Spectral Analysis of Accelerometer Data

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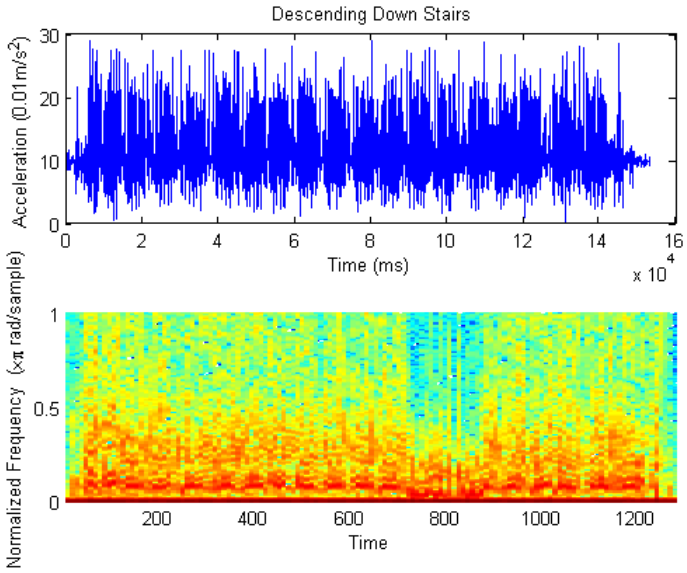
1 Introduction

This report includes the analysis of data captured using the app named 'Accelerometer Monitor' on HTC One M8 (android device), which records the data in a text file. The text file can be accessed and converted into CSV file for plotting purpose. The duration of activities varied, and can be found in the plots of the graphs below.

The raw data that we receive was acceleration in x, y and z directions and time difference between two values. The sampling rate was 50Hz. We took the magnitude of the accelerations ($\sqrt{x^2 + y^2 + z^2}$) for analysis purpose; as the orientation of the phone is not constant from person to person. Therefore we get more generalised result.

Below are the plots for the data collected for various activities like climbing stairs, jogging, running, travelling in lift and in bus. For the spectrogram we choose the window size of 120 sample points with a 50% overlap.

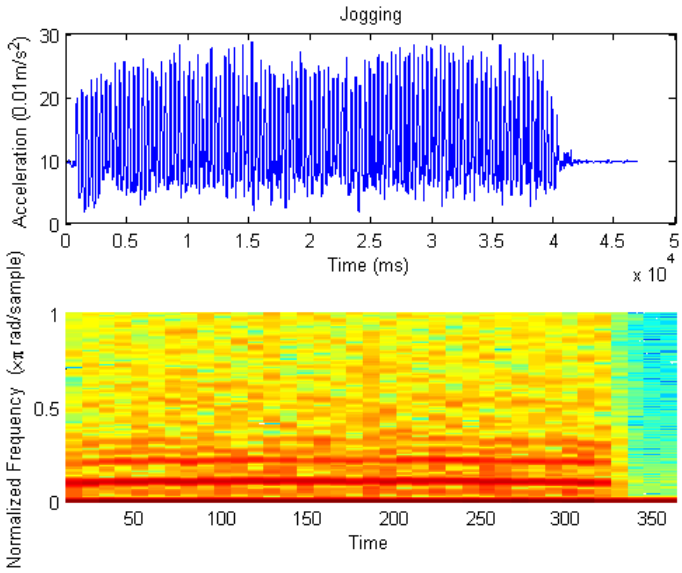
2 Descending Stairs



The first plot in the subplot shows the acceleration versus time graph. The y-axis shows the acceleration of the person having the accelerometer. It is clearly seen that the acceleration changes very frequently and quite uniformly over time. The quick change of acceleration suggests that the person is either changing positions very fast or he is going up and down very fast since these are the only two possibilities in which the acceleration can change quickly. Now, if the person is changing positions very quickly then the uniformity of the graph cannot be explained. The only mode of travelling among the five modes listed above which has an almost periodic acceleration is descending stairs.

The corresponding spectrogram in the second part of the subplot shows the intensity of the frequencies. The intensity of the frequencies decreases from red to blue which means the frequency with the red color has the highest intensity and the frequency with the violet color has the lowest intensity at time t. The time scale in both the plots is in milliseconds(ms). The spectrogram was plotted with a window size of 120 sample points (2.4 sec.), with a 50% overlap to reduce unwanted variance. Short-time Fourier Transform was applied by default.

