



Speed-Breaker Early Warning System

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Overview

- Motivation
- Introduction
- Detection Methodology
- Data Set
- Evaluation
- Discussion

Motivation

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

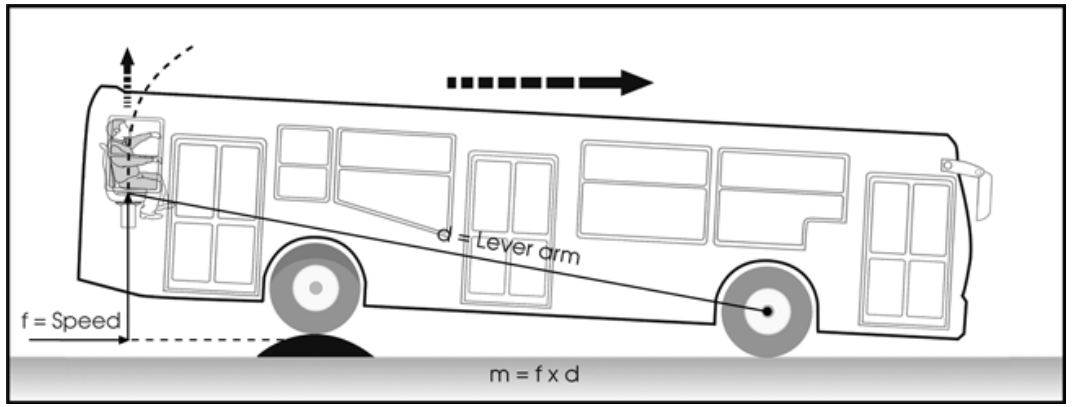


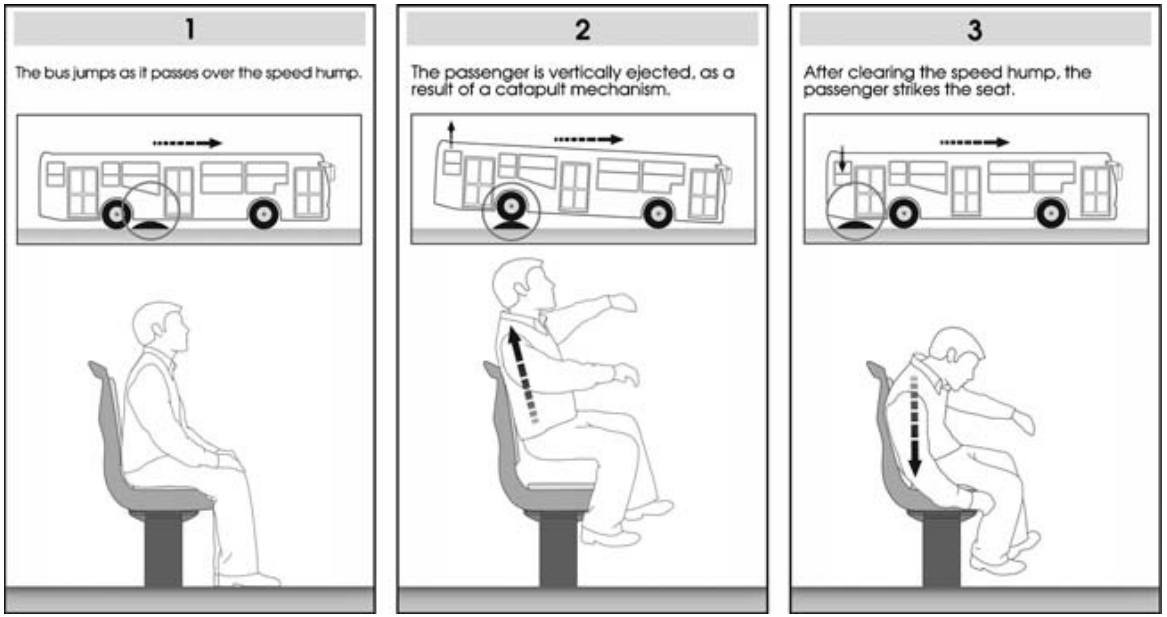
- Popular in many developing countries
  - Shortage of enforcement resources
  - India, Chile, Egypt, Ghana, Pakistan, etc.

