Milestone 1

Self-Driving Infrastructure

Engineer 2PX3 – Integrated Eng Design

Team 17

T06

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Executive Summary

With the rise in advanced technology, the future of self-driving vehicles is nearby. Society, as well as engineers of several specializations are presented with the opportunity to redesign infrastructure that is custom-built for the use of self-driving technology.

When pursuing design options, many stakeholders and their concerns must be considered. Along with drivers, pedestrians, as well as cyclists are significant stakeholders that share roads and intersections with the rest of society. Each stakeholder expresses concerns regarding different PERSEID layers including performance, environmental, regulatory, and socio-economic. Although some concerns conflict with one another, certain concerns will take precedence over others as they are crucial in ensuring the safety and overall success of the design. Attributes such as performance, fairness, and accessibility are defining features that distinguish a poor design from a well-thought design. Along with meeting design specifications, the consideration of outlying factors such as unintended consequences are also crucial in ensuring an efficient design. The focus of this project was decided to be the redesigning of an intersection as it contains more relatable and complex aspects that will provide a challenging experience for the team.

Introduction

As time progresses, so does society, more specifically, our wishes to live a more comfortable life, and with that the technology available also advances to meet our needs. Even our vehicles have become so advanced that we have been able to create electric cars and self-driving cars. They make our lives easier and some of them are better alternatives for the environment as opposed to regular cars, but not all the roads are best suited for self-driving vehicles. If all vehicles were to be self-driving, the chance to create a much more efficient traffic intersection that would include shorter wait times for all vehicles and other stakeholders (such as pedestrians) would present itself. Unfortunately, that is not the case, as there will always be a point in time where the entire population will not have a self-driving vehicle, just like how everyone does not own a hybrid or electric car. The problem that now arises is how do we redesign the infrastructure for a normal traffic intersection so that it is customized to benefit

users for not only self-driving vehicles and human-driven vehicles, but also additional stakeholders involved.

Stakeholder analysis

Listed below are the main stakeholders roughly in order of how important road designs are for them, along with the details of their concerns.

Self-driven Vehicle Users:

The broad category including all self-driven vehicle users, which possibly overlaps with later mentioned stakeholders. Self-driven vehicle users want to get to their destinations as fast as possible, which would be achieved by optimizing road rules to allow self-driving vehicles to use their full capabilities. Current roads were not designed with self-driven vehicle users in mind.

Human-driven Vehicle Users:

The broad category including all human-driven vehicle users, which possibly overlaps with later mentioned stakeholders. Like self-driven vehicle users, they're primary concerns for road designs are how the roads will help them spend the least time on their journeys. Current roads were designed with the concerns of human-driven vehicle users in mind.

Pedestrians:

Pedestrians concerns on road design pertain to safety, accessibility, and travel time. They want to be able to cross the roads without danger; to be able to get where they need to go via sidewalks, inclusive of those with accessibility needs; and they want to minimize time spent waiting at crosswalks and intersections.

Emergency First Response Teams:

The concerns of emergency response teams pertain to being able to get to their destination as fast as possible, and to have priority in doing so over other users of the road when necessary. They need to be able get through things like traffic jams, if necessary, in order to get

where they need to go; as a result, they need roads to have extra space to allow other vehicles to move aside for them. They also need to be able to break road rules as necessary to save lives.

Public Transportation & Logistics/Transportation Companies:

The concerns of these companies pertain to being able to get to their destinations as fast and efficiently as possible, and to have their services accommodated on roads. Public transportation in particular want accommodation on roads for bus stops. Both transport companies and public transportation want roads that accommodate for large vehicles (busses, and trucks).

Cyclists:

Cyclists are primarily concerned with being able to get where they need to go in the least amount of time possible safely. Cyclists want accommodations on roads to get to places faster; however, being on roads along with cars is significantly more dangerous to cyclists, making safety a concern.

Government:

Governing bodies are concerned with road design and regulation as they are ultimately responsible for creating and maintaining road laws. They want roads to accommodate for the needs of society. They also need to be able to determine who is at fault in road incidents, which is made difficult by self-driven vehicles.

Vehicle Manufacturers:

Vehicle Manufacturers' concerns with road design pertain to designing their cars to be best for roads. If self-driven vehicles are given special accommodations on roads, vehicle manufacturers will have to produce self-driven vehicles to compete.

System definition

There are a lot of input parameters outlined for the system. The system consists of a one-lane intersection, meaning there is one lane for incoming traffic and one lane for ongoing traffic,

going in all four directions. There are 100 cars going through the intersection per hour, driving at 60km/h. The distance between the cars is 6 metres. The communication range for self-driving vehicles is 100m, meaning that cars can communicate with each other, including the sensors at the intersection, within a 100m radius.

There are a lot of assumptions being made regarding the system to simplify the system. All self-driving cars will travel at 50 to 60km/h and are aware of every object and people around them. The car will start slowing down when it is within 100m of the centre of the intersection if the traffic lights are yellow or red. The car wait time at an intersection will not exceed over 2 minutes. All vehicles will always wait for pedestrians to finish crossing before moving. The intersection will be a single lane road but left and right turning lanes will be created closer to the centre of the intersection.

For human driven vehicles, they will depart after pedestrians have crossed and before the 2-minute mark. These cars will arrive at the intersection every 30 seconds, from all four directions. These cars will slow down by 10 km/h in case for any blind spots, rushed drivers or pedestrians. Human-driven vehicles will behave similarly to self-driving vehicles; however, the main difference is that a human driven vehicle has the ability to not obey all traffic rules for all time. Also, human driven vehicles will drive at varying speeds and may go over the max speed limit and will follow other cars at a distance of 2 cars apart.

One of the metrics for measuring performance includes measuring travel smoothness. This considers the time taken with cars stopping and turning. To measure fairness, one of the metrics used is determining the accessibility of the intersection. However, there are no traditional ways of measuring this so user input on preliminary prototypes would be the best way to approach measuring accessibility.

With this set of parameters given, the model is non-trivial as changing the inputs may not have obvious results. For instance, if the speed limit for all vehicles was increased by 10km/h, it may not chance the travel time or wait time for all vehicles on the road.

Conclusion

In conclusion, the redesigning of the infrastructure for a smart intersection will bring about many concerns from various stakeholders such as self-driving and traditional vehicle drivers, pedestrians, emergency vehicle drivers, and more. Given that, crucial decisions will be made as not all concerns will be accounted for since some take precedence over the other and hold a greater value. The defining problem and basis of this project is how the new design of the infrastructure will be accommodated to satisfy the important stakeholders, by ensuring it is structured to be efficient, safe, and advanced for all members sharing the road. In order to do this, many parameters are defined to create an outline of the system and metrics are put in to place to measure important factors that determine the overall success of the project objectives.

References

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Appendix

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