Dedicated Autonomous Driving Lanes to Increase the Viability of Driverless Autonomous Vehicles

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Autonomous driving has been touted as the future and many vehicles have now been created that meet the various levels of autonomous driving. Even with the hype and celebration around these achievements, safety concerns and regulation prevent driverless vehicles from being on the road. We propose that dedicated autonomous driving lanes may ease safety concerns, so that truly driverless vehicles could hit the road.

The distinction between autonomous vehicles and driverless autonomous vehicles is huge. In terms of regulation, there are concerns about who is responsible if there is a crash or legal infraction involving a driverless autonomous vehicle. Is it the manufacturer? The fact that a driver still needs to be behind the wheel, means, that driver is still responsible for all crashes and legal infractions. Safety concerns also abound. Even though statistics show that autonomous drivers may be safter than human drivers, we can understand human error, but many do not know how to perceive machine error. Especially if that machine error can lead to a crash that will injure humans or lead to their death. Many believe that any deaths are too many to allow for driverless autonomous driving.

The benefit to driverless autonomous vehicles from an economic and quality of life perspective could also be huge. Companies could utilize driverless autonomous trucks to ship goods. Driverless vehicles could be used to pick people up and take them where they need to go, which could allow for a reduced need to own vehicles. People could engage in other activities while being taken to their destinations.

As a start we would propose implementing autonomous driving lanes on interstate freeways. This would allow for driverless commercial trucking and driverless commutes to work or vacation trips. A possible implementation would be to utilize the left lane as an autonomous driving lane. To avoid human and autonomous driving interaction, ramps could be created to load autonomous vehicles into the left lane without interacting with human drivers. Of course, for this to work and to continue to avoid driverless and human vehicle interaction, driverless vehicles could not just exit the freeway and start down local roads where there is not a dedicated autonomous vehicle lane. In order to resolve this, autonomous driving ports could be available. These ports could be created along the freeway and allow for autonomous vehicles to exit and enter the autonomous driving lane. The ports would allow autonomous vehicles to refuel or recharge and also allow for a human driver to take the wheel and enter local roads to finish short local routes after longer freeway driving.

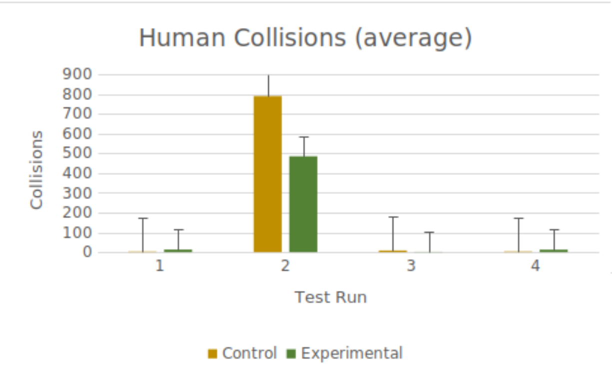
This proposal is not without its issues. First, the infrastructure cost would be large. Specifically, creating autonomous vehicle ports and special entrance and exit ramps for the dedicated autonomous driving lane would be expensive. Another concern is traffic. There is already a lot of traffic on freeways. If a lane was removed, it would seem that traffic would be worse. This would especially be the case during busy times of the day. Possible resolutions would be to create alternative routes for the autonomous vehicle lane in large traffic areas or to turn off the autonomous driving lane during peak traffic hours. This would force driverless vehicles to stay in ports during these hours. Safety would also still be a concern. Even though driverless vehicles would have a dedicated lane, there is still a possibility for human and driverless vehicles to interact. To reduce the safety concerns even further, it may be required to create barriers between the driverless and human vehicles. These barriers would also have a large infrastructure cost associated with them.