- 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

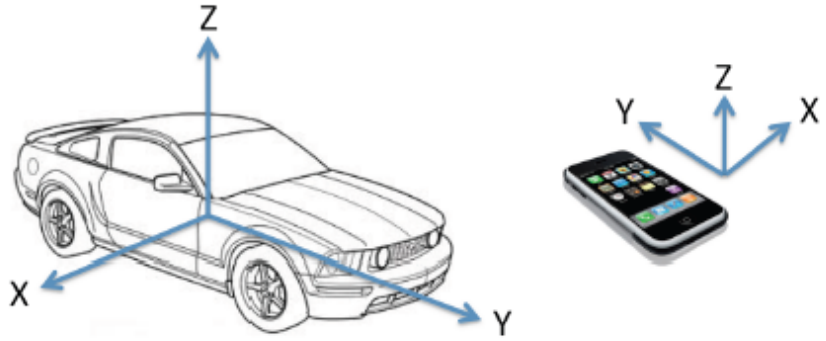
- Speed-breaker early warning system (SWAS)
  - Smartphone application
  - Downloads nearby speed-breaker locations
  - Warns when approaching one
- Populating the speed-breaker location database
  - Smartphone application collects accelerometer readings
  - When it detects a speed-breaker, reports location 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 ?

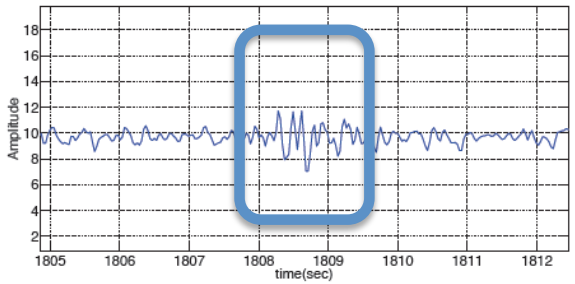
- Phone axes don't always align with car's axes



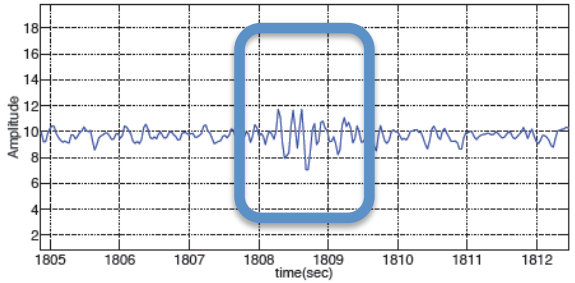
- Given a window of 3N accelerometer samples
  - Transform to a window of N amplitude vectors

