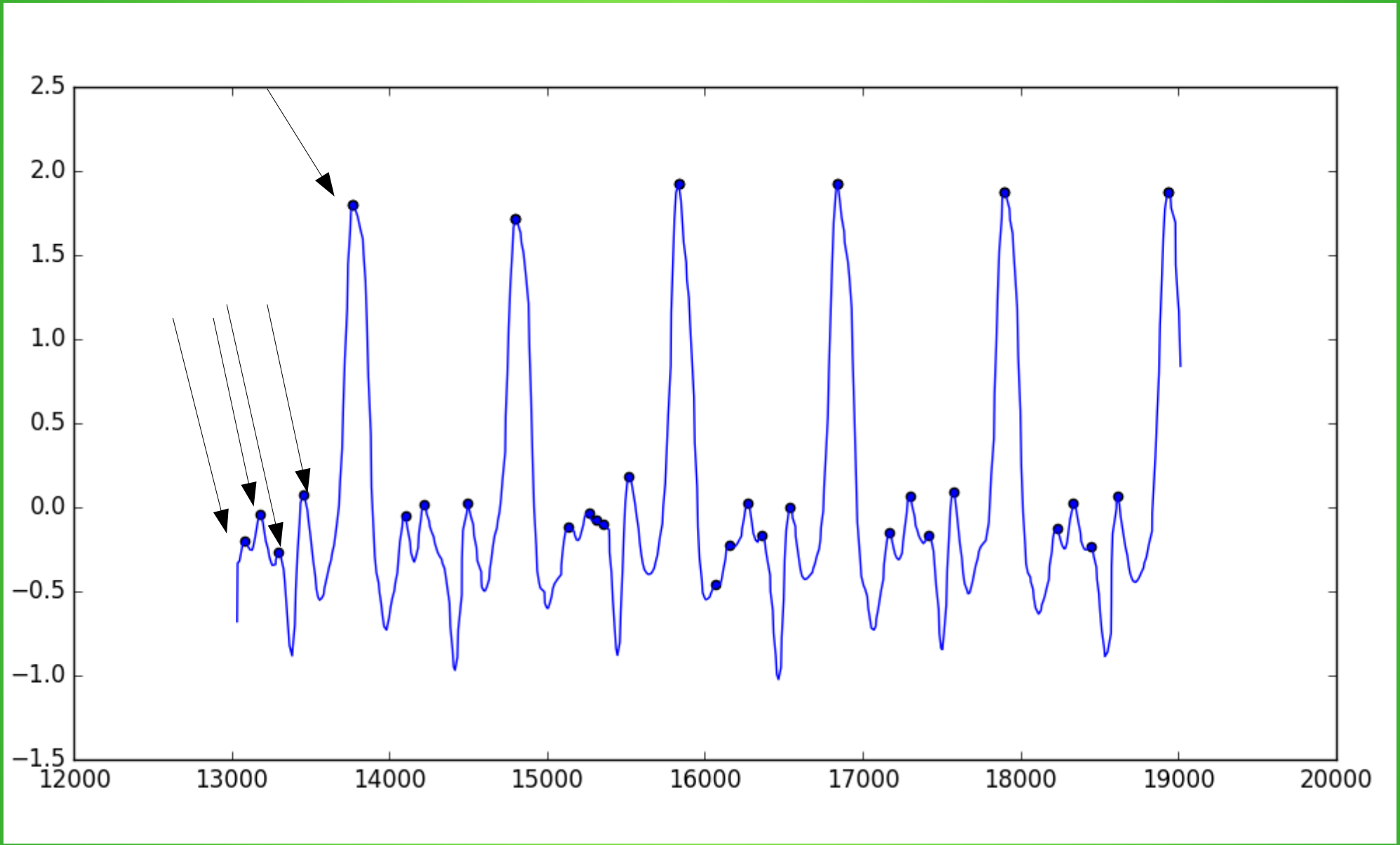


Fig: Extracted local maximal points

Gait Cycle

The picture clearly explains the gait cycle.
As walking is a periodic motion, each period/cycle is called gait cycle.

