Detecting passenger discomfort from abnormal driving manoeuvres

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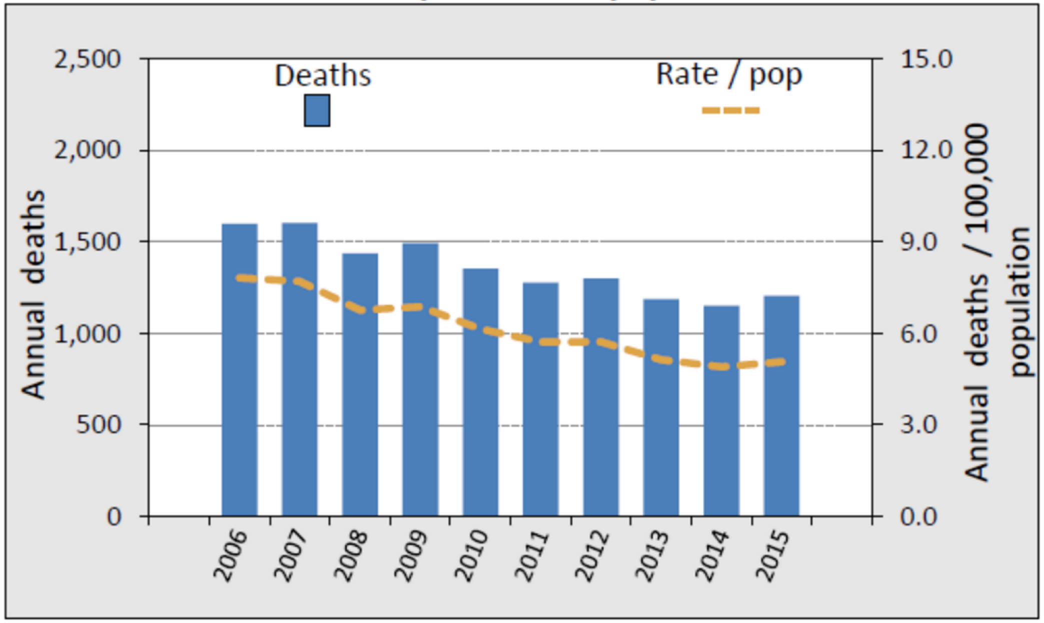
Introduction

- Deaths by road crashes
  - Devastating social impacts and economic cost (~ $27 billion per annum)

Year	Deaths
1970	3,798
…	…
2012	1,300
…	…
2014	1,155
2015	1,205

Annual fatalities and rate per 100,000 population, 2006 – 2015



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Background

- Common studies involve:
  - Driving events (e.g. acceleration, braking and swerving) [1,2,3,4]
  - Analysis on road condition (e.g. detection of potholes and bumps) [4,5,6]
  - Etc
- Emerging research area in ITS for smarter and robust solution using smartphones.
- Many studies have different experiment settings:
  - Sampling frequency for sensor reading
  - Phone orientation
  - Phone model
- Recognising abnormal driving manoeuvres is crucial to raise awareness of human driver's behaviours.

Abnormal Driving Manoeuvres

- Abnormal Driving Manoeuvres:
  - Extreme Acceleration
  - Hard Braking
  - Swerving

- Observation on accelerometer data of smartphones can help to identify these abnormal events.
- Abnormal driving manoeuvres cause passenger discomfort
- Smartphone capabilities in providing cheap and robust solution for smart applications.
- Research objectives:
  - How to detect passenger discomfort from these abnormal maneuvres?
  - How to recognise these abnormal events from smartphone sensor data?

Problems

- Observed problems:
  - Human lag in labeling abnormal events that cause passenger discomfort.
  - Misannotations that can cause false alarms for an abnormal event.
  - Detecting abnormal events on streaming sensor data from smartphone.

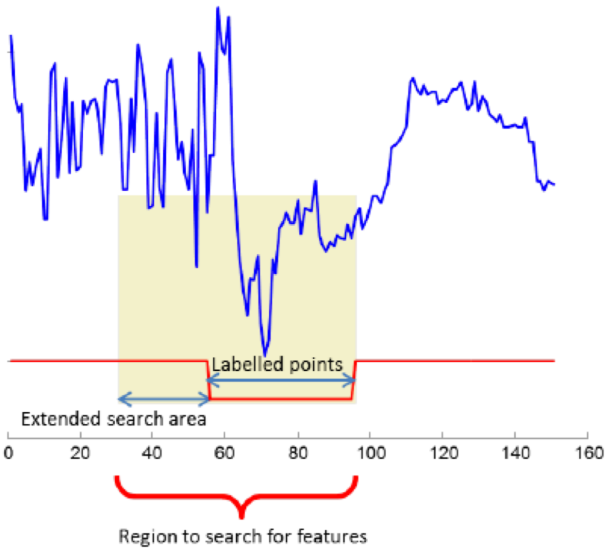
- Problem definitions:
  1. Temporal segmentation of abnormal driving event given annotations of passenger discomfort
  2. Detecting passenger discomfort from high change in car acceleration.