$$a_i = \sqrt{x_i^2 + y_i^2 + z_i^2}$$

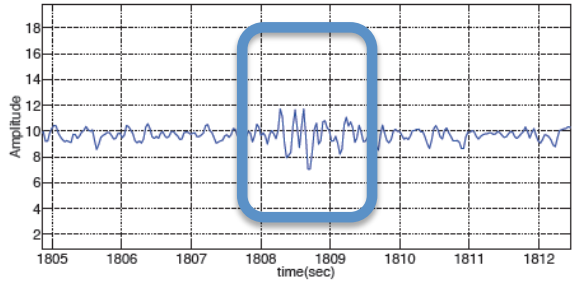
Detection Methodology



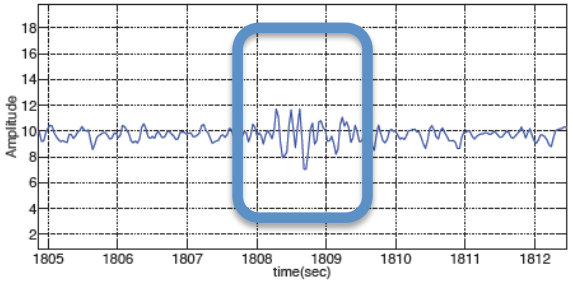
X-axis



Y-axis



Z-axis



Amplitude

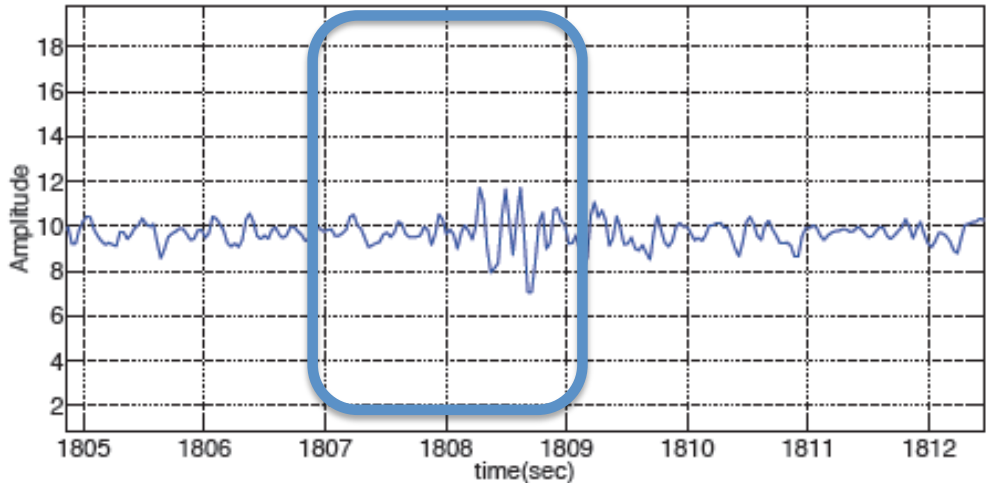
Feature Extraction

Classification

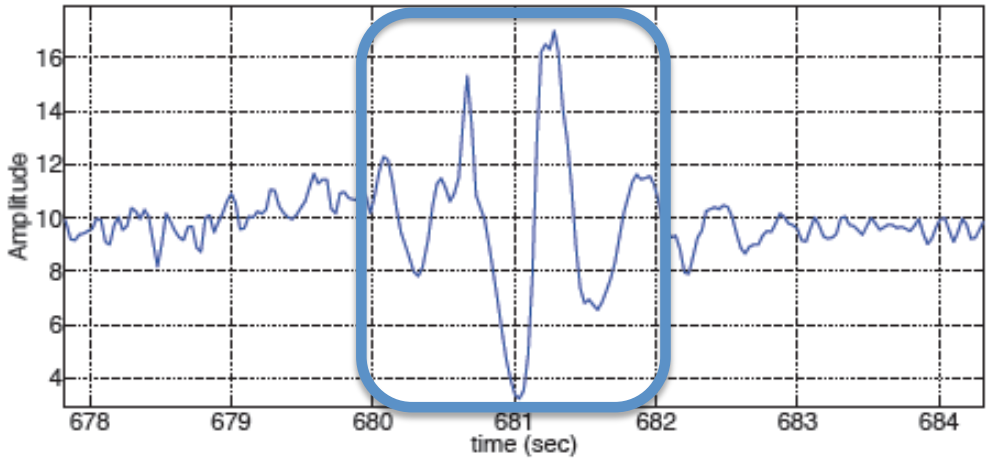
Decision

Feature Vector

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



{0.34,11,0.245,0.8812,0.7729}

