Q3
2018

AUTONOMOUS VEHICLE TESTING

PROGRESS REPORT

Quarterly update for the City of Boston on Optimus Ride's autonomous vehicle testing program.

OPTIMUS RIDE

Optimus Ride Inc. is a self-driving vehicle technology company. Emerging from Boston's vibrant robotics ecosystem, we carefully bring together the promise of self-driving technologies with real-world considerations. We design our software to enable efficient, sustainable, and equitable mobility systems and solutions.

Introduction

As of the end of September, Optimus Ride has operated its self-driving cars in autonomous mode for more than 2,400 miles. Nearly half of those miles have been on streets in the typical urban environment of Boston, particularly in the Seaport area.

Research Achievements

Since receiving approval for a passenger transport pilot earlier this year, we have been hard at work testing our vehicle's performance prior to commencing a pilot service. These tests ensure each of our vehicles meet our rigorous safety and operational standards. We test our new software first in simulation, then in closed-course testing in our indoor facility, and finally on public roads. While simulation and closed-course scenario testing can demonstrate our software's core driving skills, our vehicles' complete set of behaviors need to be capable of driving on real roads, where the diversity and variations in the environment are challenging to simulate and replicate on a closed course.

Handling non-determinism in testing is important because it can be challenging to test what we call "edge-case situations". An "edge-case situation" is a situation that does not normally occur in every day interactions. Testing a particular edge case situation can be difficult because the system may only behave in a certain way that exhibits that edge case if the system receives an exact sequence of inputs from the world. Replicating that exact sequence of inputs reliably is what poses a great challenge. Additionally, when testing a system with probabilistic behaviors, passing a test once does not mean that the test will be passed every time. In other words, even if a self-driving vehicle can drive perfectly through a complicated intersection once, that does not mean it can do so reliably in all conditions. Ensuring the later requires a much higher bar of testing. Therefore, our testing seeks to validate that the statistical characteristics of probabilistic behaviors are accurately specified. This takes many more samples to build a test result which can be determined statistically significant within some confidence interval, especially if the behavior in question is safety critical and expected to have an extremely low failure rate. So if we return to our "perfect drive through a complicated intersection" example from above, it follows that testing just that one intersection behavior requires, at minimum, a large number of hours of testing in order to understand the probability by which the vehicle may perform certain behaviors. Furthermore, making a left-hand turn across traffic requires more hours of testing than just making a protected left-hand turn on a closed-course with no randomly behaving traffic.

Operational Design Domain

Optimus Ride was encouraged to define and document the primary Operational Design Domain (ODD) for our self-driving fleet as it is tested or deployed for use on public roadways, adhering to guidelines set by the NHTSA, as well as the *"Application to Test AVs on Public Ways in Massachusetts"* from MassDOT and the City of Boston. Our ODD defines where (e.g., what roadway types and speeds), and when (e.g., under what conditions, such as day/night, weather conditions, etc.) our self-driving cars are designed to operate safely. The settings in which we operate our vehicles are critical because mastering autonomous driving on urban roadways requires us to drive challenging urban street features. These features include handling unprotected left-hand turns, interacting with a diversity of road users including bicyclists and pedestrians, and reacting to potentially unsafe behavior from other road users. In order for us to ensure safe operation, the most straightforward way to assess our autonomy is to test-drive in real traffic within our ODD and observe our fleet's performance.

Public road testing provides a continuous feedback loop that enables us to continually improve our system. Our engineers rely upon these real-world scenarios to evaluate and improve our systems, always with the added safety of trained vehicle operators behind the wheel who are ready to take control for any event that presents too much risk. This is a critical step where we can validate the capabilities we have developed, uncover new challenging situations, and develop new abilities. Our team is ready to analyze any and all unexpected behaviors after the fact to assess what our autonomous vehicles would have done without intervention, whether it would have resulted in a collision or other safety issue. We then resolve any issues by refining our software, firmware, or hardware and incorporate those changes across our entire fleet. This iterative approach to testing and public-road validation helps us safely expand both our operational design domain and the capabilities of our vehicles.

Potential Improvements

As discussed in previous reports, there are some areas in the Marine Park that are overdue for road surface marking striping. In particular, the bike lanes in the Seaport, specifically on Northern Avenue, are worn to the point that neither bicyclists nor drivers take notice of the bike lane. This leads to confusion between our autonomous vehicles, which have been programmed to respect bike lanes, and human drivers who may be unaware of the bike lane. If our vehicle leaves room for the bicyclists, we find other drivers trying to overtake our vehicles on the right, using the bike lane, which leads to dangerous situations for all road users. Restriping in the Marine Park could help clarify traffic laws and allow all road users to understand the best practices for driving in the Park.

(LEFT) *Bike lane markings along Tide Street.* *(RIGHT)* *Stop lines and pedestrian crosswalk along Northern Avenue.*

Thank you

We are thankful to the State of Massachusetts and the City of Boston for supporting the development of the autonomous vehicle industry. As the only Boston-based startup in the autonomous vehicle technology industry, we are excited to grow our operations in the state and continue pursuing efficient, sustainable, and equitable mobility systems and solutions.