Digital Signal Processing Assignment 3 : Activity Classification

Report

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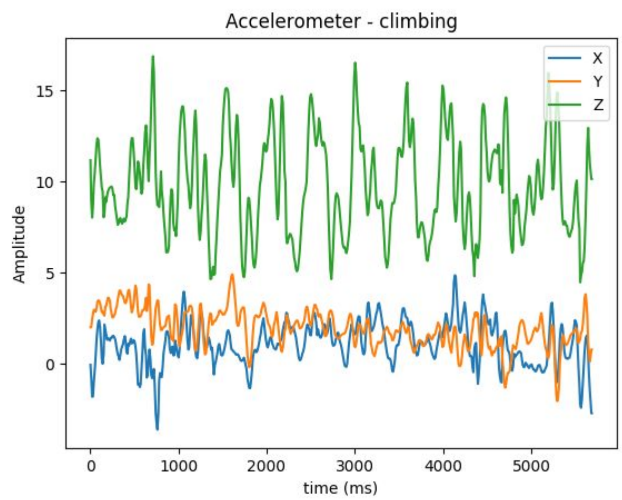
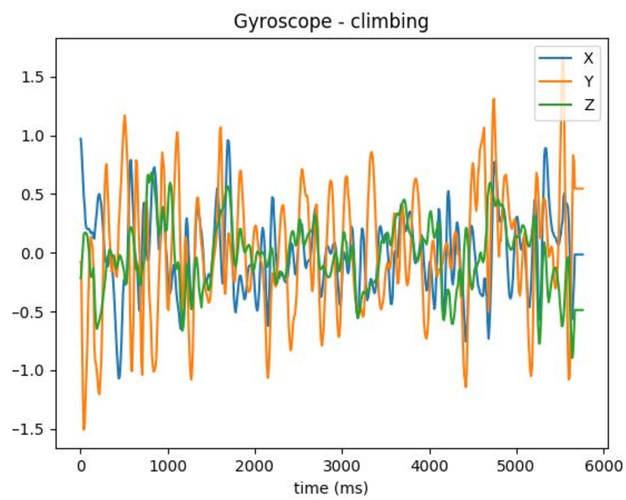
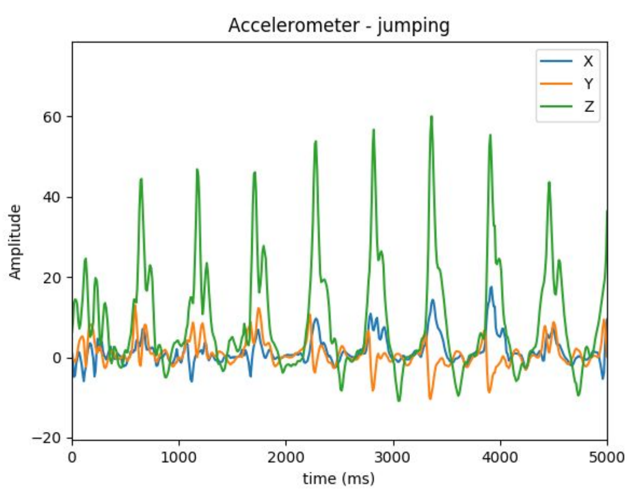
INTRODUCTION

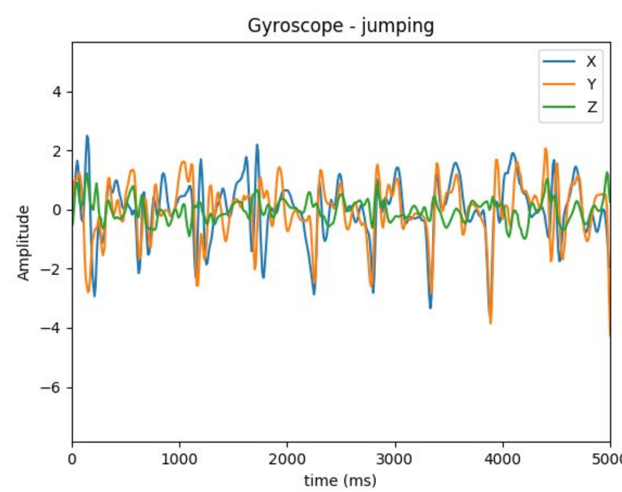
Activity classification has many important applications. This report summarizes the classification of four activities - Climbing, Jumping, Running and Walking using the data obtained from a mobile phone's accelerometer and gyroscope sensors. The Sensor Record app was used to collect the data at a sampling rate of 100Hz. Using 6 simple time domain features a 94.73% accuracy is achieved.

