Deep Learning Will Make Truly Self-Driving Cars a Reality

Tomorrow’s truly driverless cars will be the safest vehicles on the road.

While many vehicles today use “driver assist” systems to automate some aspect of driving, cars today still require a human at the wheel, ready and able to take over. But the automotive industry is on track to create a truly autonomous car, using a much more robust set of sensor data and the ability to process that data fast. Artificial intelligence—deep learning and neural networks—can help:

- Use sensor data to “paint the scene”
- Identify signs and road rules
- Learn continuously to improve safety and performance

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Soon, Self-Driving Cars Will Be the Safest Vehicles on the Road

<table>
<thead>
<tr>
<th>Today</th>
<th>Tomorrow</th>
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<tr>
<td>Driver assistance systems automate or enhance driving functions like</td>
<td>Artificial intelligence and deep learning technologies will leverage advanced</td>
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<td>navigation, lane control, collision avoidance, and parking. But cars</td>
<td>sensor technology and real-time route mapping to make cars fully autonomous and</td>
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<td>today still require a human at the wheel, ready and able to take over.</td>
<td>safer than those driven by humans.</td>
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Why the Time is Right

The driverless car is increasingly in sight, as three prominent efforts demonstrate:

- Tesla Autopilot, a semi-autonomous driver assist feature, is currently built into most Tesla models
- Google’s self-driving car project has logged more than two million miles
- Uber is testing a fleet of driverless Volvos in Pittsburgh, home to its Advanced Technologies Center

At TCS, we’re working on advancements in deep learning technologies and neural networks that enable cars to process huge volumes of sensor data faster than ever before. Artificial intelligence will help truly autonomous cars:

- Use sensor data to “paint the scene”
- Identify signs and road rules, understand laws
- Continuously improve performance with self-learning intelligence

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How We’ll Make it Happen

The roadmap to an autonomous car future has multiple levels:

0 A human driver is in complete control of the vehicle.

1 Steering, braking, acceleration, parking, and other functions can be done automatically by the car, but the driver is always prepared to take control of the car.

2 At least one driver assistance system is fully automated (like cruise control and lane centering), but the driver is required to detect events or objects and respond in case the automated system fails to respond properly.

3 Drivers can completely shift critical functions to the vehicle when traffic and environmental conditions are good. The human driver isn’t required to monitor the vehicle at all times, as in Levels 0, 1, or 2.

4 The vehicle is fully autonomous and capable of performing all safety-critical driving functions and monitoring roadway conditions for an entire trip.

5 A fully autonomous vehicle that is proven to drive better than a human.

Deep learning in autonomous cars

Today, many cars are equipped with Automated Driver Assist Systems to handle routine tasks like blind spot monitoring, but it will take deep learning and massive computing power (including graphics processing units powering neural networks) to enable the fully autonomous car.

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Most cars on the road today are at Level 0, while many vehicles produced in the last few years have Level 1 or 2 autonomy. Higher levels will require artificial intelligence, and Levels 4 and 5 will be built using advanced deep learning technologies.

**Driving without a driver: Functional needs**

Autonomous driving demands a complex set of advanced functionalities for sensing what’s happening, mapping the route, and building driving policies to deal with predictable and unpredictable situations:

**Sensing.** Most autonomous vehicles use LiDAR (a surveying method that uses laser light to measure distance), radar (for detecting objects), and digital cameras to perceive and understand the driving environment. They examine and interpret:

- Static objects like road curbs, guard rails, and bike lanes
- Moving objects including other vehicles, pedestrians, and bicycles
- Semantic data such as lane markers, parking zones, and traffic signs and lights

Accurate sensing in self-driving cars

Multiple sensors enable autonomous vehicles to accurately detect both moving and static objects. These sensors detect and classify the scene around the entire periphery of the vehicle several times a second.

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**Mapping.** Autonomous vehicles use GPS data to get from point A to point B, but also need the ability to factor in real-time traffic conditions and driver preferences to make route mapping as effective as possible.

**Driving Policy.** An autonomous vehicle also needs policies for planning decisions and for successfully negotiating traffic. The autonomous system needs to know when to change lanes and when to slow down (or speed up). Human drivers create a set of “policies” tailored to their style of driving and the driving conditions. Driverless cars need a set of comprehensive policies as well to make safe, real-time decisions continuously and automatically.

Autonomous driving platforms must:

- Run continuously, in real-time
- Work reliably under difficult driving conditions (bad weather, heavy traffic) and at night
- Respond—with no margin for error—to unpredictable behavior by other vehicles and pedestrians and to conditions like road work

Each of these requirements represents multiple technological challenges. One of the most important requirements is one that is ideally suited to deep learning: the ability to understand the entire image (formed by multiple sensors) correctly and in real-time.

**Neural networks “paint” the scene**

Sensor hardware built into a Tesla (as of October 2016) includes eight surround cameras, 12 ultrasonic sensors, plus forward-facing radar. All of these sensors are gathering data several times a second.

If the sensors are the eyes of an autonomous vehicle, then a convolutional neural network (CNN) functions as the cerebral cortex, turning sensor data into a usable image of the road space. A CNN “paints” the scene around the car in motion. It reads the posted speed limit and follows it. It recognizes a stop sign and a green light. It identifies people, businesses, and even trash in the road.
Current manual software engineering and rules-based tools are simply not powerful enough to solve complex problems like sensor data interpretation and autonomous driving. There are too many variables, and too many unanticipated issues for a human to "prethink" and program all of them.

Most important for the future of autonomous driving, deep learning and neural networks enable continuous learning from new situations and new circumstances in a constantly changing driving environment.

About Tata Consultancy Services Ltd (TCS)

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