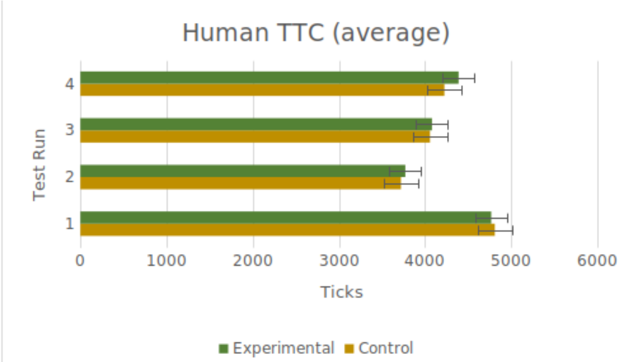
To tease out the viability of a dedicated autonomous vehicle lane we created a simulation within the Carla simulator. Based off the Carla provided autonomous agents, an autonomous vehicle agent and a human vehicle agent were created. The autonomous vehicle agent was created to be normal driving and stable. The human vehicle agent was created to use random Carla behaviours, so that some would be cautious, others normal, and others reckless. The human agents also calculate a random speed with variation from the average. The local planner of the autonomous vehicles was modified so that they would remain in the dedicated autonomous vehicle lane only, along with interior lanes as needed. The local planner of the human vehicles was modified so that they would mostly remain in the non-dedicated autonomous driving lanes. Mostly is mentioned because due to the uncertain nature of the behaviour of the agents, some human vehicles still roam into the autonomous vehicle lane as could also occur in real world scenarios. Multiple vehicles of the autonomous and human agents are created during the simulation. We tracked different data of the agents as they moved along the course. Here are the results.

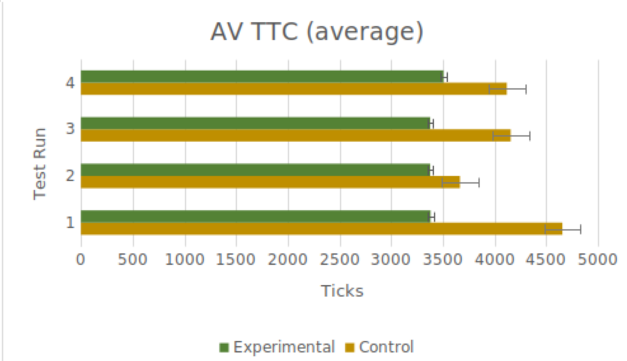
Results.

To assist with collecting our results and eliminating the influence of outliers we conducted four tests, utilising an experimental group (specialized lanes are enforced) and a control group where we do not enforce special lanes. For our four runs, we utilised these four random seeds: 5100, 5101, 5102, and 5104. In the results below, the mapping is as follows: 5100 -> 1, 5101 -> 2, 5102 -> 3, and 5103 -> 4. To further assist with reproducibility, we ran the CARLA simulator in synchronous mode. Synchronous mode and consistent random seeds allowed us to cut down on any sizeable non-determinism that could influence our results. Unfortunately, it appeared that if our computer running the simulation was under high load that occasionally vehicles would become “stuck” and influence our results. We corrected for this by only allowing simulations a fixed number of ticks, and redoing any experiment that reached the tick timeout.

Our results indicate that having a dedicated lane for our “AV” reduces their respective travel time while not impacting the travel time of human drivers. The results were also inconclusive as to whether the rate of collisions will be reduced with a dedicated lane. See below for two charts summarizing the data we collected.







Conclusion.

From our results, we can conclude that the introduction of AV lanes leads to a noticeably reduced number of ticks for all AVs to complete their path compared to the control. For collisions, we cannot conclude a significant difference between the experimental and control groups.

Further Research.

Further research in this area would require a better approximation of how an AV should react. For our purposes, we only used a vehicle that drives conservatively all the time, using a real AV model will yield better results. Outside of the technical realm, further research could be focused on how human drivers react to seeing an AV sharing the road with them. It is entirely possible that upon seeing a vehicle with no driver, human drivers will act cautiously and avoid it. This is a prescient research question as Cruise is deploying driverless vehicles in San Francisco to pick up passengers.

Notes.

The finer technical details of our implementation are not discussed in this report to keep it brief. The exact code & setup used for these experiments can be found on our shared GitHub repository.