UNIVERSITY OF DELAWARE

INSTITUTE FOR PUBLIC ADMINISTRATION

High Definition Mapping and Data Needs for Connected and Automated Vehicles

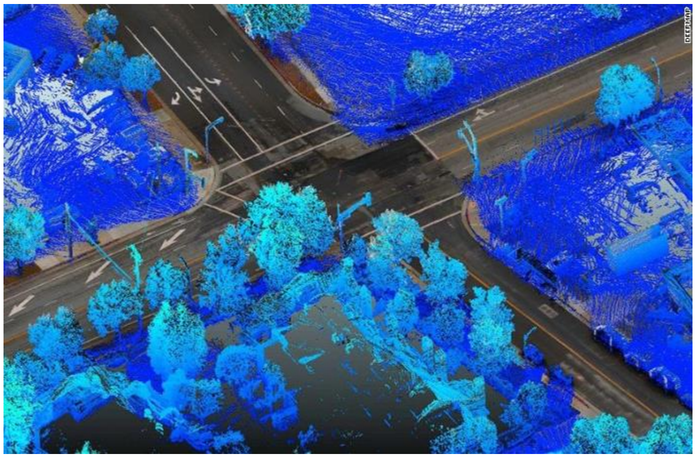
By Philip Barnes and Brett Swan, January 2019

High-definition (HD) maps are essential for the safe operation of connected and automated vehicles (CAVs). The maps are not the traditional two-dimensional paper or GPS versions we are familiar with, but rather are three-dimensional representations of the real world—such as we see with our own eyes. HD maps, which come within centimeters of accuracy, allow a CAV to understand its location, surrounding physical environment, and rules of the road. Due to the complexity and data-intensity of HD maps, CAVs require extensive on-board computing power to quickly collect, store, process, and transmit a tremendous amount of data.

Mapping Technology

HD maps are composed of several individual maps layered on top each other. A key sensing technology used to generate the 3D environment of HD maps is LiDAR (light detection and ranging). LiDAR is a "laser-based process that senses objects in the near-field environment of the car" by emitting light pulses and measuring the time it takes the pulses to reflect off the objects.[1] These systems have an approximate 100-meter range in all directions and can take more than 2 million readings per second. Additional on-board sensors such as GPS, radar, ultrasonic technology, and normal cameras combine with LiDAR sensors to create the centimeter accurate 3D image that CAVs require for safe navigation.[2]

A semantic map is an additional layer that is superimposed onto the 3D image to ensure the vehicle follows the rules of the road. Semantic maps include information such as lane

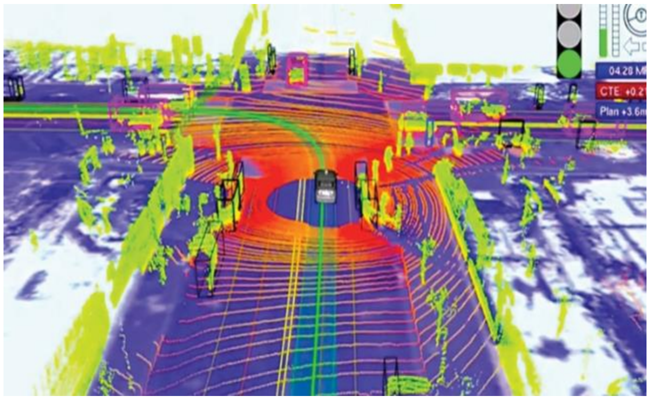


boundaries, speed limits, turn restrictions, and stopping points.[3] The fusion of semantic map layers with digital 3D map layers results in a data-rich HD map that contains the needed information for safe CAV functionality.

The HD Mapping Race

Being the standard bearer and owning the HD maps that all CAVs require could easily be worth billions of dollars. Years ago, Google asserted itself as a mapping force by developing and commercializing consumer-accessible products such as Google Maps and Street View. Google is also a leader in CAV development and testing and the Google-affiliated CAV company Waymo is in a strong position to win the HD-mapping race. But competition is intensifying as a plethora of companies and start-ups like Tesla, DeepMap, HERE, NVIDIA, Uber, Lyft, and Civil Maps are joining the race.[4] Vehicle manufacturers such as Ford, General Motors, and Honda are also developing HD maps.

One consequence of having different HD maps for different vehicles and systems is poor interoperability. For instance, Ford's map may not integrate with Uber's map since they would be developed with different methods and techniques. Non-standardization of HD maps could lead to economic inefficiencies in the transportation sector.



Mapping Challenges

HD mapping introduces several challenges. The current process is slow and expensive, and a usable base map can take weeks or even months to develop.[5] CAVs must be equipped with an in-vehicle data storage system that must be physically removed from the vehicle and sent to a data center for processing. The data must then be analyzed by humans to ensure accuracy. Base maps must also be updated continually. A slight change in the environment—emergency road work, for example—can jeopardize the ability of a CAV to function.

A Potential Data Explosion

CAVs will generate a tremendous amount of data from the technology required for HD mapping. In a single hour of operation, a CAV can generate 4 terabytes (TB) of data—the equivalent of 1,500 CD-ROM discs—through its LiDAR, cameras, and other equipment.[6]

Significant data-processing and computing capacity is needed to analyze all the data and make safe driving decisions. CAVs have powerful on-board computers that consume significant energy and reduce the vehicle's fuel efficiency.[7] It is unclear how much energy will be required for external data transfer and processing (cloud and edge computing, for example).

The Uncertain Future of 5G

With 5G expected to appear in the coming years, expectations grow about its potential impact on the autonomous vehicle industry.[8] The combination of faster speeds, greater bandwidth, and the ability to utilize existing infrastructure means 5G could make CAV data collection and transmission more efficient.[9] To be truly revolutionary however, 5G will have to prove its reliability, speed, and cost. These aspects of 5G are uncertain, which opens the possibility for other vehicle-to-infrastructure communication means such as short range Wi-Fi that links a CAV with a traffic signal.

Regardless of which communication technologies predominate, the crucial features will be speed and reliability. Data transfer and processing for CAVs must be nearly instantaneous to ensure safe and secure travel.

About the Institute for Public Administration

The University of Delaware's Institute for Public Administration (IPA) addresses the policy, planning, and management needs of its partners through the integration of applied research, professional development, and the education of tomorrow's leaders.

180 Graham Hall | Newark, DE 19716-7380
302-831-8971 | ipa@udel.edu | www.ipa.udel.edu

[1] Seif & Hu, 2016
[2] ibid.
[3] Chellapilla, 2018
[4] Bergen, 2018
[5] Puttagunta, 2017
[6] Quain, 2018
[7] Gawron et al., 2018
[8] Krasniqi & Hajrizi, 2016
[9] Anadiotis, 2018
Image Sources: DeepMap and Google
For the full work cited visit: www.bidenschool.udel.edu/ipa/serving-delaware/transportation/cav