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

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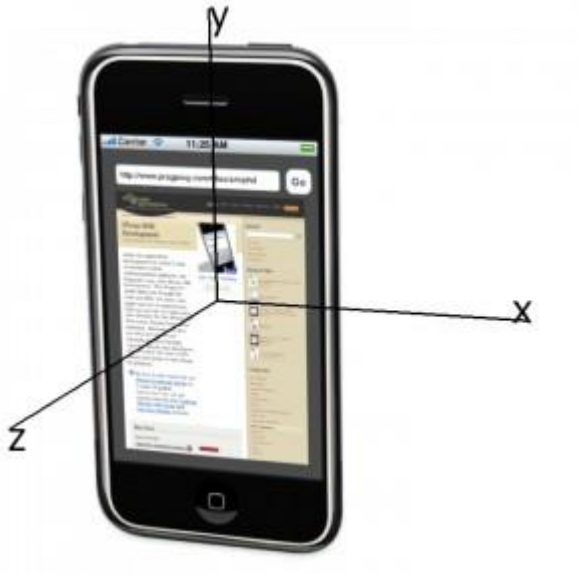
Driving in US

- 10.8 million car accidents in 2009, which means 1 in 27 that year [US Census Bureau]
- 88% drivers regard themsleves as safer drivers than average [Psychological Study in 1981]

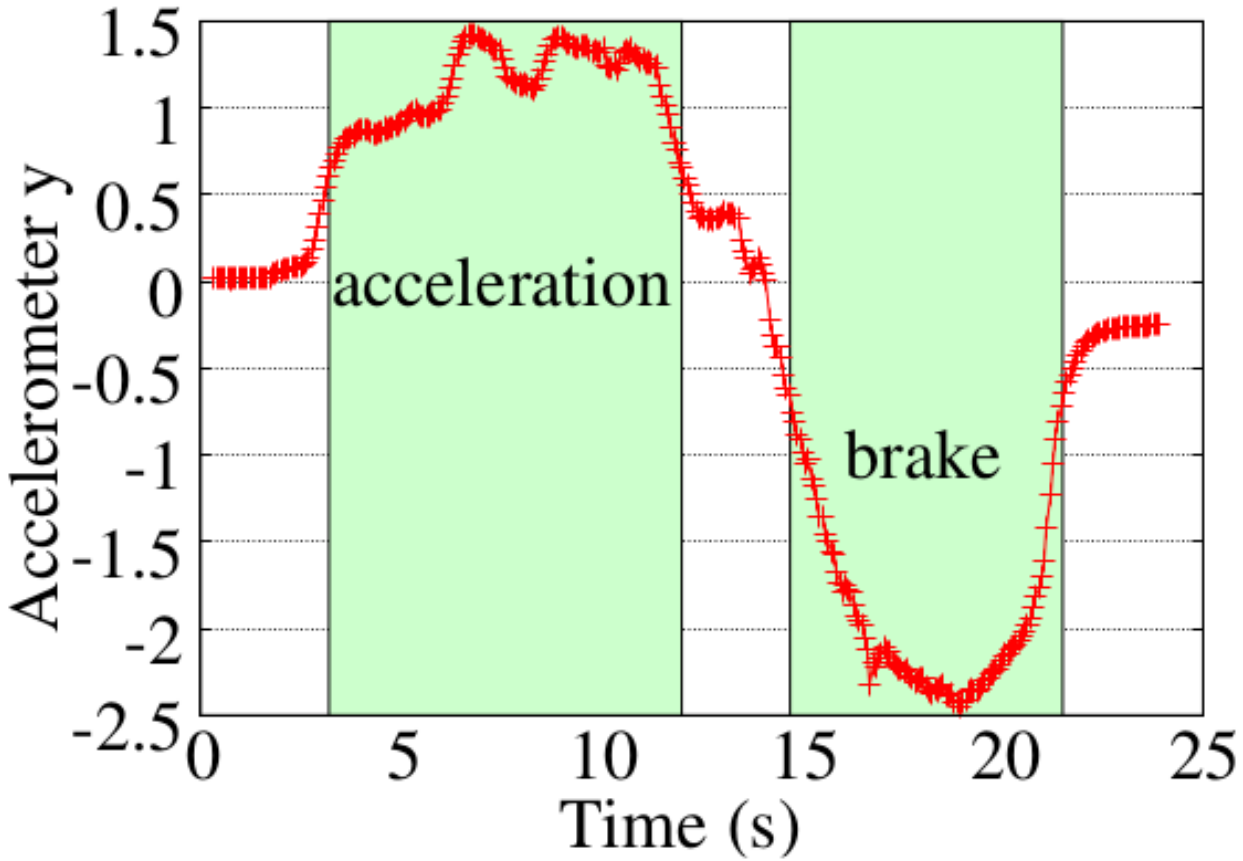
Driving Sensing by Smartphones

- Accelerometer: measure three-axis accelerations, e.g., gravity.