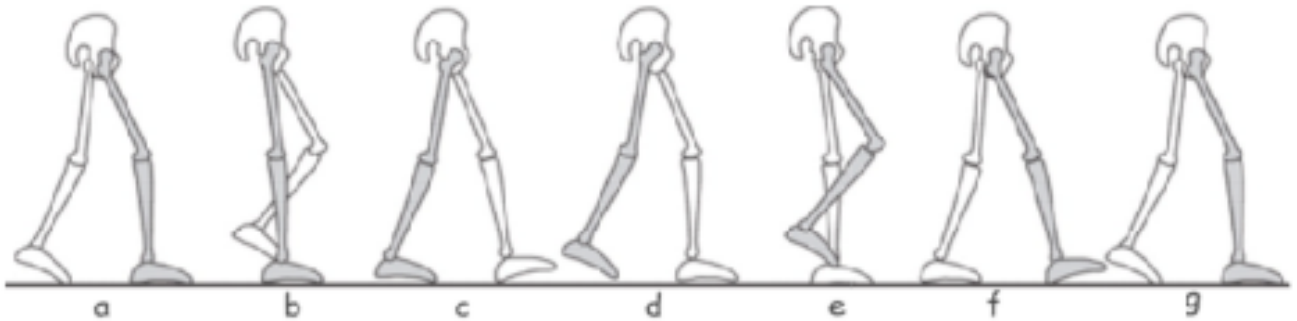


Fig. 5. Illustration of a gait cycle

ImageSource:http://web.engr.oregonstate.edu/~hoangmin/pub/c/2012_ICCAIS.pdf

Gait Cycle Points

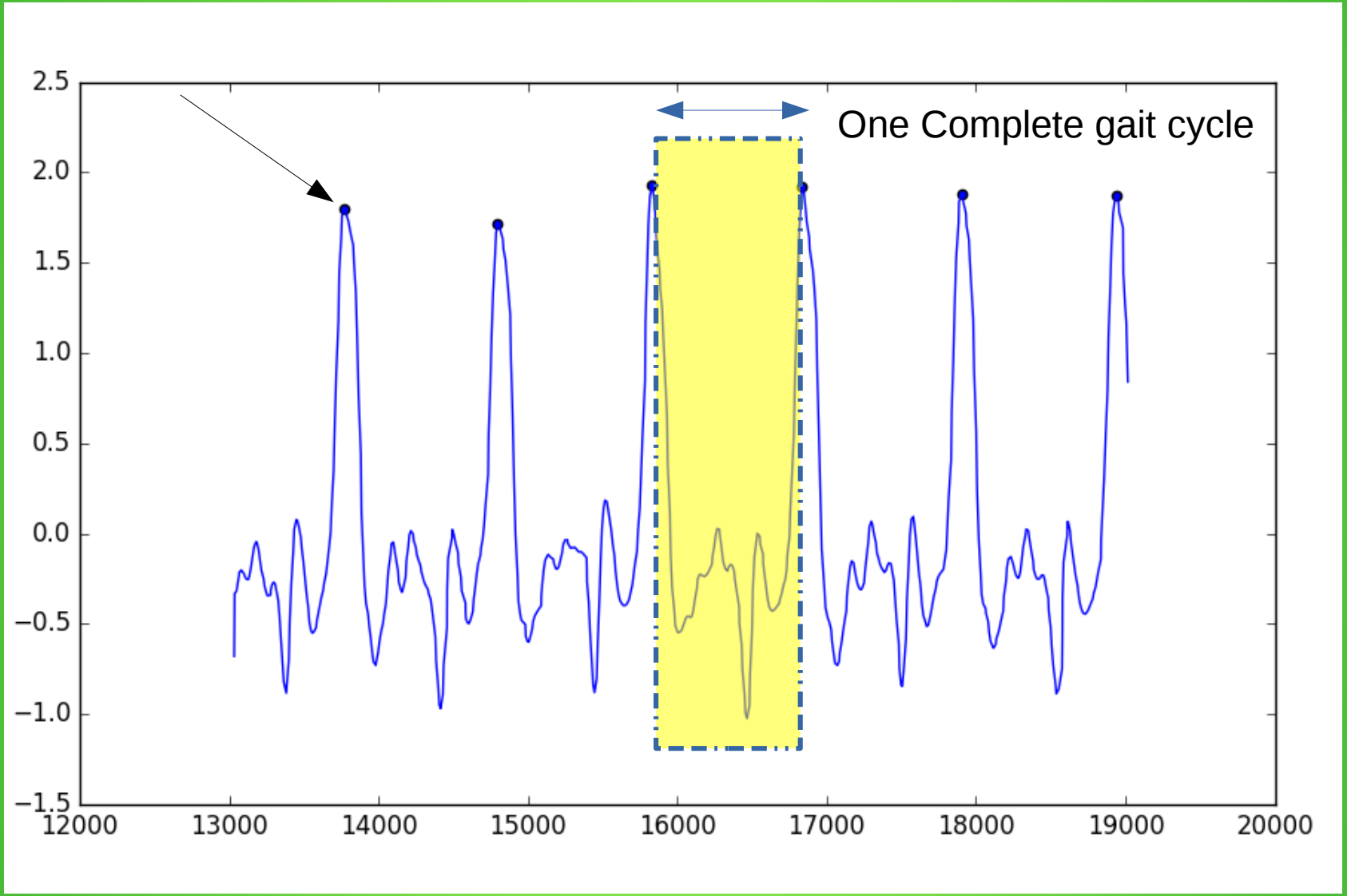


Figure: These consecutive points represent the start and end of single gait cycle.

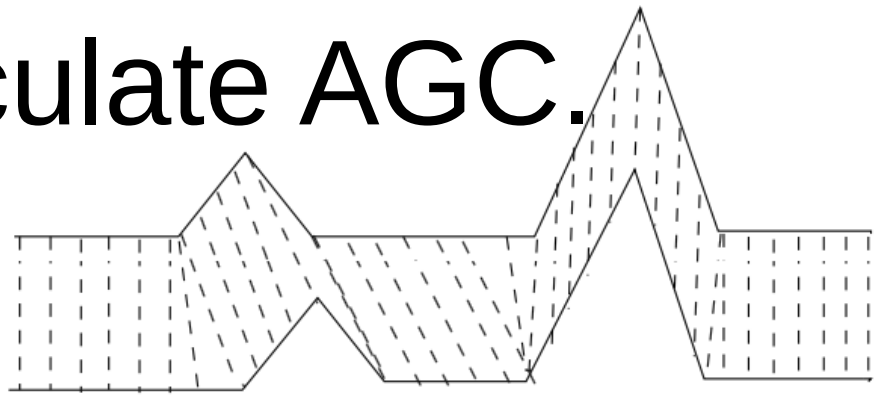
Average Gait Cycle

- AGC $AGCs = \left\{ gaitcycle_i \mid d_i = \text{agrmin}\left(\frac{1}{N-1}\sum_{j \neq t}^{N} dtw_{t,j}\right)\right\}$ [1].
- Gait cycle which has maximum resemblance to other gait cycle of same time series data is called average gait cycle.
- This resemblance is calculated using Dynamic Time Wrapping(DWT).

[1].http://web.engr.oregonstate.edu/~hoangmin/pub/c/2012_ICCAIS.pdf

Dynamic Time Wrapping

- Used for measuring similarity between two time series data.
- Advantage, we don’t have to normalize the length of each gait cycle.
- We use this to calculate AGC.



ImageSource:https://en.wikipedia.org/wiki/Dynamic_time_warping#/media/File:Dynamic_time_warping.png

Average Gait Cycle[1]

