Introduction

- Theory of Mind models are used by autonomous agents to predict a human agent’s future actions so the autonomous agent can accurately plan safe trajectories. These models often assume human’s act as rational agents, however, humans can actually be unpredictable. To address this uncertainty, we attempt to introduce a Bayesian confidence value into the model.
- The model then needs to be validated using real world data provided by the Berkeley INTERACTION Dataset.

INTERACTION Dataset

- The Berkeley INTERACTION Dataset combines traffic data from around the world to provide hours of traffic footage that has been broken down into data files containing position, velocity, angle, and dimensions for each car.
- Cases are selected by their display of a clear negotiation. A negotiation is defined when any two cars interact with each other in some form (e.g. slowing down to allow someone more room to enter a roundabout).
- Specifically, more complex negotiations were selected. These typically involved one car (M) actively changing the mind of another car’s belief about M’s intent. These negotiations will be used in our future work.

Implementation Status

- We have been able to run the model provided by the Berkeley group locally and manipulate the agent’s goals and trajectories.
- Currently, we are working to reimplment this functionality within our current interaction framework to provide a baseline for future expansion.
- This code is intended to be scalable and will expand the Berkeley model into a two-agent interaction scenario. The framework is projected to be done early June.

A Probabilistic and Confidence-Driven Approach to Theory of Mind Models in Autonomous Agents

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Question

How can we create a more accurate Theory of Mind Model for Autonomous Agents?

INTERACTION Dataset Example

The types of cases selected are very important as the better quality the cases, the better quality experiments we have. Provided here is one such example in which one car (green) changes the mind of another car (red) about its intentions:

- The green car is exiting a roundabout (e.g. slowing down to allow someone more room to enter a roundabout). (Fig. 1)
- Green negotiates by slowing down and maintaining constant direction. Red’s belief about Green’s intent is now changed. (Fig. 2)
- A probability distribution of Green’s next action would clearly display a high probability of a straight line from Green to the new green triangle. (Fig. 3)
- Red now enters the intersection, allowing Green to pass safely to its destination. (Fig. 4)
- Red initially believes Green’s destination is the green triangle. The gray arrows represent each cars’ velocity vector. The goal is to create a more dynamic and realistic model for more socially graceful movements by autonomous agents. (Fig. 5)

The goal of our autonomous vehicle is to simulate a human’s ability to be socially graceful in their reaction to the various types of roadway negotiations.

Dataset Conclusions

Applying a confidence-aware model to previous INTERACTION Dataset example, as simulated using the framework developed by Fridovich-Keil et al., yields the following:

Future Work

- The group would like to incorporate intent inference into this model moving forward, as well as expand it into a multi-agent interaction case. The goal is to create a more dynamic and realistic model for more socially graceful movements by autonomous agents.
- Adding intent inference allows the autonomous agent (M) to consider what the human agent (H) is thinking, as well as what H thinks about M. Considering these factors means that M can better predict what H will do and also understand roadway negotiations much better than just probabilistic inference alone. Intent inference requires a multi-agent framework, which is currently in development.

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References


Berkeley INTERACTION Dataset provides real-world traffic data that can be used to train autonomous vehicles to make safe decisions in complex traffic scenarios. The group's approach involves implementing a probabilistic and confidence-driven theory of mind model to improve autonomous vehicle decision-making. The example illustrated demonstrates how an autonomous vehicle adjusts its trajectory based on the intentions of another vehicle, showcasing the potential of this approach to enhance social grace and safety in autonomous driving.