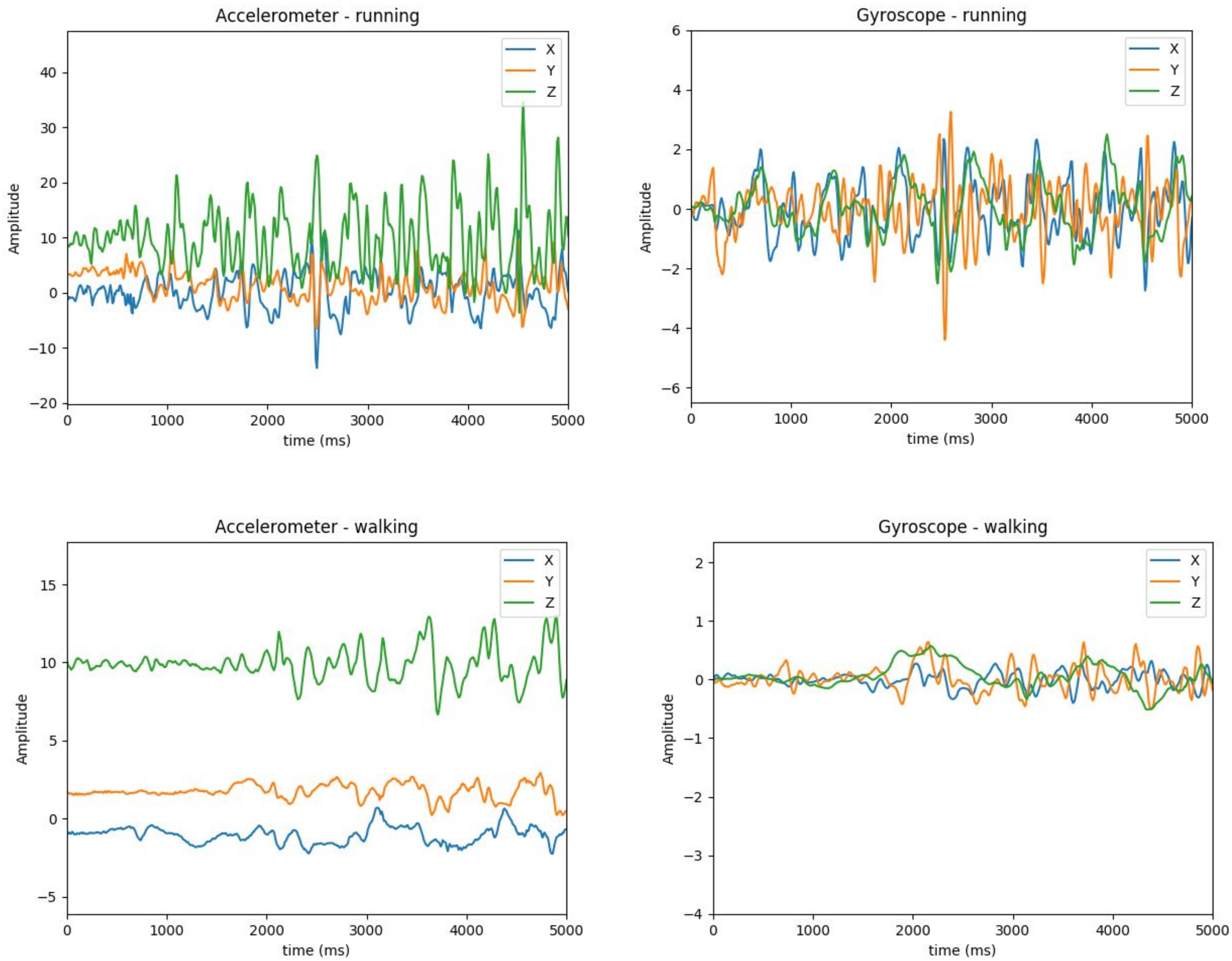
The following graphs show the accelerometer and gyroscope signals for the four activities.











Each of the sensors record data for the 3 dimensions - X,Y and Z. Considering data from all three dimensions help classify the kind of activity. For example - In the case of jumping, the acceleration in the Z direction will be more prominent whereas for running, the acceleration reading in the X or Y direction would be prominent than the Z direction. Running would result in higher accelerometer values than walking. Thus, various features can be extracted and learned from the two sensor’s data.

DATA PRE-PROCESSING

The data was sampled at 100Hz. A small portion of the data at the beginning and the end was eliminated as the initial and final parts of the sensor's signal correspond to the abrupt beginning and start of the action, or a motion- less position before starting the action.