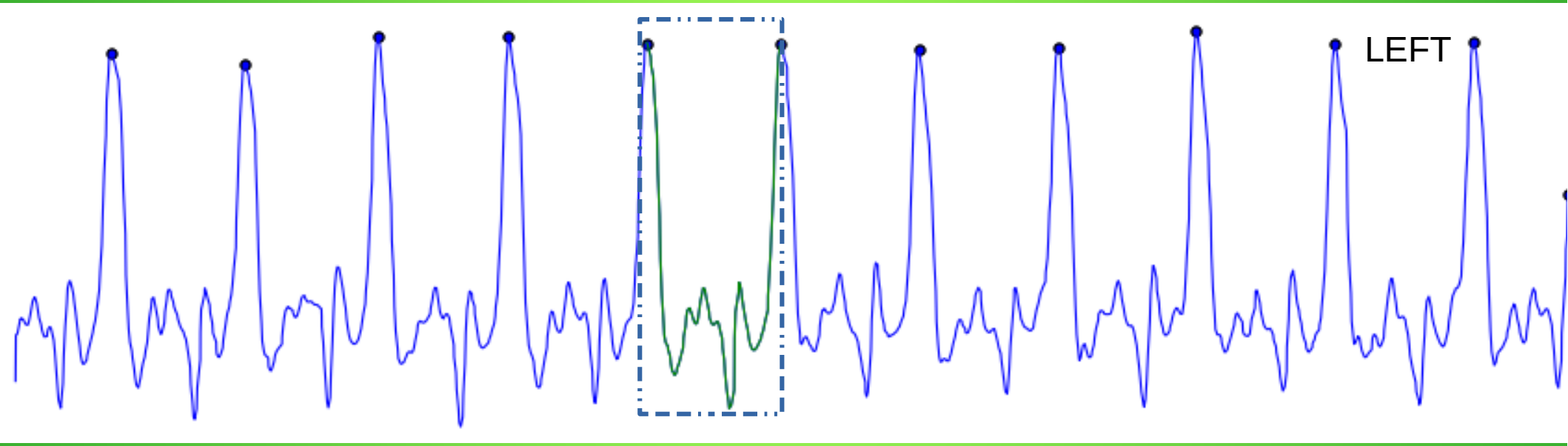


Fig: Average gait cycle calculated for the *LEFT* leg as shown enclosed in dash-dotted rectangular box.

[1http://web.engr.oregonstate.edu/~hoangmin/pub/c/2012_ICCAIS.pdf]