Data Collection - Racecourse

- Smartphones for recording mobile sensor data (sampling rate: 10Hz)
- Passenger labeling for discomfort
- Participants:
  - 9 expert drivers
  - 3 annotators (as passenger)
- 3 cars for a driving session

Contributions

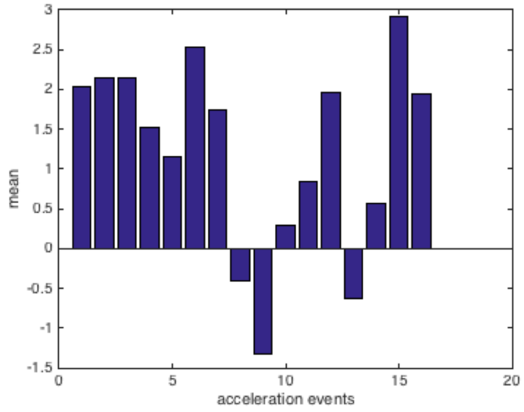
- Methodologies to detect passenger discomfort:
  – Extended temporal segmentation technique for handling discomfort annotations



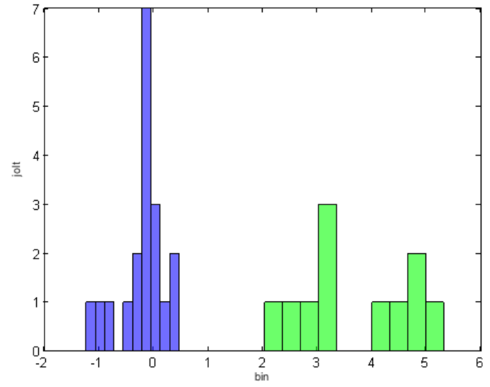
  – Recognising abnormal driving manoeuvres through threshold-based technique.
    1. Average acceleration for extreme acceleration
    2. Jolt (rate of change in acceleration with respect to time) for hard braking and swerving.

Recognising Abnormal Driving Manoeuvres

- Observation over data distributions of smartphone accelerometer
  - **Extreme Acceleration**: Average acceleration (linear acceleration) for direction that pushes a passenger back into the seat.

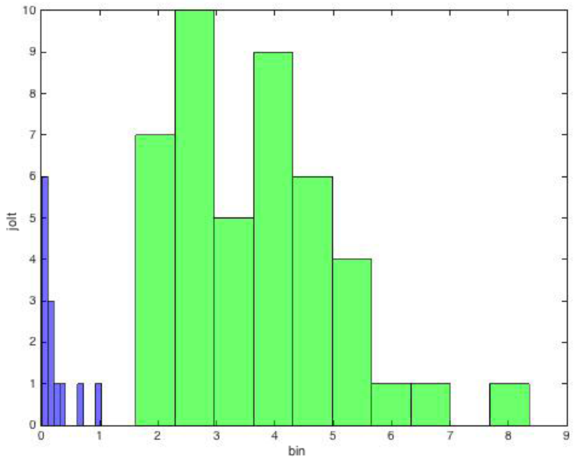


  - **Hard Braking**: Jolt for the direction opposite to extreme acceleration



Recognising Abnormal Driving Manoeuvres

- **Swerving**: Jolt in horizontal direction of accelerometer
  - (sideways force for non-linear acceleration)



Threshold-based abnormal event detection

- Extreme acceleration

$$acc\_threshold = mean(acc_1, acc_2..., acc_n)$$

- Hard Braking

$$J_i = mean(Acc\_z_{i:(i+k)}) - mean(Acc\_z_{(i-k):i})$$

$$brake\_threshold = min(brake_1, brake_2..., brake_n)$$

- Swerving

$$J_i = abs(mean(Acc\_x_{i:(i+k)}) - mean(Acc\_x_{(i-k):i}))$$

$$swerving\_threshold = min(swrv_1, swrv_2..., swrv_n)$$

Experiment and Evaluation

- Evaluation metric:
  - F-measure (harmonic mean of precision and recall)

$$\text{precision} = \frac{TP}{TP + FP}$$
$$\text{recall} = \frac{TP}{TP + FN}$$
$$\text{F-measure} = 2 * \frac{precision * recall}{precision + recall}$$

- **Extreme Acceleration**: **96%**
- **Hard Braking**: **82.8%**
- **Swerving**: 57.3%

Conclusion

- Threshold based technique is introduced to recognise driving manoeuvres that cause passenger discomfort.
- Effective recognition for abnormal acceleration and braking events.
- Lesson learnt: threshold based technique is not suitable for a complex event such as swerving.

Future Works

- How to deliver highly accurate recognition of abnormal driving manoeuvres (including swerving)?
  - Ensemble machine learning techniques

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Q&A