Risk-based Driver Modeling and Analysis

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Question

How do humans perceive and operationalize risk in interaction scenarios?

Introduction

Modelling human behavior is essential to safe and graceful human-robot interactions[1]. How a human perceives the environment can greatly influence their decisions[2], so by modeling the perceived environment (with a cost function) and a human's belief of their role in that environment, you can predict a human's behavior. Specifically, it is the human's perceived risk of the environment that leads to trajectory changing actions. Fig. 1 shows how [3] has implemented environment perception and operationalized a scalar 'risk' value. With this, a human will maintain action until a risk threshold is exceeded.

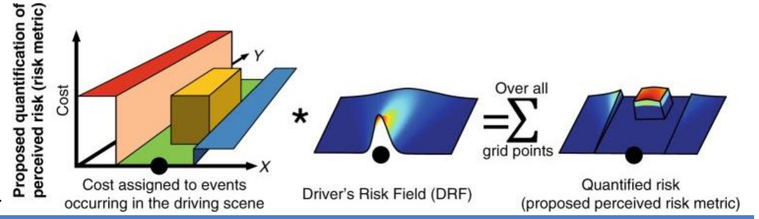

Fig.1.

INTERACTION Dataset

The Berkeley INTERACTION Dataset combines traffic data from around the world to provide hours of traffic footage in various scenarios. This dataset was chosen due to its diverse infrastructure cases and driver data (position, velocity, heading, size).

Implementation Status

Currently we are formulating this risk-based model within an interaction setting. We have developed an analytics tool to help this formulation by doing the following:

- Calculating polynomial representations of trajectories
- Visualizing trajectory data for better analysis
- Classify trajectories into contextual settings (e.g. interactions)

Trajectory comparison

Each trajectory was graphed on the map with a set opacity. The darker areas are where trajectories overlap. From Fig. 2 a clear preferred path is present between this entrance/exit pair. We believe this general preferred path to be the result of the road's structure influencing human trajectories

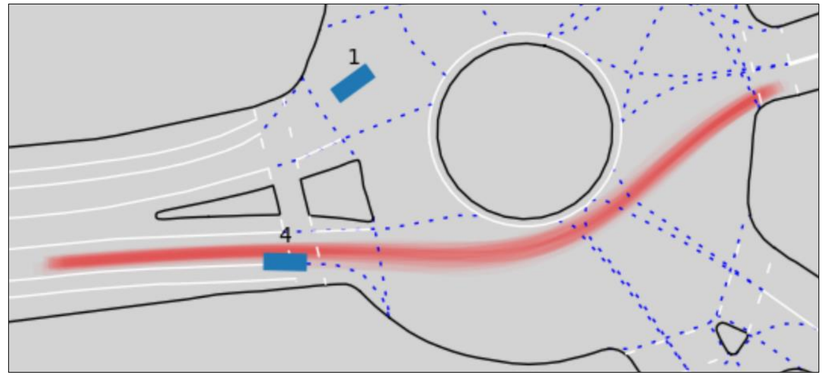

Fig. 2. **Car trajectories for a USA roundabout case**

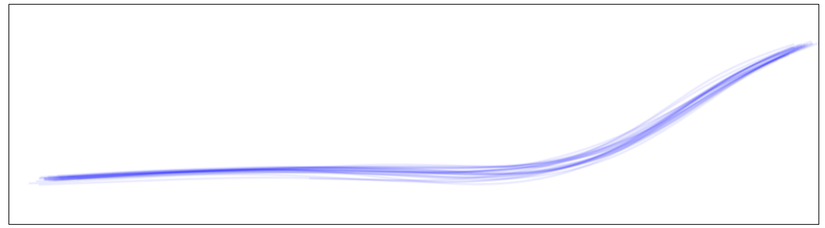

Fig. 3. **Car trajectories for USA roundabout case isolated and thinned**

Observations:

- Each entrance/exit pair has a general path that is followed
- Fig 3. shows individual deviations within the general path
  - Inside path: higher risk (closer to curbs) more optimal
  - Wider path: Lower risk but less optimal
- Individuals vary in their ideas of acceptable perceived risk
- Wider lane width allows drivers more freedom to choose how to cut a corner
- Narrow lane widths follow a uniform path

Current Hypotheses

Current factors believed to influence human driving behavior:

- **Road width**
  - Wider roads lead to smoother trajectories
  - Narrow roads provide less option for optimal trajectories
  - Wider roads lead to increased variability from car to car
- **Turn Sharpness** (Turn Radii)
  - Heavily influences lane positioning
  - Drivers 'cut' corners to reduce turning angle
- **Risk Threshold**
  - The quantified level of acceptable risk each individual is willing to maintain while driving

Future Work

. The goal for the future is to incorporate a risk-aware model into two agent interactions. This involves creating an improved environment cost function, an improved controller that interprets risk, and moving this concept into a dynamic game-theoretic scenario. Currently, we are looking to define the mathematical relationship between perception (how it is represented) and response to other agents. We hope that beyond this paper we can implement this concept into multi-agent interactions and expand the human model to explicitly consider things like social value orientation or intent inference.

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