Transportation Mode Detection Using Smartphone Sensors

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Introduction

Recent advances in smartphones have sustained them as a better alternative to detect the transportation mode of the users. To the best of our knowledge, none of the existing systems consider motorised two-wheelers and aeroplane for detection task and according to a survey done in March 2014 , the current two-wheeler population in India is more than 70%. Therefore, we prospose to (i) take motorized two wheelers into account for detection of transportation modalities and (ii) use gyroscope along with accelerometer and GPS for detection purpose. Our system is flexible in terms of orientation and position of smartphone.

Approach

Our system divides the overall detection task into 3 subtasks:

- **Pedestrian Classifier:** still, walking, others
- **Two-wheeler Classifier:** Bicycle, Motorbike, others.
- **3rd Classifier:** Car, Bus, Train, Plane

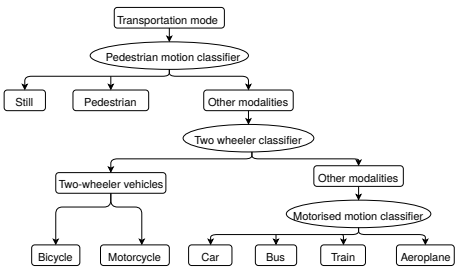

Figure 1: Overview of the classifiers used in our system

Pedestrian motion classification utilizes the frame-based features extracted from each window of accelerometer and GPS sensory data to distinguish between still, pedestrian and other modalities. We observed that still motion has GPS speed equal to zero. For pedestrians, we can easily differentiate their accelerometer patterns from other modalities as the patterns for walking are mostly periodic disturbances.

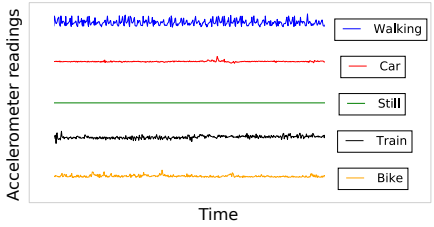

Figure 2: Comparison of gyroscope magnitude values for motorcycle and car

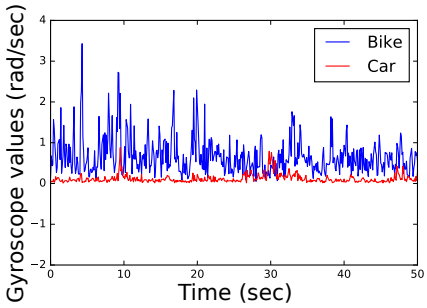

Figure 3: Comparison of gyroscope magnitude values for motorcycle and car

Features for Pedestrian Classifier
Mean, Variance, Interquartile Range, STD, RMS

- **Data Collection:** We have collected 20 hours of sensor data (accelerometer, gyroscope and GPS) from 5 individuals from IIT (BHU) Varanasi on Samsung Alpha and One Plus 3. The sampling frequency was set low at 10 Hz.
- **Preprocessing:** To remove noise due to vibrations of vehicle, Kalman filter is applied.
- **Feature Extraction:** We consider a sliding time window of 2 seconds with 50% overlap. We have converted the accelerometer readings into world coordinate system using rotation matrix and then, subtracted gravity from it.

$$\text{Horizontal Acceleration} = \sqrt{A_x^2 + A_y^2},$$

$$\text{Vertical Acceleration} = A_z - \text{Gravity}.$$

$$G_{mag} = \sqrt{G_x^2 + G_y^2 + G_z^2}$$

A_x, A_y, A_z: filtered acc. components,
G_x, G_y, G_z: gyroscopic components

For different classifiers, we extracted features as described in the Table.

Domain	Two-wheeler Classifier Features
Statistical	Min, Max, Mean, RMS, STD, Range, Variance, Interquartile Range, Kurtosis, Skewness
Frequency	Spectral Energy, Spectral Entropy, Spectrum peak pos., Wavelet Entropy & Magnitude
Time	Integral, Auto-Correlation, Mean-Crossing Rate

- **Classification:** We used Random Forest with no. of tress kept at 25 for Pedestrian Motion Classifer and SVM for Two-wheeler Classifier.

Results

We performed 10-fold cross validation on both classifiers. The Pedestrian Motion Classifier achieves an overall accuracy of **98.07%** in which 99.82%, 94%, 92.02% are the individual accuracies for still, pedestrian and others respectively. The Two-wheeler Classifier achieved an overall accuracy of **91.93%** where 68.65% and 96.42% are the individual accuracies for two-wheeler and other modalities.

	Pedestrian	Still	Others
Pedestrian	2761	0	169
Still	4	12087	17
Others	122	155	8914

Table 1: Confusion Matrix for Pedestrian Motion Classifier

	Two-wheeler	Others
Two-wheeler	1886	861
Others	509	13732

Table 2: Confusion Matrix for Two-wheeler Classifier

Conclusions

In this work, we detected pedestrian motion and two-wheeler by accelerometer, gyroscope, and GPS sensors. We used Kalman filter for filtering sensory data and RF and SVM for classifying the vehicles. In the future, we will extend the work for the overall transportation mode detection, i.e., still, walking, bicycle, motorcycle, car, bus, train, and aeroplane.