How's My Driving: Sensing Driving Behaviors by Using Smartphones

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Driving in US

- 10.8 million car accidents in 2009, which means 1 in 27 that year [US Census Bureau]

- 88% drivers regard themselves as safer drivers than average [Psychological Study in 1981]
Driving Sensing by Smartphones

- Accelerometer: measure three-axis accelerations, e.g., gravity.
- Gyroscope: measure three-axis angular change speed.
Acceleration and Brake
Turn and Lane Change
Challenges/Solutions

- Various device orientations and orientation may change during driving
  - Movement-aware coordinate projection: works under arbitrary device rotation
Challenges/Solutions

- How to define one driving behavior is good or bad
  - Compare system rating with passenger rating: as smart/justice as human being
Coordinate Projection
Coordinate Projection

1. Extract stop intervals
2. Project phone to earth
3. Extract car moving straight intervals
4. Check if the car is moving ahead or reverse

Car movement mess up sensor reading

When \((x, y)\) does not change too much

??
Before and After Projection

![Graph showing accelerometer data over time, comparing rotated and rotated + projected with ground truth.](image)
Projection Differences

![CDF Graphs](image-url)

- Left graph: Accelerometer Difference (m/s$^2$)
- Right graph: Gyroscope Difference (rad/s)
Orientation Change Detection During Driving

- Construct coarse-grained acceleration and angular changes by GPS, and compare with fine-grained sensor readings.
Multi-Attribute Rating System

- An aggressive skilled driver should receive higher score than those less skilled
- Attributes (from Accelerometer, y for acceleration and brake, x for turn and lane change):
  - Average: early planing
  - Peak: aggressiveness
  - Deviation: smoothness
Field Study

- 15 different passengers (6 females and 9 males)
- 60 rounds for each driving behavior
- 4 passengers rating for each round in a scale 1 to 10 (10 for the best)
- Compare passenger ratings with corresponding system ratings
Field Study: Ratings

- Ratings from 4 passengers in the same 10 rounds, with correlation 0.79
Driving Behavior Evaluation

- Calculate Pearson correlation for different rating scale
  - between each pair of passengers, and between the system rating and each passenger in each round

\[ r_{xy} = \frac{\sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n} (x_i - \bar{x})^2 \sum_{i=1}^{n} (y_i - \bar{y})^2}}. \]
Brake

- Correlation comparison between passengers and system ratings (90% higher than 0.6)
- Similar curve for other three behaviors
Rating on Daily Driving

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Scores of Turns

5
8
7
Thanks

Q & A