Lower-cost lidar is key to self-driving future

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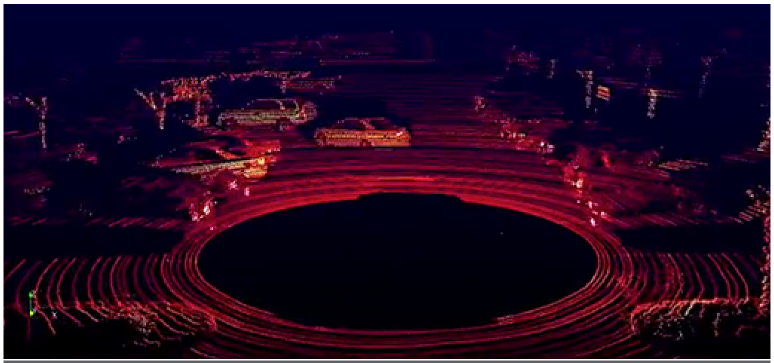

This is a still shot from a stream of images using Velodyne's HDL-64E lidar mounted on a Lexus vehicle. In the ride through a shopping center parking lot, you can easily see people crossing the street and a car pulling out from a parking space.

Advances in automotive technology over the past century can be marked by distinct innovations. The list includes production firsts for the electric self-starter (1914), automatic transmission (1940), and anti-lock braking (1971). Next up? First mass-produced car with lidar (to be determined).

Laser sensors, or lidar, could be dismissed as a better light-based form of radar. But that underestimates the radical impact of quickly obtaining detailed distance measurements from a vertical array of spinning lasers sending and receiving a pulse of light more than a million times a second, to form a complete picture of a vehicle's surroundings at a frame rate that matches video's 30 times a second.

Unlike camera imagery, which has an abundance of information, but requires pattern-recognizing software to bring meaning to all those pixels, lidar systems deliver a potent stream of point-clouds that is easily digestible by a car's computer network. These rapid-fire accurate 3D snapshots of every object surrounding the vehicle can occur day or night, rain or shine.

Lidar would turn cars into machines keenly aware of their surroundings—with the ability to discern details to the centimeter from 100 meters away. How the stream of data is utilized by automotive engineers is a proprietary matter. "Almost everybody on my team is a programmer," said Dr. Ralf Guido Herrtwich, Director of Driver Assistance at Daimler, standing in front of the Mercedes-Benz F 015 autonomous concept vehicle at the 2015 Computer Electronics Show in Las Vegas.

But wait a second. The Mercedes F 015 doesn't use lidar—but relies instead on a suite of video, radar, and ultrasonic sensors. "We don't use lidar at this point, but that doesn't mean that we won't in the future," he said.

Herrtwich explained that, at this stage, the ability to obtain the necessary amount of data about a car's surroundings for robust levels of assisted driving is a matter of performance and cost. "It's a question of how many sensors you need, and how few you can manage with," he said. For its showy autonomous car, Daimler tried to manage without lidar, while BMW's self-driving i3 electric concept car, also at CES 2015, parked itself relying exclusively on six lidar sensors.

More than a year ago, Tetsuya Iijima, General Manager of Intelligent Transportation Systems Engineering at Nissan, said: "Other companies still have not decided to use a laser scanner, but we have come to the conclusion that laser scanners are required [for self-driving]." This occurred while riding in a Nissan Leaf that can self-pilot on highways up to 80 mph (129 km/h).

The criticality of lidar notwithstanding, there is universal agreement that the technology is currently too expensive for wide deployment. The most recognized lidar machine—the rooftop 64-beam Velodyne HDL-64E used on Google's autonomous car and for mapping streets by Nokia's Here division and Microsoft Bing—is sold for about $80,000 each.

"Three-hundred-sixty degrees on top of the car is obviously the best," said Dr. Wolfgang Juchmann, Velodyne's Director of Sales and Marketing. "It's like a castle built on a mountain," he said. "The king can see who's coming from any direction."

The high cost, and the aesthetic desire to hide the lidar in the body of the car, led Velodyne to develop smaller units with fewer than 64 beams. The company now offers a lidar with 32 beams at about $40,000, and its "puck" with 16 beams for $8000. The reduction in cost represents a price drop of a factor of 10 in just seven years since the introduction of the 64-beam lidar in 2007.

"The puck costs $8000 today, but car companies want it for $100 to $200," Juchmann said during a recent visit to the company's Morgan Hill, CA, headquarters and plant, where about 60 employees work. He believes that, in the coming years, the industry will see the same downward cost curves in lidar that occurred with radar in the past few years.

"If you look at 10 or so years ago, radar sensors were $10,000. I'm sure the first people said, 'radar? Putting six of those on every car is completely unbelievable,'" said Juchmann. "But everybody saw the benefits. The market got there, and the price came down." He said there is nothing intrinsically cost-prohibitive, in terms of components, in today's lidar—except the inordinate amount of manual labor that goes into building the scanners.

Today, Velodyne, which has sold a thousand or so of its lidars, is considered the dominant player. With high-volume production, in the millions of units, the cost will come way down. But that requires market demand that is practically non-existent today.

Osram Opto Semiconductors, a tier-two supplier that supplies lasers and photodiodes to Phantom Intelligence (a tier-one firm formerly called Aerostar), in January announced its plans to offer a lidar aimed at $150 to $200 a unit. Again, this will require high-volume production—which Rajeev Thakur, Product Marketing Manager in Osram's infrared business unit, believes will occur as safety agencies in Europe and North America incentivize automakers to implement automated emergency braking systems across product lines.

But consider that Osram's target is not the high-resolution picture of a vehicle's surrounding, but the ability, when paired with a camera, to recognize pedestrians about 1 m (3.3 ft) apart, at a range of 30 m (98 ft). Its specific purpose is automated braking. Thakur believes the combination of performance (through innovative signal processing) and low cost will be an improvement over similar systems that use a single beam, split into multiple channels—but that can only detect cars (not pedestrians) at about 12 m (39 ft) rather than pedestrians at the longer distance.

The difference between Velodyne's $80,000 64-beam lidar, and a $150 single-beam unit, underscores an important point: not all lidar is created equal. There are three primary levels of automotive applications—one for mapping (like what Google and Nokia do); another for limited driver-assistance functions; and the more forward-looking fully self-driving vehicles.

The Holy Grail is a small set of lidars scanning fully around the vehicle, from the foot of a pedestrian 1 m away to vehicles 100 m (328 m) down the road—at the same cost as today's radar. Cameras or radar will likely provide redundancy.

The feasibility of that proposition is beyond question for Louay Eldada, Chief Executive of Quanergy, a Silicon Valley startup. He is aiming to achieve that ambitious goal by using a solid-state strategy—an evolution of packaging and manufacturing for mass production that Velodyne also hopes to achieve. Valeo, Bosch, and other Tier-1 auto suppliers are also working on lidar.

Eldada's big promises for $100 lidar by 2018 helped Quanergy earn $30 million in Series A venture funding (announced in December). The company obtained Mercedes, Renault-Nissan, and Hyundai as its first automotive customers. "I'm not aware of anyone who disagrees that if lidar is at the right price and performance level, it is the ideal sensor," said Eldada.

Unlike radar that can't make the distinction between a bridge and a stalled vehicle under the bridge, lidar can provide the precise location of the stalled vehicle under the bridge, according to Eldada. "It can determine that the car is halfway in the lane and halfway on the shoulder, and that it's a Volkswagen," he said. That's the level of rock-solid reliable 3D data needed to fully entrust a vehicle to drive without a driver.

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