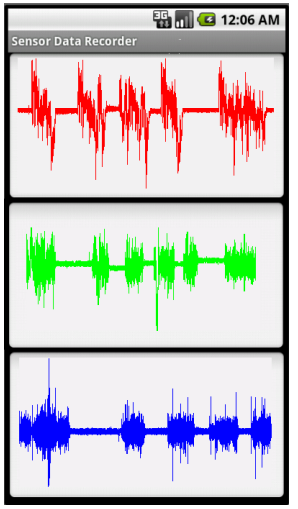


{2.622,6,0.399,3.5744,5.0066}

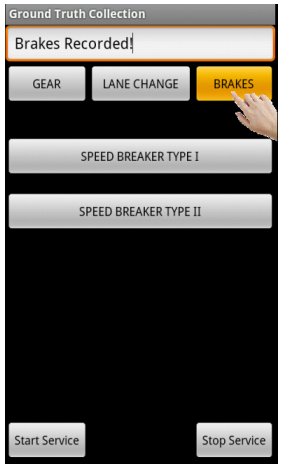
Data Set

- 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





Measurer



Marker

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



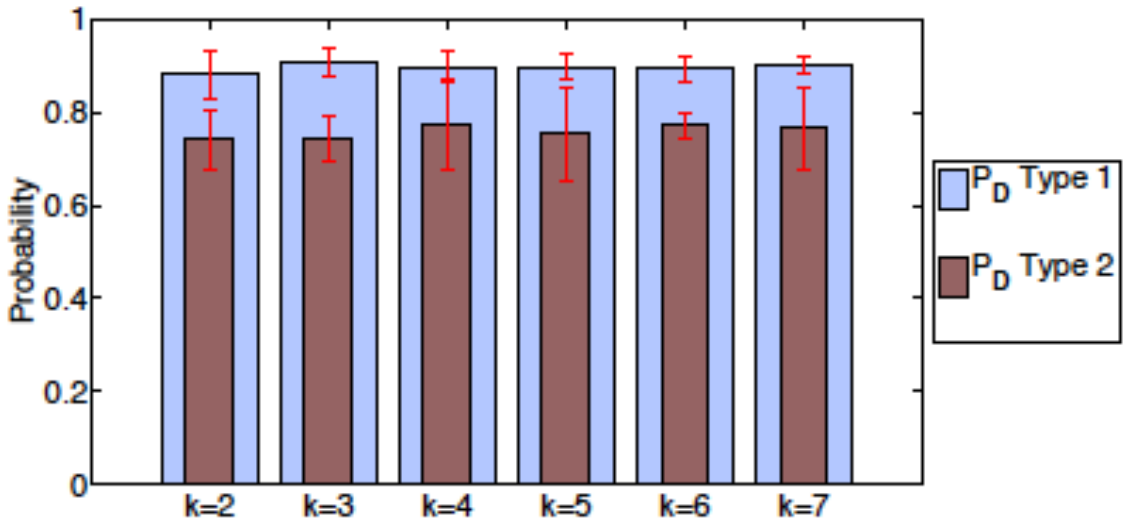
Auto rickshaw



Cycle rickshaw

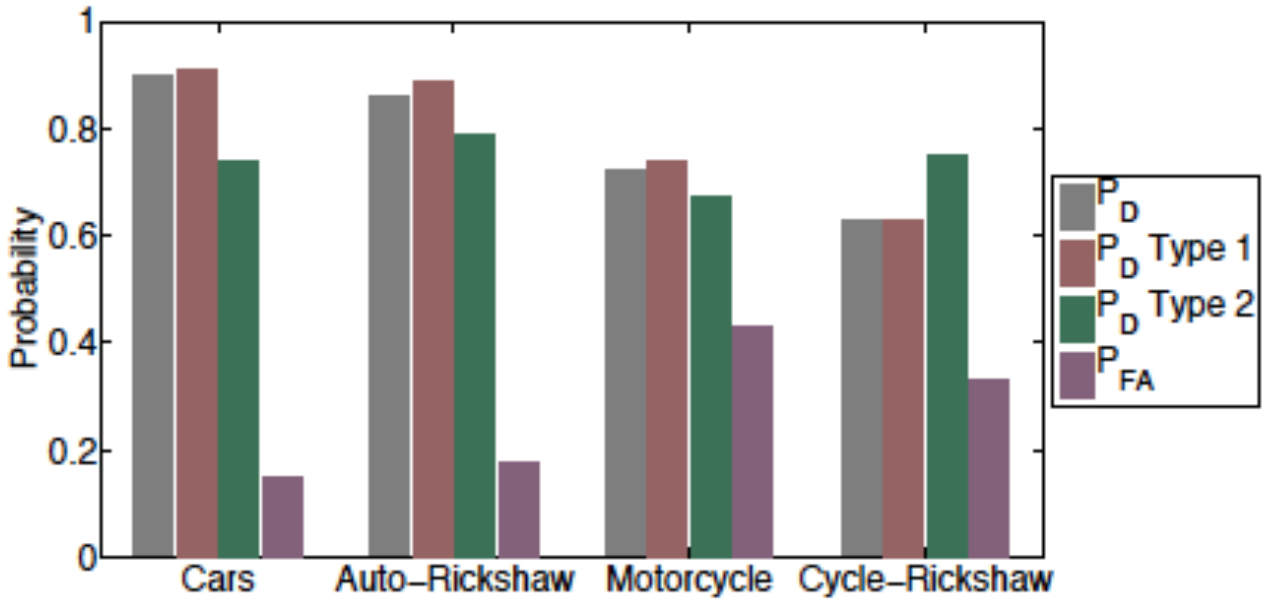
Evaluation

- 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