INNOVATIVE 1550 NANOMETER WAVELENGTH LIDAR SYSTEM SETTING THE STANDARD FOR SENSOR TECHNOLOGY IN SELF DRIVING CARS

Jeff Buscher, Mike Marynchak, Theodore Storl-Desmond

PITT | SWANSON ENGINEERING

ABSTRACT

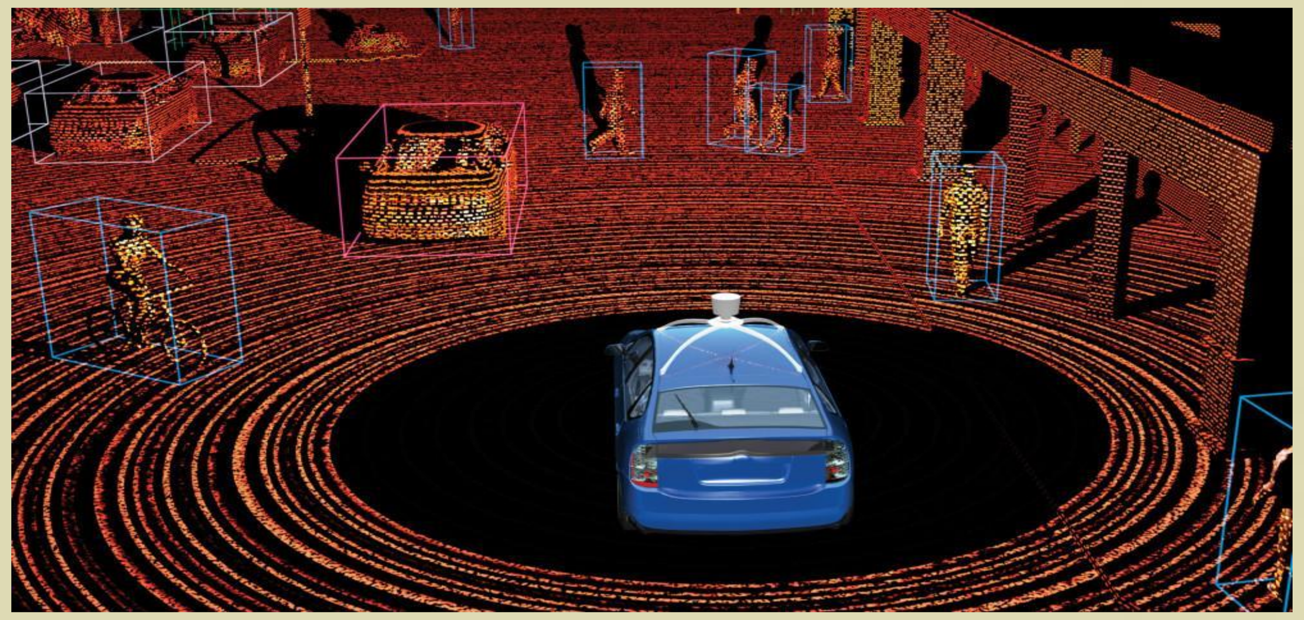
The ability to be spatially aware is a pressing concern in the performance and safety of self-driving cars. With current LiDAR technologies, a car traveling at 70mph can only detect obstructions up to 35 meters away. This offers less than one second of reaction time. However, there is a new sensor technology that was recently developed, a 1550 nanometer wavelength LiDAR system. This innovation, developed by the company Luminar, solves many of the cost and safety concerns that have arisen with the emergence of automated vehicles. This LiDAR system is designed to fire pulses from semiconductor diode lasers emitted at 1550 nanometers and then record the light reflected from the car's surroundings. The data collected is then used to map the surroundings of the car using a point cloud map. The use of a 1550nm wavelength allows a detectability range of 200 meters and reaction time of seven seconds.

Other LiDAR systems only produce wavelengths of 905nm, mainly because any greater wavelength could cause damage to a bystander's eyes. However, essentially no light at wavelengths greater than 1400nm reach the retina, meaning the 1550nm LiDAR can operate at a much higher power without compromising the safety of the public. The 1550nm LiDAR system's photon efficiency also means that this is one of the least expensive sensor technologies on the market. We will analyze the innovative LiDAR system and describe its potential impact on the automated vehicle industry.

INNOVATE

EXPLAINING THE TECHNOLOGY; WHAT IS LiDAR?

LiDAR, short for Light Detection and Ranging, is a sensing system used to measure the exact distance from an object. There are three main components to a basic LiDAR system: the scanner, lasers, and GPS receiver. The principle mechanism is simple – the lasers fire a light wave pulse at an object, the scanner then receives the reflection from the object and records the time that has elapsed, and lastly the GPS receiver uses the recorded time and calculates the distance from the object and maps the surroundings.



