July 9, 2018

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What Makes Autonomous Vehicles Autonomous?

By Jay Campbell

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To properly understand the legal issues presented by the burgeoning field of autonomous vehicles, we must first understand how they work. In a word: magic.

Unlike most other devices which operate by a defined set of computer-encoded rules, it is impossible to determine how an autonomous vehicle makes a decision. It may as well be magic.

We cannot burrow into an autonomous vehicle's computer code and see a traditional "If-then" statement. There is no code that says, "If the car in front slows, then apply the brakes." That is because an autonomous vehicle decides what to do based on its learning, as opposed to the knowledge of a smart computer programmer.

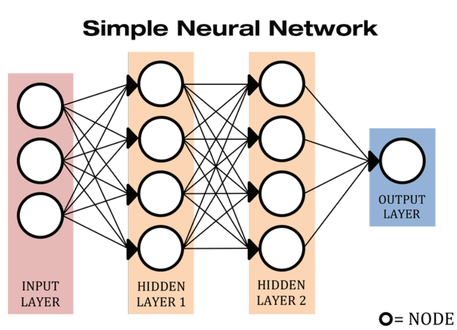
And its learning is embedded into a black box known as a neural network.

What is a neural network? First, a neural network is short for an artificial neural network. Artificial neural networks are computers that simulate a real neural network – a human brain. Like we did at age 16, neural networks learn to drive based on the same input: what they are taught.

They then encode that learning in multiple layers of highly interconnected nodes. Each of these nodes functions somewhat like a neuron in your brain. They sum up various inputs from other nodes, perform a simple function and send an output to all nodes in the next layer.

An artificial neural network is trained by showing it a driving situation and telling it the desired response. It then adjusts each node so the response of the neural network mimics the desired response.

Here is an example of a very simple neural network (below):



In this neural network, the inputs to the input layer nodes may be the brightness of three pixels of an image. The output layer node is the decision that the neural network has been trained to make based on the inputs. The hidden layers represent the training of the neural network.

Each node in the hidden layers is connected to each of the input nodes and to the output node. During the training process, the neural network assigns a weighting to each input of each node in the hidden layers. In operation, each node simply totals each input with its respective weighting.

If the sum exceeds a certain threshold, then that node exports a 1 or a 0 to each node in the next layer. Of course, the neural network in an autonomous vehicle would be more complex and receive many more inputs, but it functions in the same fashion.

If we wanted to "slice open" a trained neural network to attempt to see how our autonomous vehicle made a decision, we could

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determine little more than the weighting of each input at a certain node.

But an individual node means nothing. It is the interconnections and weightings of all the nodes in all of the layers, collectively, that determine the operation of the neural network. We would not see a meaningful decision made at any one node or layer.

The fact that a neural network is undefined and works as if by magic – without the constraints of programming a set of defined rules – is the key to its effectiveness. The real world is immensely complicated, unstructured and unpredictable. No set of rules could ever account for every situation the driver of a vehicle may encounter. But a neural network can infer the proper decision in an unprecedented situation because it has been trained in many similar situations.

As it encounters more situations, the artificial neural network learns to make correct inferences in situations that were not part of the training. In other words, the neural network learns to "act" like the driver of a car, only better – in part because it has more training.

Indeed, the world's most experienced drivers today are the neural networks employed by Waymo, Uber and Tesla. They have been trained with literally millions of miles of cumulative driving from thousands of cars – far more than any human driver – and thus potentially are better able to instantly recognize an atypical driving situation than a human driver can.

In an autonomous vehicle, the artificial neural network has many advantages over the human neural network it replaces. An artificial neural network can handle several inputs simultaneously, like those from ultrasound, radar, cameras, lidar and GPS.

An artificial neural network is much more responsive than the reaction time of the human brain. And most importantly, an artificial neural network is never distracted. It does not fumble through radio stations, drop a phone, respond to texts, get tired or drink a drop of alcohol.

Despite the advantages of artificial neural networks over our brains, autonomous vehicles likely will never be perfect. Currently, they are far from it, but even today they are generally safer than a human driver.

Unfortunately, autonomous vehicles are judged by a wholly different (and largely unfair) standard than humans. They are expected to be perfect because, after all, they are computers.

Thus each accident in an autonomous vehicle is highly publicized regardless of its circumstances. Hopefully, this unrealistic standard will not slow the introduction of autonomous vehicles into our world.

Autonomous vehicles soon will change the way we look at our laws, regulations and our court system. Down the road, they will even change the way cities are planned. Farther down the road, human driving will be viewed as dangerous and may not even be permitted on public roads.

Jay Campbell is a partner and department chair of the Intellectual Property Department at Tucker Ellis LLP. For more information on the legal ramifications of autonomous vehicles, please see "Defensive Driving for Manufacturers in the Autonomous Revolution" by Tucker Ellis attorneys Jonathan Feczko and Zachary Adams. Jay can be reached at jay.campbell@tuckerellis.com.

The article originally appeared on WardsAuto:
http://www.wardsauto.com/industry-voices/what-makes-autonomous-vehicles-autonomous