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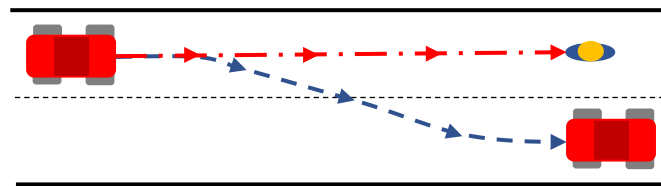
## Programming an Autonomous Vehicle Ethical Decision Maker Based on Injury Severity

James E. Pickering

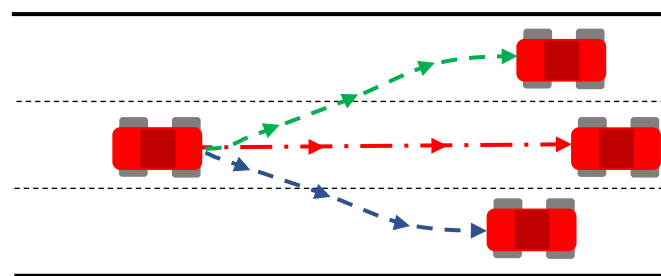
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### Extended abstract:

Fully autonomous vehicles (AVs) are likely to be on the roads in the next 10 to 20 years. AVs are expected to make fewer errors than human-driven vehicles (HDVs), hence reducing the number of accidents on the roads and the number of fatalities. However, just like HDVs, it is expected that AVs will enter into unavoidable collision scenarios (especially in the early years of operation). Since 2013, there have been a number of key publications on the ethical dilemma of AVs, see (Lin, 2013), (Goodall, 2014) and (Bonnefon, Shariff and Rahwan, 2016). In these publications, scenarios have been introduced that are similar to those given in Figures 1 and 2. Figure 1 involves an AV entering into an unavoidable collision scenario, where the AV must decide between steering into an oncoming AV or remaining on course to collide with one pedestrian. Figure 2 involves three AVs applying emergency braking due to a collision ahead (not considered here), with the following AV then facing an unavoidable collision. The AV must decide whether to stay on course to collide into the AV ahead, or to take steering action to collide into the AV to the left or right.



**Figure 1:** *Autonomous Vehicle (AV) Deciding Between Continuing On-Course to Collide into One Pedestrian or Steering and Colliding into An Oncoming AV – What Action Should the AV Take?*



**Figure 2:** *Three Autonomous Vehicles (AVs) Ahead Applying Emergency Braking, with the Following AV Entering into an Unavoidable Collision – What Action Should the AV Take?*

The scenarios detailed in Figures 1 and 2 introduce the motivation for this presentation, i.e., how should AVs be programmed to deal with unavoidable collisions. In (Gilbert et al., 2021), (Pickering and Burnham, 2021), (Pickering et al., 2019) and (Pickering et al., 2018), research has been undertaken to develop an ethical model-to-decision (EM2D) approach. The EM2D approach involves the use of mathematical models/data/logic to determine the collision injury severities of those involved in the collisions (although the number of occupants in each AV has not been detailed here). The knowledge gained from the models/data/logic would then be used to determine the severity of each potential

outcome. This approach would then allow decisions to be made based on this information. A utilitarian approach would involve the AV steering into the path that causes the smallest utility cost, i.e., lowest cost to society. For example, considering Figure 2, with the use of a mathematical model, it is possible to predict/estimate the injury severities of the three possible collision paths. In terms of the injury severities of the three potential collisions, peak acceleration could be an outcome of interest. Based on such knowledge (i.e., peak acceleration), it is possible to estimate the severity of each of the possible collision outcomes, and then invoke an ethical approach, e.g., apply a utilitarian approach that would result in the AV steering into the collision path that has the overall lowest injury severity to all of those involved, i.e., the occupants of the two colliding AVs.

This presentation will detail the EM2D approach to programming AVs based on predicted/estimated injury severity, and will address further questions in regards to how AVs should be morally/ethically programmed in the event of unavoidable collisions.

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