POINT CLOUD MAP

THE 1550 NANOMETER WAVELENGTH LIDAR SYSTEM

The 1550 nanometer wavelength LiDAR system operates with the same basic functions. The semiconductor diode laser first fires a 1550 nanometer wavelength pulse at an obstruction. The pulses of light collide with the object, and then reflect to phased-array antennas that act as the scanners. The antennas measure the time elapsed from the time of firing to the time of receiving, and then record this data. The GPS receiver used is a specialized LnGaAs receiver developed by Luminar specifically for this system. The LnGaAs receiver uploads the data from the phased-array antennas, and then calculates the distance from the object using the following, otherwise incomplete distance formula.

Distance = (Speed of Light * Time that has elapsed) / 2

Lastly, the LnGaAs receiver constructs a 3-D point cloud map using the calculated distances. The LiDAR system's operations have now completed one cycle. The point cloud map is sent to a computer mainframe that decides whether to accelerate or decelerate the car. The LiDAR system then repeats this process, creating and sending thousands of point cloud maps per second.

IMPLEMENT

IMPLEMENTING THE 1550 nm LiDAR INTO TOYOTA'S PLATFORM 2.1 PROJECT

In April of 2017, Luminar announced that they would be working with Toyota Motors in their autonomous vehicle project, Platform 2.1. The 1550 nanometer wavelength LiDAR system would be used as the sensing technology for the vehicle. Mounted on the top of the Lexus LS 600hL hybrid, the system has a full 360-degree view of the car's surroundings. The system consists of multiple LiDAR, all pointing out in different directions to fully map out the area. In each LiDAR there is one laser, one antenna, and one receiver. Toyota plans to be done with the project and selling these new cars by 2020.

TOYOTA PLATFORM 2.1

THE BEST PERFORMING LiDAR SYSTEM YET

When past LiDAR systems are compared to the 1550 nanometer LiDAR, the differences are subtle and meaningful. The 1550 nanometer wavelength is of a much more intense magnitude, meaning the detectability range improves from 35 meters to 200 meters. At seventy miles per hour, this offers a jump in reaction time from seven full seconds to less than a second. The more intense wavelength also allows the point cloud map to contain a much higher resolution of up to fifty times the previous. A higher resolution offers color schemes to be clearer and more visible, allowing the car to make better judgements on whether to accelerate or decelerate.

Previous LiDAR systems also implemented an opto-mechanical scanner, instead of using a phased array antenna. Opto-mechanical scanners are heavy, expensive, and overall a very inefficient way of catching reflections and recording time data. Phased array antennas, also used in cell phones, offer an affordable and convenient alternative. These antennas possess slotted radiating elements that provide constructive and destructive interference, thus directing the fired pulse directly back to the car. These antennas require basically no hardware, thus drastically reducing the overall size and power consumption.

SUSTAIN

COST EFFECTIVENESS AND ACCESSIBILITY

Vehicles with self-driving features and techniques today can cost anywhere from $70,000-$150,000. For these cars to be successful and have a lasting effect on society, the price must go down. There are several key factors that contribute to the overall cost effectiveness of the 1550 nm LiDAR system, however the LnGaAs receiver is the main factor contributing to this.

Luminar designed the receiver to be paired with an application-specific integrated circuit (ASIC) design, and this allows the time data to be uploaded from the antenna at an extremely rapid pace. By eliminating the need for a heavy computer operating system, the ASIC design allows the system to operate at one third of its previous size, weight, and power. **According to an official statement by Luminar, "The move brings the cost of our LiDAR receiver from what originally would have been tens of thousands to just three dollars" [3].** A cut in production costs of this magnitude would allow the LiDAR system to be readily available to all automated vehicle manufacturers, not just Toyota. This would mark a major shift in the economy of self-driving cars.

SAFETY

Past regulations on LiDAR systems that had direct contact with the public stated that pulses fired could not have wavelengths in the range of 905 to 1400 nanometers. Any light entering the lens at this wavelength will cause severe damage to the retina, thus causing hazardous conditions for the public. This explains why LiDAR systems on past automated vehicle models only contained wavelengths of 905 nanometers. It would require a tremendous amount of power to fire pulses at a wavelength of 1400 nanometers using the commonly used gallium arsenide as a conductor. Luminar found a way around this with the switch to indium phosphide. Indium phosphide allows photons to travel more easily through the conductors, thus requiring only one third of the energy previously used with gallium arsenide. A 1550 nanometer wavelength never reaches the retina, because the lens becomes less transparent at 1400 nanometers due to water absorption.

This is a breakthrough innovation for LiDAR systems in automated vehicles that offers a plethora of sustainability benefits. The 1550 nanometer wavelength offers a better overall performance, while not compromising the health of an innocent bystander's eyes.

IMPROVEMENTS

The addition of global communication between autonomous vehicles would create a class of cars that learned from each other's mistakes. This would make possible the rerouting of traffic automatically, which would drastically reduce congestion and confusion on the roadways. Vehicles could alert each other in any type of circumstance; scheduled road maintenance, dangerous road conditions, or even accidents blocking a roadway.