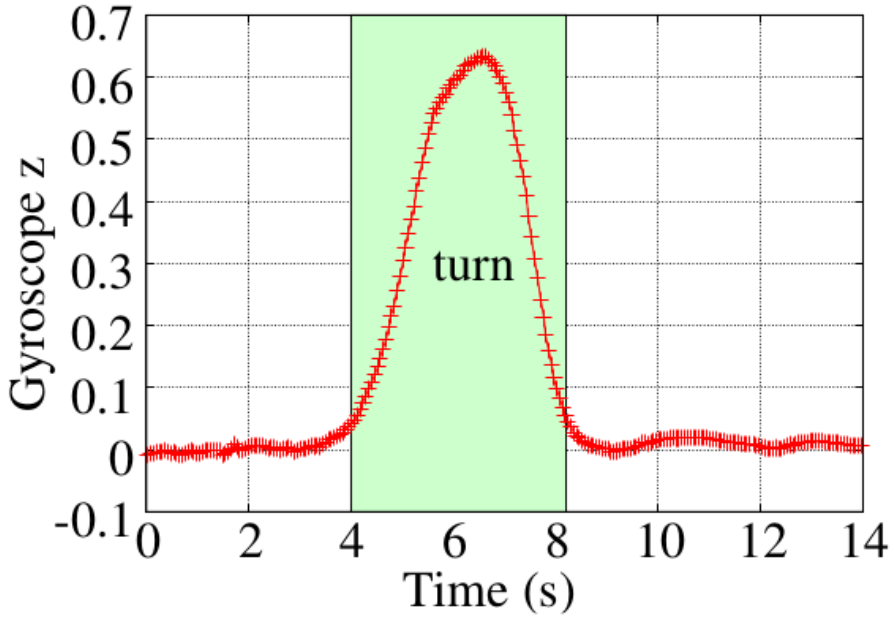


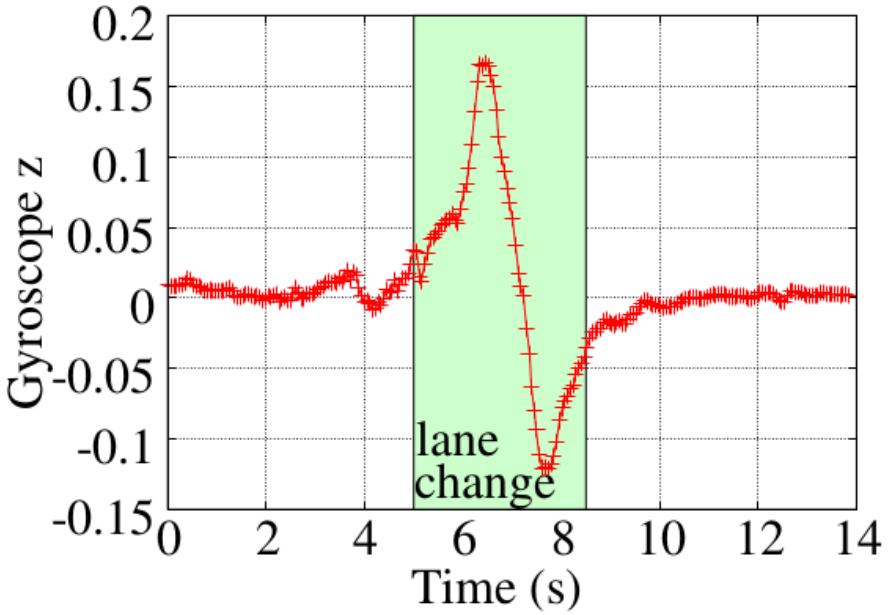
- Gyroscope: measure three-axis angular change speed.

