Speed-Breaker Early Warning System

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Overview

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• Detection Methodology
• Data Set
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Motivation

• Speed-breakers reduce accidents
  – Reduce speed and increase safety

• Popular in many developing countries
  – Shortage of enforcement resources
  – India, Chile, Egypt, Ghana, Pakistan, etc.

• Can also cause accidents
  – Frequent reports of speed-breaker fatalities
  – Two wheelers: motorcycles, scooters
  – Last row of a bus
Motivation

From Reference [17]
Motivation

• Inconspicuous under special conditions
  – Night, Rain, Snow, Fog, etc.

• Warning signs/light
  – England DoT: must accompany lights
  – Guidelines ignored in developing countries

• Standard dimensions?
  – No, many different shapes
  – Transportation researchers consider unsafe

• Illegal speed-breakers
  – 4,536 in Bangalore
  – Some on national highways
  – Pakistan, Malaysia, Russia, etc.
Introduction

• Speed-breaker early warning system (SWAS)
  – Smartphone application
  – Downloads nearby speed-breaker locations
  – Warns when approaching one

• Populating the speed-breaker location database
  – Smartphone application collects accelerometer readings
  – When it detects a speed-breaker, reports location to server
  – Server examines reports from multiple phones before confirming

• Cost? Is it an affordable solution for developing world?
  – Android phones available for < $100 today, getting cheaper
  – Data plan? Store known speed-breaker locations locally
Main Contributions

• Algorithm for detecting speed-breakers
  – Feature vector, SVM, Decision Trees

• Amplitude vector has enough information
  – Previous work : GPS, magnetometer
  – No need for expensive reorientation

• Validated using an extensive data set
  – 678 Km of drive data from New Delhi, India
  – Several different vehicle types: cars, motorcycle, auto, etc.
  – Several different phones
  – 22 different drivers
Accelerometer Reorientation?

- Phone axes don’t always align with car’s axes

- Given a window of 3N accelerometer samples
  - Transform to a window of N amplitude vectors

\[ a_i = \sqrt{x_i^2 + y_i^2 + z_i^2} \]
Detection Methodology

X-axis

Y-axis

Z-axis

Feature Extraction

Classification

Decision
Feature Vector

- Standard deviation, number of mean crossings, maximum mean crossing interval, ratio of standard deviations (previous, next)

\[\{2.622, 6, 0.399, 3.5744, 5.0066\}\]

\[\{0.34, 11, 0.245, 0.8812, 0.7729\}\]
Data Set

• At least two phones used in every drive
  – Measurer, Marker
  – Measurer: pant pocket, dashboard, car seat, etc.
  – Marker: in observer’s hands
  – Time synchronized

• Speed-breaker types
  – Type 1: 3 to 6 ft long, 5 to 10 inches high
  – Type 2: 1 to 2 ft long, 3 to 6 inches high
Data Set

- Total length: 678 Km of drive data
- Location: National Capital Region
- Vehicles
  - 219.5 Km in Auto Rickshaw
  - 40.15 Km in Cycle Rickshaw
  - 290.5 Km in Car
  - 53.6 Km in Motor Cycle
  - 74.1 Km in Bus
- 22 different drivers
Evaluation

- **K-fold cross validation**
  - If there are n speed-breakers in any drive
  - Randomly select n windows that don’t have any speed-breakers
  - Total of 2n labeled samples
  - Divide 2n labeled samples into k groups
  - Train with k-1 groups, test with 1 group
Evaluation

• Train and test using same type of vehicle
  – Motorcycle: phone in pocket, frequent stops, brake
  – Cycle-Rickshaw: poor/no suspension system
Discussion

• False alarm probability can be reduced further
  – Server only accepts locations reported by multiple users
  – Reject reports from vehicles known to have high false alarms, e.g., motor-cycle, cycle rickshaw

• Battery consumption
  – Continuous GPS monitoring increases battery consumption
  – Download locations of nearby speed-breakers
  – Estimate the drive time to nearest speed-breaker and stop GPS
  – Start monitoring GPS again after getting close to the speed-breaker

• Other applications
  – SWAS can be integrated with navigation systems (Garmin, mapmyindia, etc.)
  – Emergency vehicles delayed by 10 seconds per speed-breaker; If locations of illegal speed-breakers are known emergency vehicles can drive around them