FEATURE ENGINEERING

After collecting the data, we proceeded to extract various features. For every set of readings (X,Y and Z of each sensor), we computed six types of features. Intuitively, features like the mean, deviation, minimum and maximum would help classification since actions are performed in different directions, orientations and at different speed of movements. Features were computed in a window of 100 samples, which correspond to 1 second (sampling period = 10ms). A brief description of the features we extracted are -

1. **Mean:** Each sensors x-axis, y-axis, z-axis mean was calculated in it's window(n) using the following formula

$$\text{Mean } (\bar{x}) = \frac{\sum x}{n}$$

2. **Mean Absolute Deviation:** Each sensors x-axis, y-axis, z-axis mean absolute deviation was calculated in it's window(n) using the following formula

$$MAD = \frac{\sum_{i=1}^{n} | xi - \bar{x} |}{n}$$

xi : Performance Value for Period i

$\bar{x}$: Average Value

n : Number of Data

3. **Variance:** Each sensors x-axis, y-axis, z-axis variance was calculated in it's window(N) using the following formula

$$\sigma^2 = \frac{\sum(\chi - \mu)^2}{N}$$

4. **Maximum:** Each sensors x-axis, y-axis, z-axis maximum in it's window was calculated.
5. **Minimum:** Each sensors x-axis, y-axis, z-axis minimum in it's window(n) was calculated.

6. **Standard Deviation:** Each sensors x-axis, y-axis, z-axis standard deviation was calculated in it's window(N) using the following formula

$$\mathrm{SD} = \sqrt{\frac{\sum |x - \bar{x}|^2}{n}}$$

MODEL AND TRAINING

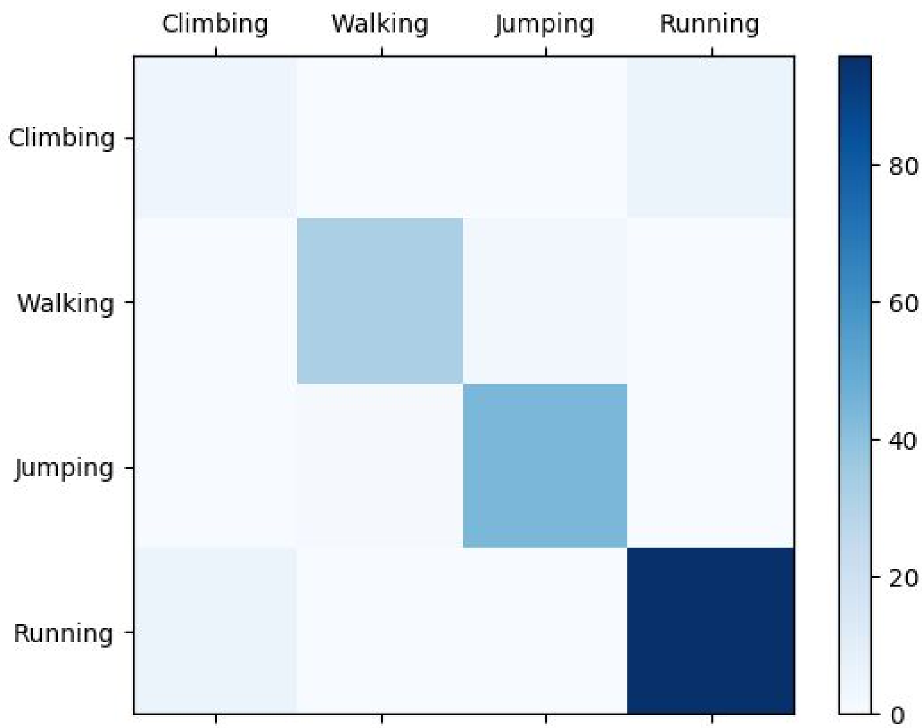
We used several classifiers such as SVM(Support Vector Machines), KNN(K- Nearest Neighbours), Logistic Regression. The features were scaled before training the model. We compared the accuracies of these three classifiers with features engineered as mentioned above.
Following were the results -

Classifier	SVM	KNN(k = 3)	Logistic Regression
Accuracy	91.05%	94.73%	93.15%

CONCLUSION

The KNN classifier resulted in the best accuracy with a ‘k’ value of 3.
A confusion matrix is a table that is often used to describe the performance of a classification model (or “classifier”) on a set of test data for which the true values are known. It allows the visualization of the performance of an algorithm.
The confusion matrix for the KNN classifier is shown below -

	Climbing	**Walking**	**Jumping**	**Running**
Climbing	4	0	0	5
Walking	0	32	3	0
Jumping	0	1	44	0
Running	5	0	0	96



REFERENCES

1. Ankita Jain, Vivek Kanhangad, “Human Activity Classification In Smartphones using Accelerometer and Gyroscope Sensors”. https://ieeexplore.ieee.org/document/8186158
2. Erhan Bulbul, Aydin Cetin, “Human Activity Recognition using Smartphones” https://ieeexplore.ieee.org/document/8567275