Acceleration and Brake



Turn and Lane Change





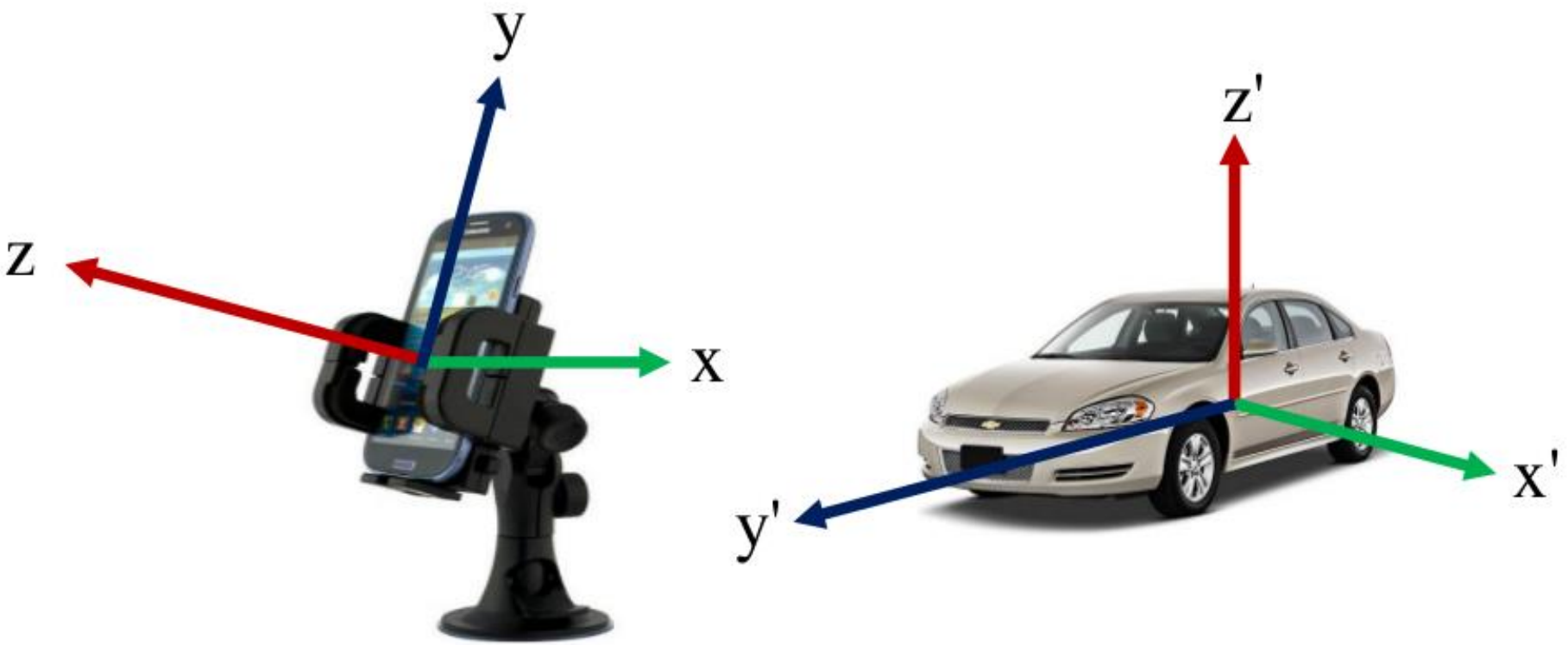
Challenges/Solutions

- 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

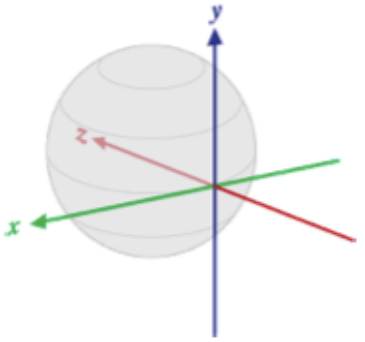


Coordinate Projection

1 Extract stop intervals

Car movement mess up sensor reading

