

# Automatic Data Collection and Processing for Cycling Experiences

Nan Jia, Sasank Reddy, Deborah Estrin

<http://urban.cens.ucla.edu>

## Introduction: Motivation is to benefit biker community in Los Angeles

### Project CycleSense

#### Participatory Sensing

Provide means for biker community to upload and share information about biking routes with *mobile phones* equipped with microphone, accelerometer, and GPS.

#### Audio provides information about traffic

Using microphone to record audio clips, extract features to interpret traffic

#### Accelerometer and GPS provide road condition and routing

Z-axis acceleration coupled with speed recorded by GPS interprets roughness of road. GPS tracks biking route.

### Integrate different sensors on phone

#### Integration of audio, accelerometer, and GPS information to provide meaning interpretation

For every instance of road (1 second), integrate audio classification (traffic or non-traffic), road roughness (indicator calculated from accelerometer and GPS) and create a visualization of entire route based on all the instances collected.

## Problem Description: There is no system that automates cycling information processing

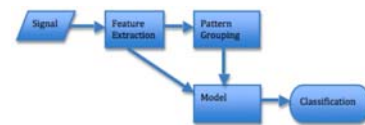
### Create efficient algorithms to collect and process audio, accelerometer, and GPS data

- Create algorithm that automatically collects audio data and classify environment as 'traffic' or 'non traffic'. This can be achieved through means of data mining.
- Create algorithm that calibrates accelerometer orientation, and automatically collects accelerometer data and calculate road roughness indicator. Users are expected to mount mobile phones differently on their bikes, therefore determining the orientation of the phone (calibration) is quintessential for clean data. Since we are mostly interested in z-axis, effort is concentrated on determining z-axis orientation.
- Create mechanism that integrates sensors' data and GPS trace, and the interpretation of the data for users' collective use.

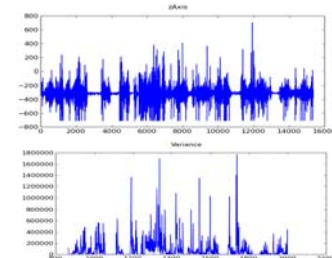
## Proposed Solution: Use different approaches for different sensors to achieve goal

### Audio Classification- data mining

- Collect audio clips manually labeled as 'traffic' or 'non-traffic' for training.
- Extract features from the training set including Mel-frequency cepstrum coefficients, zero-crossing rate, short time energy and sub-band energy, brightness and bandwidth, spectrum flux, band periodicity, and noise frame ratio.
- Train models using Correlation-based Feature Selection (CFS). Mel frequency cepstrum coefficients, sub-band energy and spectrum flux were identified as the most relevant features. The success rates of different models after using CFS is generally higher than after using Principle Component Analysis.
- K-Nearest Neighbor(KNN) and J48 Decision Tree were selected as the final algorithms based on their highest success rate of 94.5% and 93.44%, respectively.
- Further evaluation using a different data set resulted in a success rate of 95.45% using J48, and 88.64% using KNN.



Flow chart of general purpose audio classification.



Snapshot of z-axis acceleration data and variance

### Accelerometer Calibration and Road Roughness

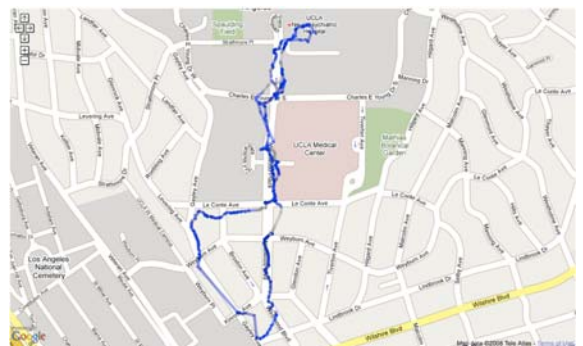
- Accelerometer is calibrated in z-y-z Euler angles format (pre-rotation about z axis, tilt about y-axis, then post rotation about z-axis) using the formula below:

$$\theta_{tilt} = \cos^{-1}\left(\frac{a_x}{a_z}\right)$$

- Segment z-axis acceleration data into 1-second windows for further processing.
- Compare window to a range between pre-determined thresholds to detect moments of stopping. If stopping is detected, discard window from further processing.
- Variance of windows are calculated against a pre-set expected value which reflects an ideally smooth road on which the accelerometer reading would not be changing at all (-319 at 1G for Nokia N95). This variance is a general reflection of how smooth the road is.
- Road roughness indicator is then calculated using the formula below:

$$Indicator = 1 - \frac{V_s}{V_r}$$

where  $V_s$  is the variance of smooth road in reality, and  $V_r$  is the variance of the window. This gives the road roughness indicator a value between 0 and 1. The closer to 1, the more rough the road is.



Snapshot of visualization of biking route and road roughness. (Bluer segments indicate rougher road)