GAME-THEORETIC MODELLING FOR VEHICLE-PEDESTRIAN INTERACTIONS

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The interaction between vehicles and pedestrians at uncontrolled pedestrian crossings might cause a disruption in vehicular traffic flow and may cause accidents. This project aims to model how pedestrians interact with vehicles (including AVs) in different crossing scenarios using and comparing both conventional and behavioural game-theoretic models. Another important objective is to see whether a controlled study is a good candidate for the game-theoretic model development as most of the past studies used naturalistic data to validate these types of models.

CONVENTIONAL VS BEHAVIOURAL GAME THEORY

Conventional Game Theory (CGT) has been employed in traffic and human factors domains for about two decades. This type of model assumes that preferences are consistent, or in other words, decisions are all rational suggesting that people are self-interested and they do not care about others' payoffs. However, later studies in economics suggest that preferences are more complicated than simple self-interest and they are, along with concern for fairness, highly context-dependent. To this end, Behavioural Game Theory (BGT) has been introduced which employs experimental evidence to make computational models of human cognitive limitations, social utility and learning rules aware of 'how people actually behave in strategic situations' (Camerer, 2003). Considering this, it is currently unclear whether CGT suffices for describing traffic interactions, or whether the more complex modelling techniques provided by BGT are needed. Hence, a comparison between these two theories seems necessary in our context to build the foundation to go further on the behavioural models.

Below, a simple comparison has been shown. The figures show the probability of vehicle and pedestrian crossing over different waiting times for the pedestrian at the kerb, respectively. The solid lines show the probability over waiting time for a CGT model (Wu et al., 2019) at different conflict distances. The dashed lines illustrate the same situations when the game has been solved by a BGT model named the Dual Accumulator model (Golman et al., 2019). Hence, everything between two sets of lines and plots is the same except for the way that the game has been solved. Looking at the figures suggest that the BGT model performs more realistically as for example, it is usually expected that when the probability of one agent increases over time, the probability of the other one goes down. Overall, the differences between two sets of lines in both figures indicate that the conventional and behavioural game theory models make different predictions, even when based on the exact same payoff matrices meaning that the models' abilities to fit human behaviour data can be compared against each other.

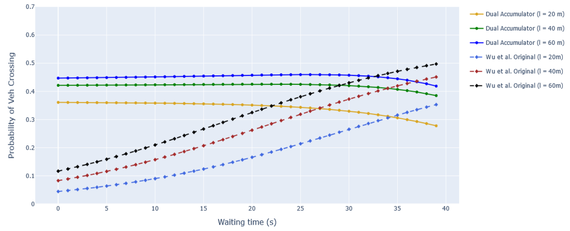

Fig 1. Probability of the vehicle crossing over the waiting time for the different conflict distances

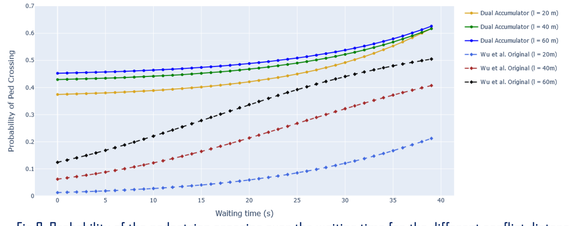

Fig 2. Probability of the pedestrian crossing over the waiting time for the different conflict distances

LEVERAGING DISTRIBUTED SIMULATION TO SUPPORT GAME-THEORETIC MODELLING

Distributed simulation is a controlled study consists of different nodes of simulation, at physically different locations which are connected over a network. An advantage of distributed simulation is that different simulators, e.g. pedestrian, car, bicycle and truck could be present in one scene and interact with each other as in the real world (Sadraei et al., 2020).

The distributed simulation in this project will be conducted by connecting a CAVE-based pedestrian lab known as the HIKER lab to the University of Leeds Driving Simulator using two interactive human agents.

Two main research questions could be addressed with this study:

- How can a controlled study be used to validate a game-theoretic framework? How can we push the participants to play a game in each interaction despite being in a non-real environment?

- Is a game-theoretic model a good tool for modelling and distinguishing pedestrian crossing decisions where there is a legal obligation like a zebra crossing and where the regulations are less clear like a mid-block?

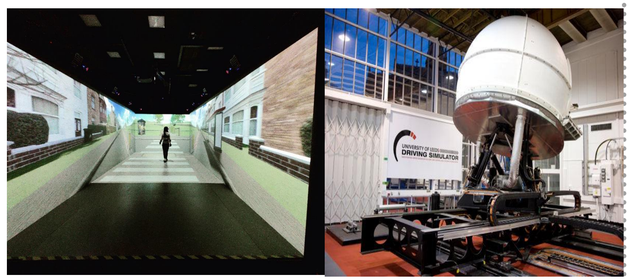

Fig 3. The HIKER pedestrian lab (left) the University of Leeds Driving Simulator (right)

Fig 4. The driver's view (left) vs the pedestrian's view (right)

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