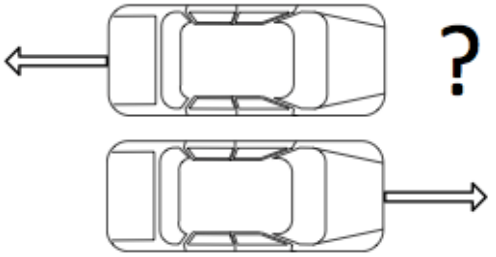
2 Project phone to earth



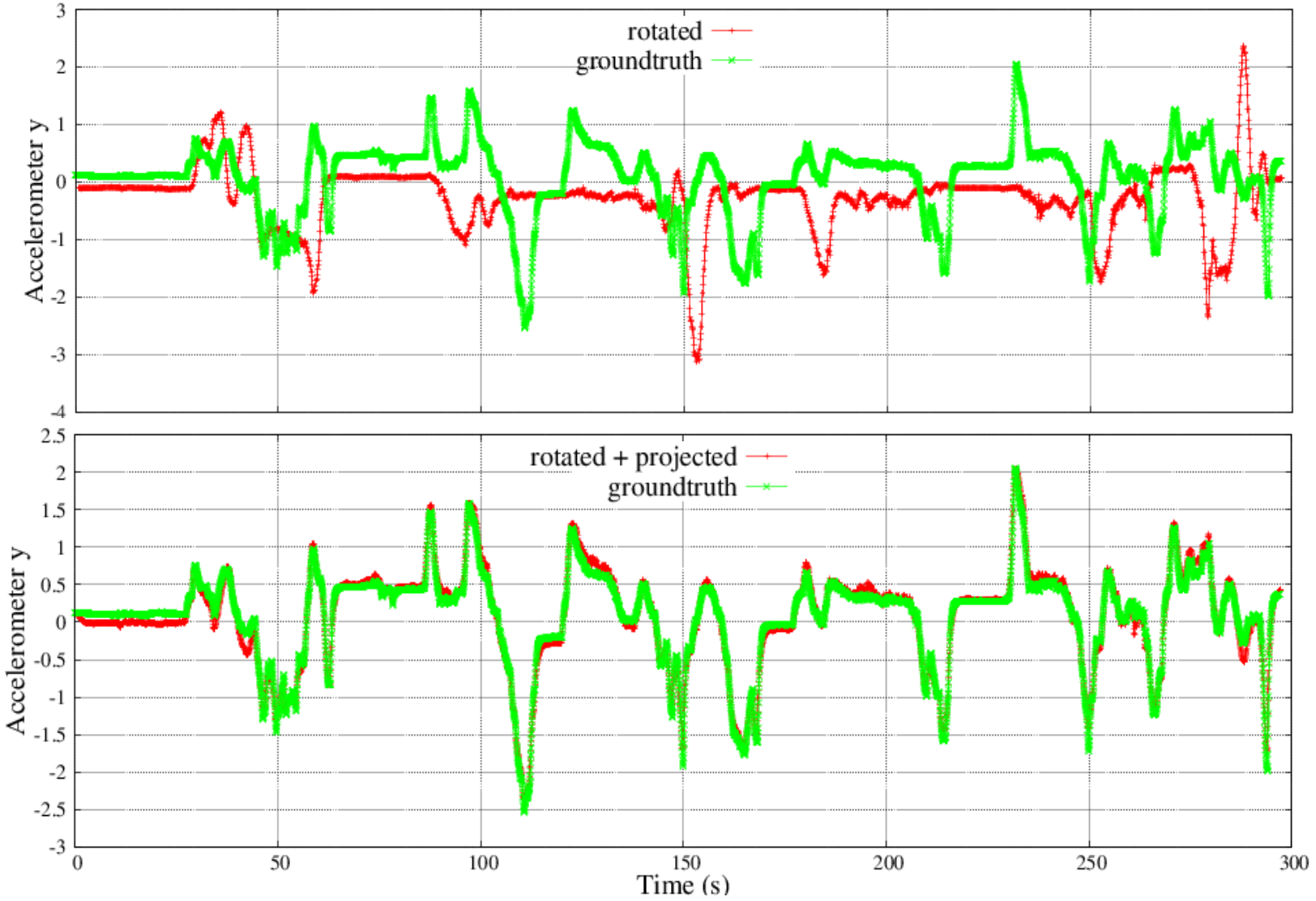
3 Extract car moving straight intervals

When (x, y) does not change too much

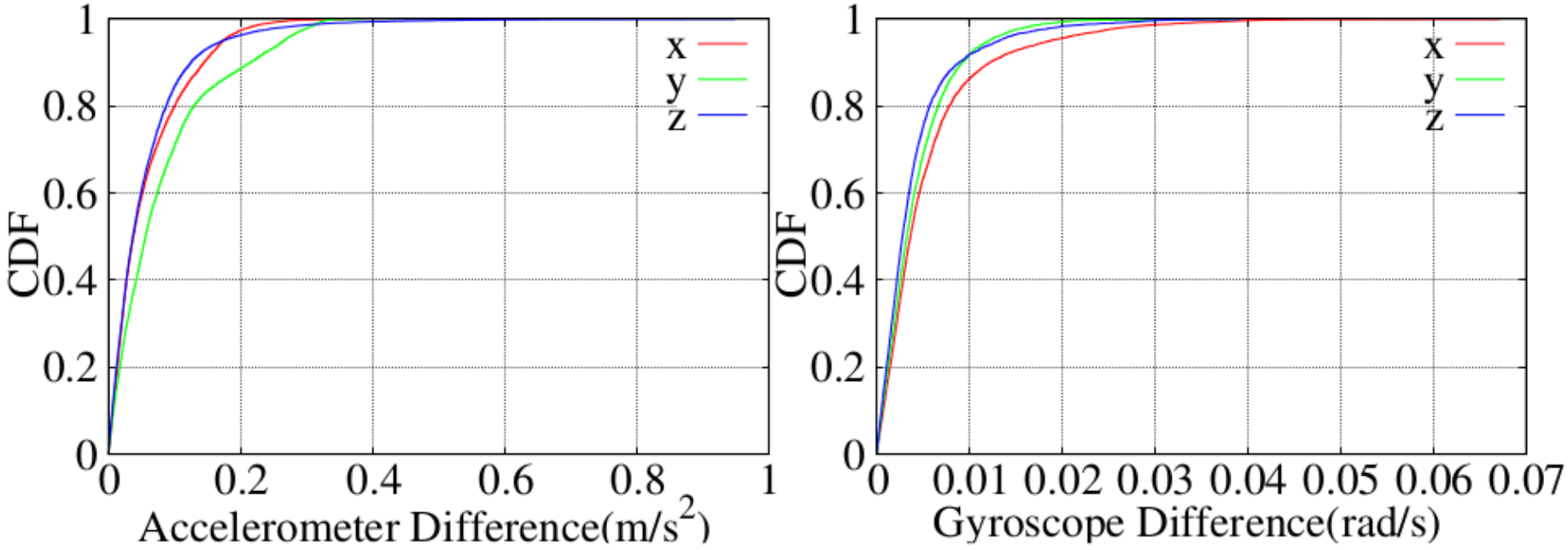
4 Check if the car is moving ahead or reverse