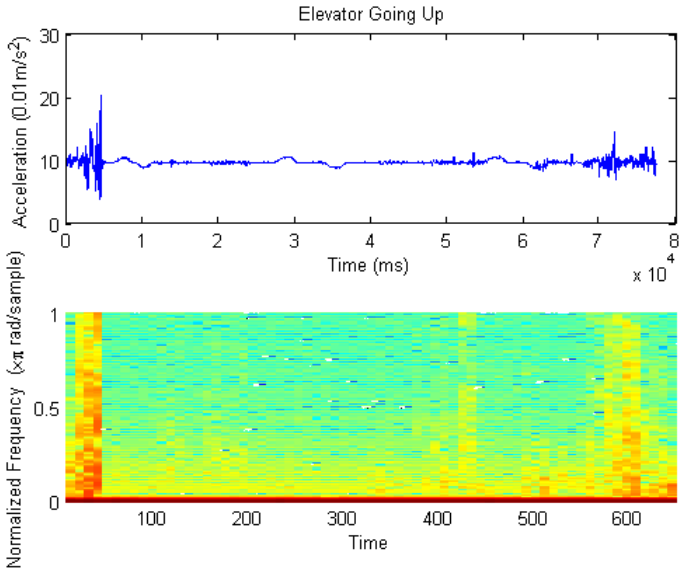
3 Jogging



This plot looks quite similar to the descending stairs plot but the difference being that it is not as periodic. The acceleration, periodically in time goes below the constant gravity acceleration 10, which suggest that the person is working against the gravity periodically. Clearly, the task can possibly be running or jogging in which the person works against the gravity.

Now, seeing the corresponding spectrogram of the same we notice that the frequencies are not so intense(not so red). There is one red line around 0.2 * π radians for every sample which means there is one dominant frequency. The energy of the signal is also more in jogging than descending down the stairs, which implies more movement. The time scale in both the plots is in milliseconds(ms). The spectrogram was plotted with a window size of 120 sample points (2.4 sec.), with a 50% overlap to reduce unwanted variance. Short-time Fourier Transform was applied by default.

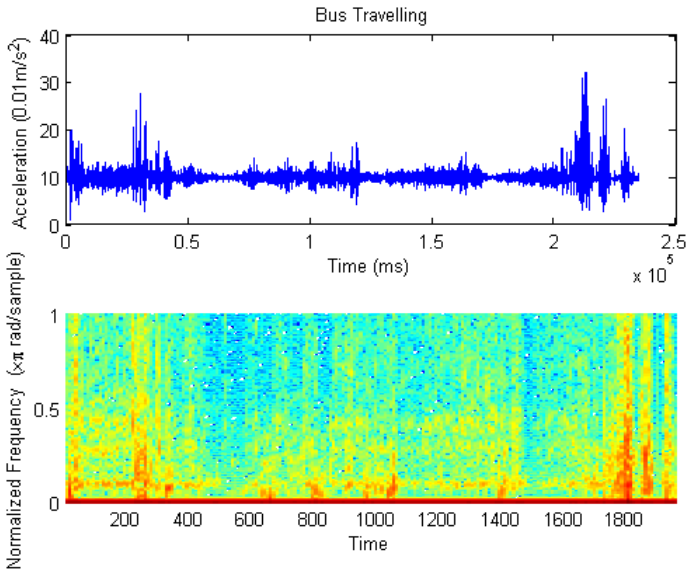
4 Going Up In Lift



The first plot in the subplot here shows the acceleration versus time graph. The y-axis shows the acceleration of the person having the accelerometer. The graph shows constant acceleration around the value of 10, which is the value of gravity except at 2 positions. At those 2 points, once the elevator started to go up and the next one the elevator stopped.

The corresponding spectrogram therefore seems more blue because there is less intensity of those frequencies over the journey of elevator except the two positions. At those two positions where the elevator starts and stops, there is acceleration observed, and hence a bit more energy. The time scale in both the plots is in milliseconds(ms). The spectrogram was plotted with a window size of 120 sample points (2.4 sec.), with a 50% overlap to reduce unwanted variance. Short-time Fourier Transform was applied by default.