Average Gait Cycle

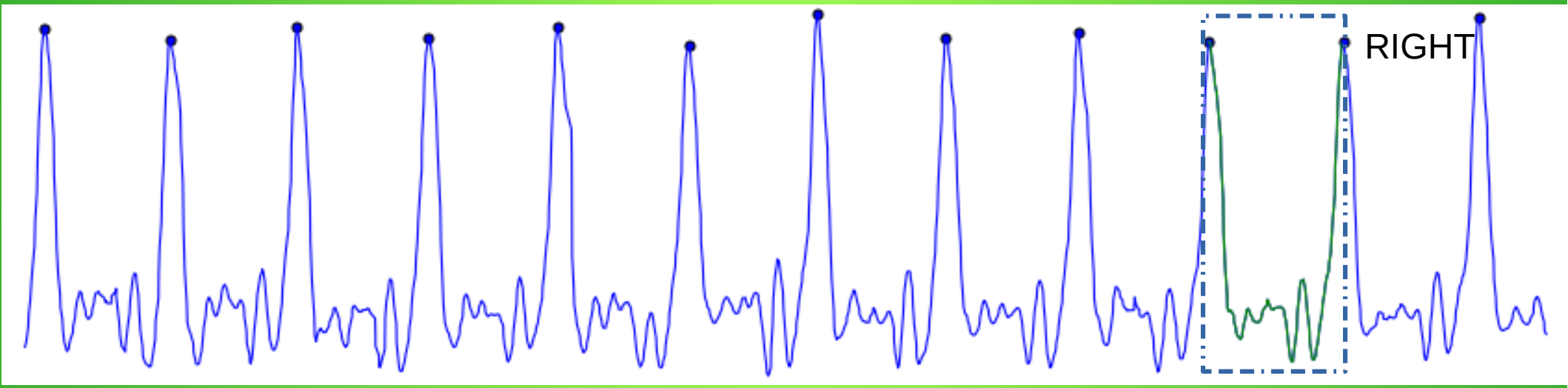
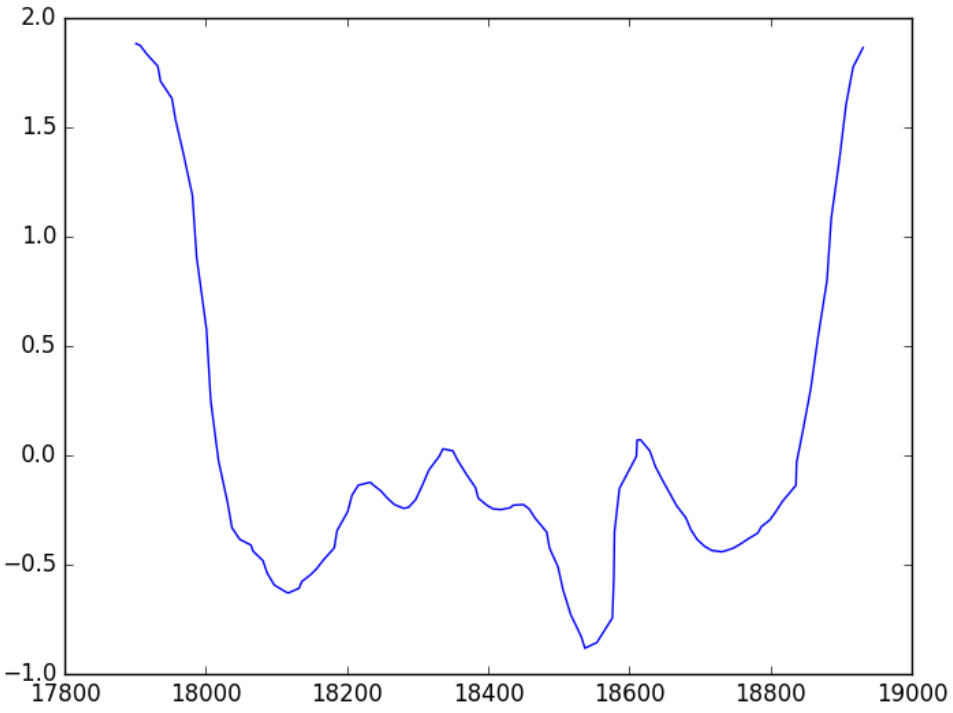
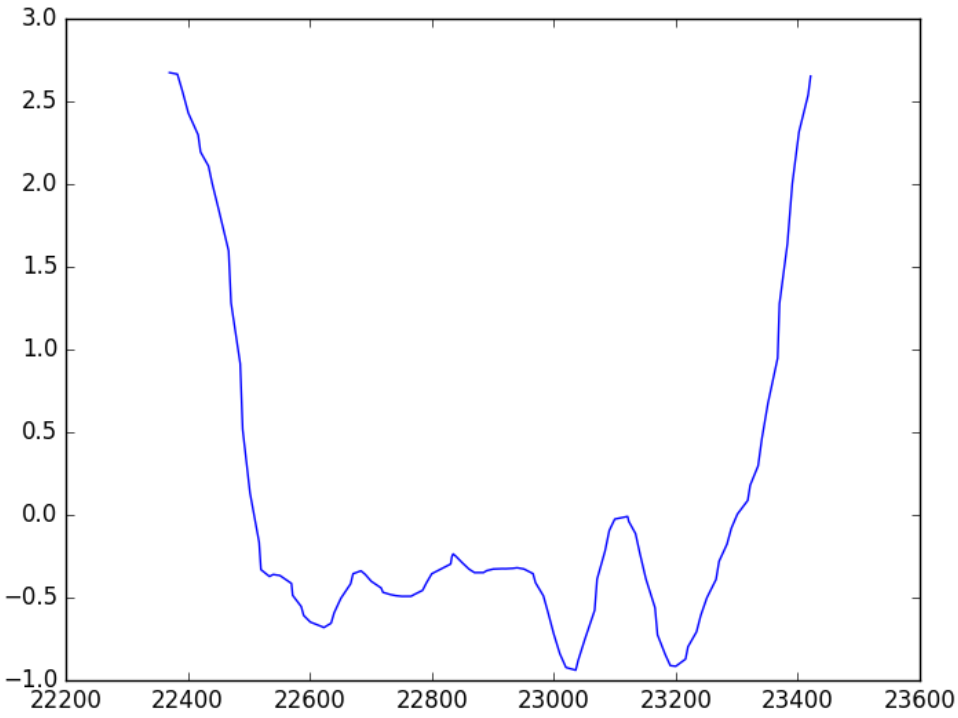


Fig: Average gait cycle calculated for the *RIGHT* leg as shown enclosed in dash-dotted rectangular box.

Extracted Gait Template



Left Leg



Right Leg

Result

- The distance(dtw) for each gait cycle template is reported which shows the inverse magnitude of similarity between walking pattern between of each legs.

Note…

- The image consisting of time series data was recorded by me using android phone.
- The method was first tested on computer in python, then it was implemented on android-studio.