Before and After Projection

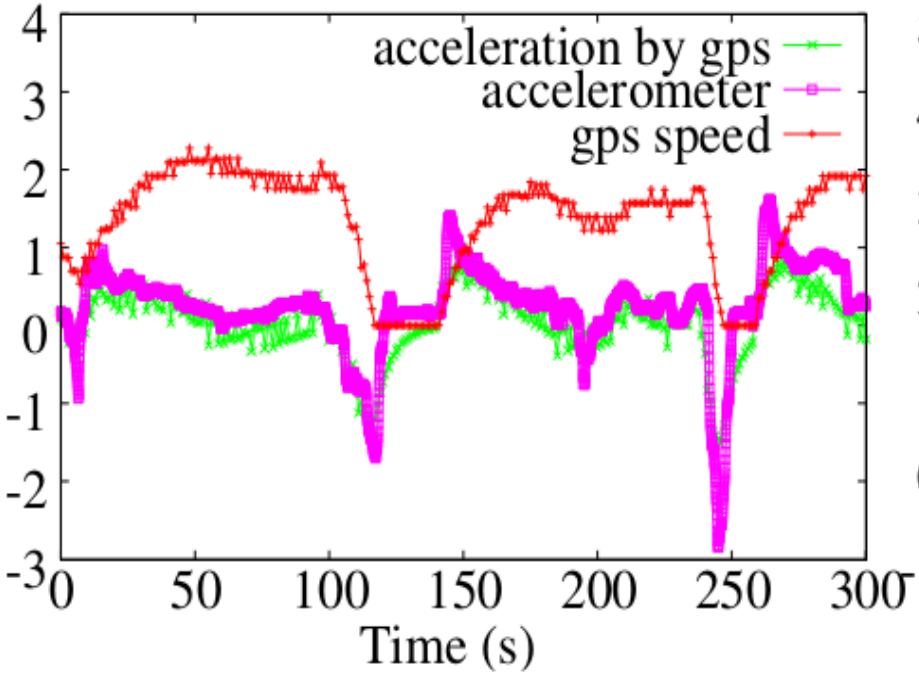


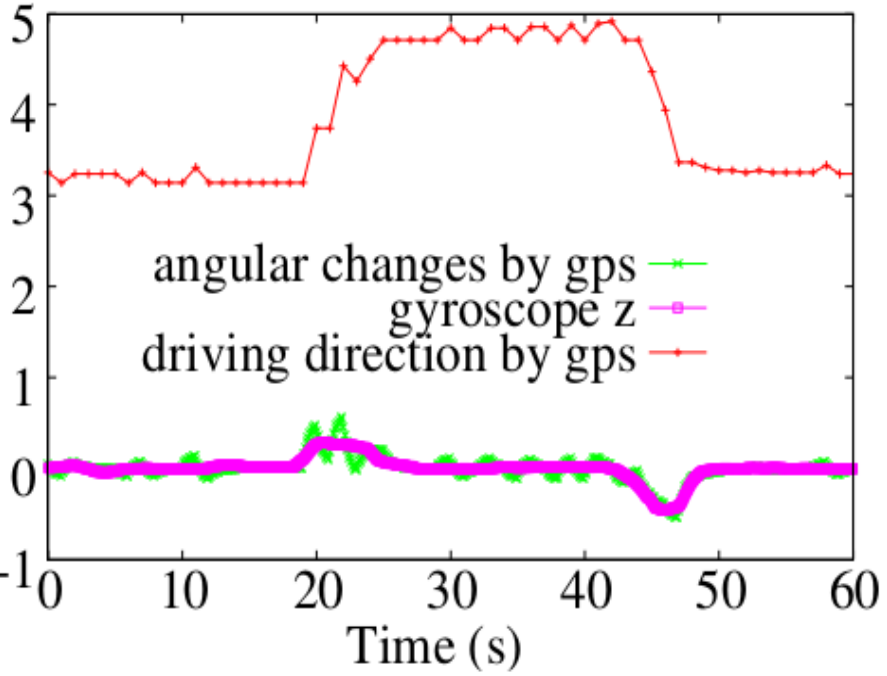
Projection Differences



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

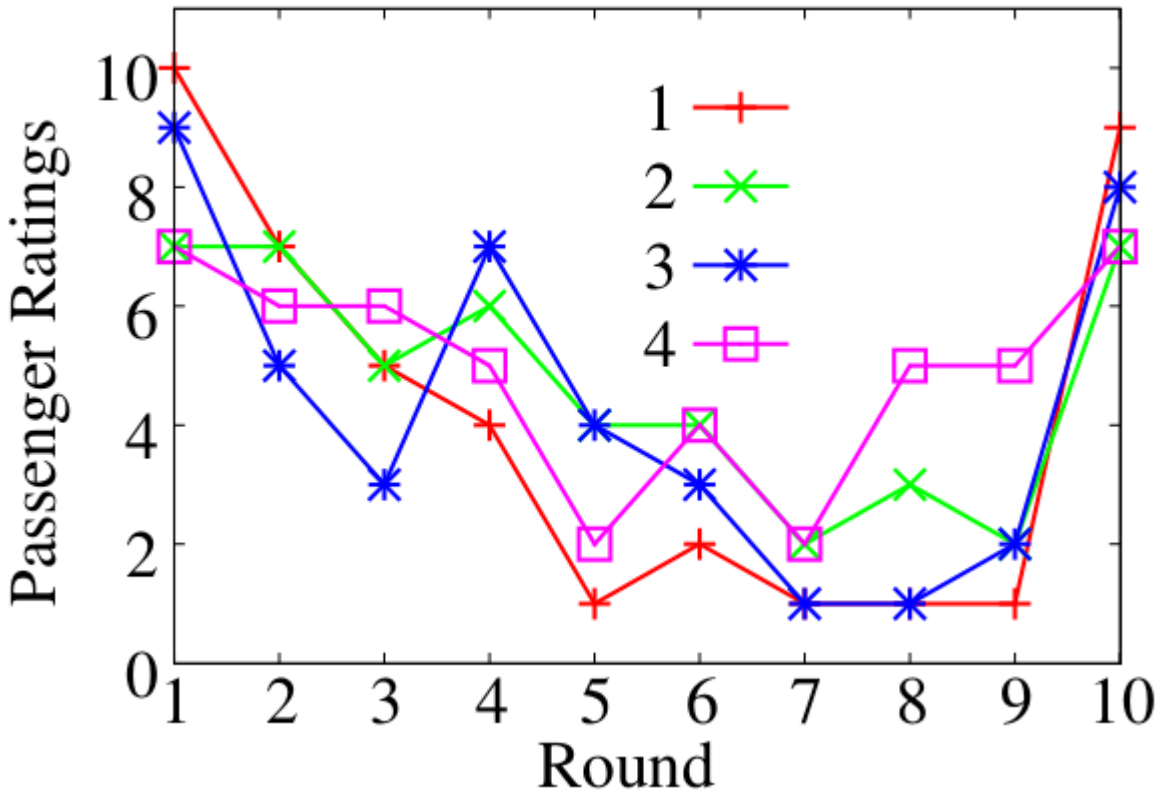
- An aggressive skilled driver should receive higher score than those less skilled
- Attributes (from Accelerometer, y for acceleration and brake, x for turn and lane change):
  - Average: early planing
  - Peak: aggressiveness
  - Deviation: smoothness