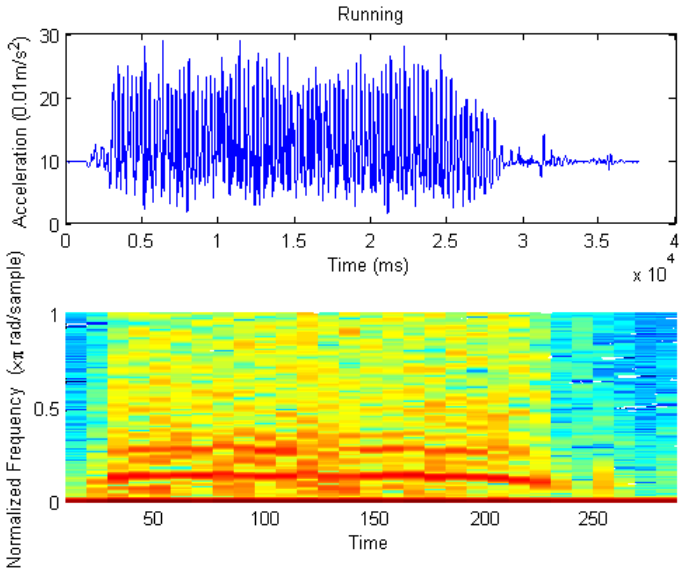
5 Bus Travel



The plot above indicates the data of a person travelling in bus. The bus stopped at 2 stops. As the bus started it took a jerk and then on acquired certain velocity. At the very first site this might look similar to the plot of the elevator, but it is not. Since, the bus takes so many sudden jerks while travelling the acceleration change is much more as compared to the elevator which is clearly seen in the plot. The sudden jerks in the above plot shows the approaching of a stop and then moving on from that stop. A high jerk in the last part of the plot is because the subject performing the experiment jumped off the bus at a stop which accounted for a greater change in acceleration.

The corresponding spectrogram shows intensity change during the above stated jerks. The energy is more in bus than compared to elevator, and hence more redness in the spectrogram. The time scale in both the plots is in milliseconds(ms). The spectrogram was plotted with a window size of 120 sample points (2.4 sec.), with a 50% overlap to reduce unwanted variance. Short-time Fourier Transform was applied by default.

6 Running



Technically running is same as jogging, just a faster version of jogging. Running is swifter than jogging, as jogging (the one we performed experiment on) was more bouncy.

From the spectrogram we can notice that jogging and running have similar kind of spectrograms except that there is less redness in the spectrogram of running compared to jogging, which can be inferred from the reason above. The time scale in both the plots is in milliseconds(ms). The spectrogram was plotted with a window size of 120 sample points (2.4 sec.), with a 50% overlap to reduce unwanted variance. Short-time Fourier Transform was applied by default.

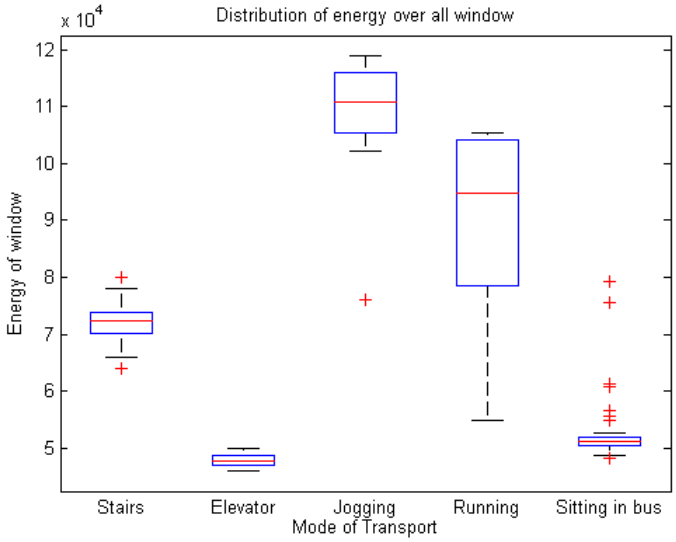
7 Dominant Frequency

Table 1: Dominant Frequencies

Activity	Dominant Frequency (Hz)
Descending Down Stairs	1.9531
Elevator Going Up	0.1953
Jogging	2.7344
Running	3.3203
Bus Travelling	2.3483

8 Conclusion

Many features can be selected from the time series data to differentiate various mode of transport. As noticed from spectrogram and also from the box plot, we know that when using foot-steps to walk, as compared to sitting/standing in a automated transport, there is more energy in the signal received.



Here the window size was taken as 250 points (5 sec.) with an overlap of 125 points between windows as it is found to be an effective window size historically [1].

References

[1] Ben Nham, Kanya Siangliulue, and Serena Yeung. *Predicting Mode of Transport from iPhone Accelerometer Data.*
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[2] Jennifer R. Kwapisz, Gary M. Weiss, Samuel A. Moore. *Activity Recognition using Cell Phone Accelerometers.*
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