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

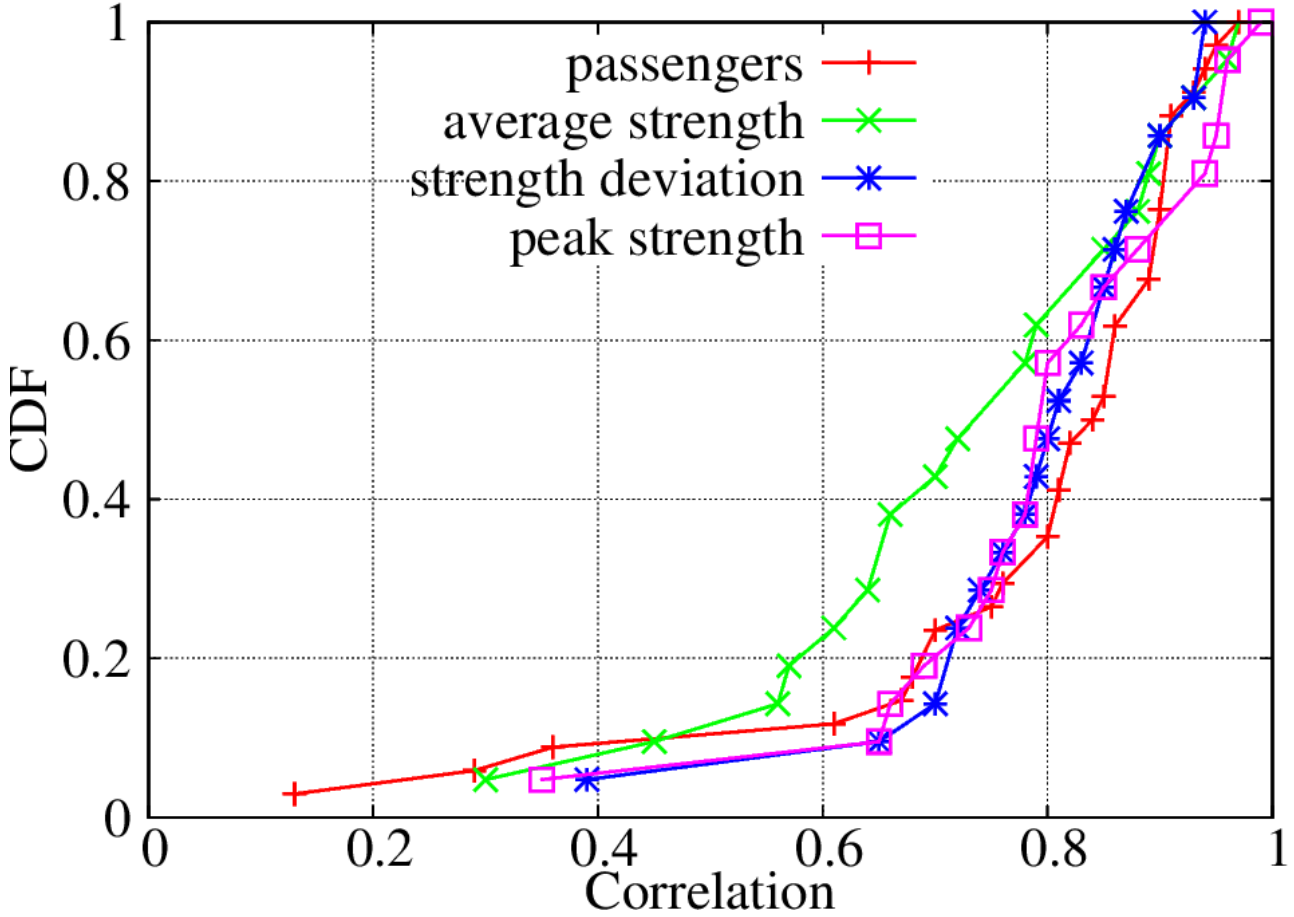


Driving Behavior Evaluation

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

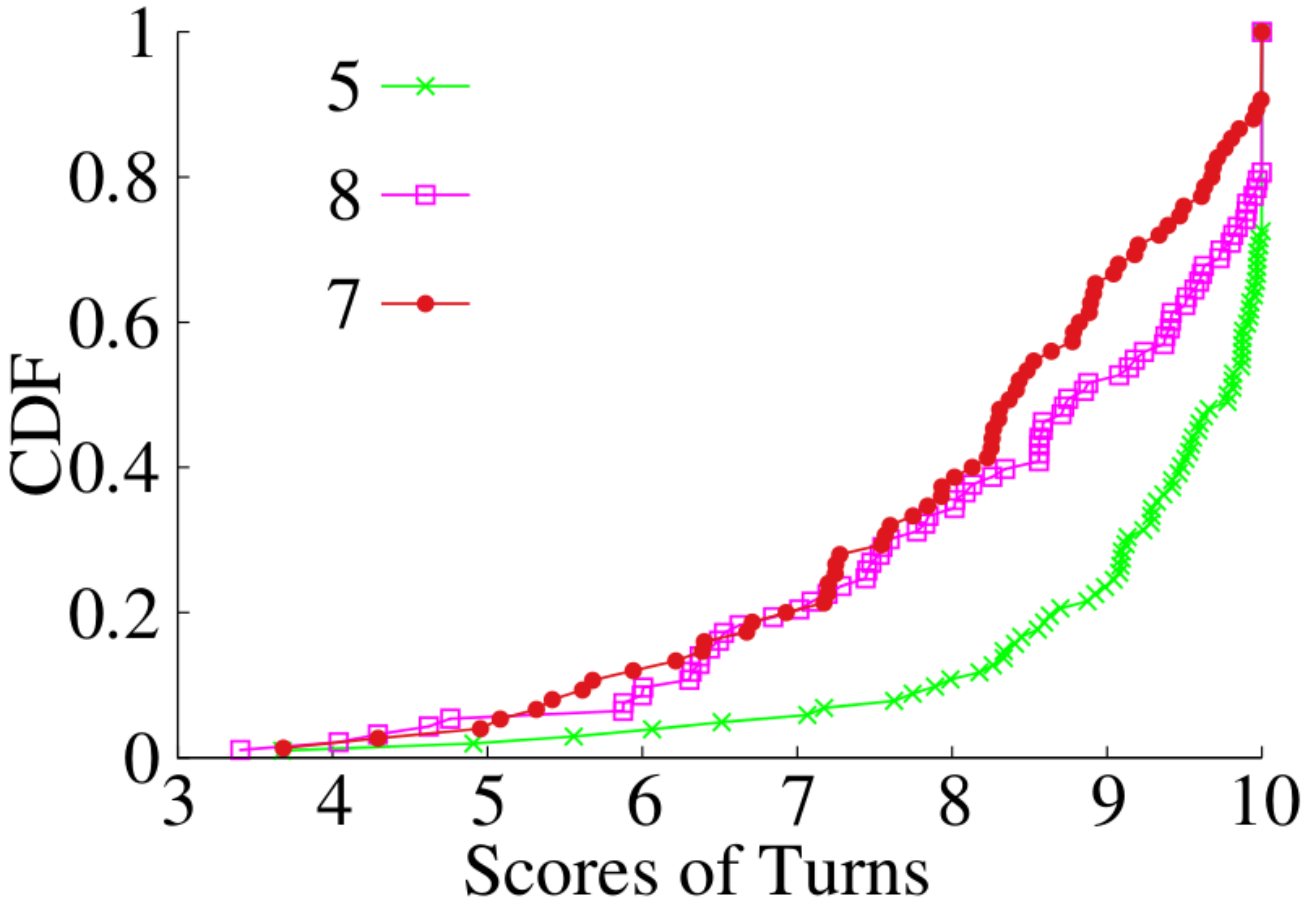
$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \overline{x})^2 \sum_{i=1}^{n}(y_i - \overline{y})^2}}.$$

Brake



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

Rating on Daily Driving



Thanks

Q & A