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LIDAR BASED AUTONOMOUS ROBOT

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Abstract - *Lidar imaging systems are one of the calescent topics in optotronics industry. The yearn to sense the surroundings of every autonomous vehicle has pushed forward a race dedicated to deciding the final solution to be implemented using various techniques. The famish of technology has led to the use of the new technology called Lidar. It enables a self-driving car or any robot, to observe the world with exiguous special super powers. The reader is provided with a detailed bibliography containing both relevant books and state-of-the-art papers for further progress in the subject.*

Keywords

LIDAR, Automatic Car.

1. Introduction:

Lidar based car can also be called as robotic cars or autonomous car. It is used for human or object transport by sensing the surroundings, without causing any harm to human beings. Combination of advanced control systems interpret sensory information to identify required appropriate navigation paths, as well as obstacles. Long distance object carriage or trucking can be preferred as the next implementation of this project design.

Simply put, the base of this research can be defined as follows:

1. Robots that can be run without human help.
2. The creation of LIDAR based robots and cars.
3. Working on lidar instead of Radar.
4. With the increase in technology, Lidar can be preferred for most of the projects.

2. History

Experiments on automated driving systems (ADS) have been conducted since at least the 1920s.The original experimental trials began in the 1950s.LIDAR was born in the 1960s, just after the advent of the laser. Although the Lidar based technology or robotics are new to the world and as much effective. Lidar has been a well-known measurement technique since the past century, with established publications and a dense bibliography corpus. Lidar stands on a simple working principle based on counting the time between events in magnitudes carried out by light backscattered energy from a pulsed beam.

3. Autonomous Vehicle

The meaning of "Autonomous" is self governing. A motor vehicle that is designed and constructed in order to move autonomously or on its own for certain periods of time without continuous driver supervision but in respect of which driver intervention is still expected or required.

4. Lidar Based

In this project Lidar is used as the primary sensor. Excluding aside machine learning, Internet of Things and the cloud, namely LIDAR (Light Detection and Ranging) can lead the way in the development of advanced autonomous vehicles.

4.1 Super Powers

LIDAR enables a any robot to sense the world and control the output of the robot.

4.1.1 Continuous 360 degrees of visibility

Lidar acts as human eyes that are allowed to see in all directions all of the time.

4.1.2 Insanely accurate depth information

Instead of guessing the location, Lidar could always predict the precise distance (to an accuracy of _2cm) of objects in relation to the sensor.

5. How it works?

Simply put a LIDAR sensor continuously fires off beams of laser light, and then measures how long it takes for the light to return to the sensor. The rapid laser signals, sometimes can vary up to 150,000 pulses per second. It can also detect the exact size of the object. LIDAR is commonly used to make high-resolution maps.

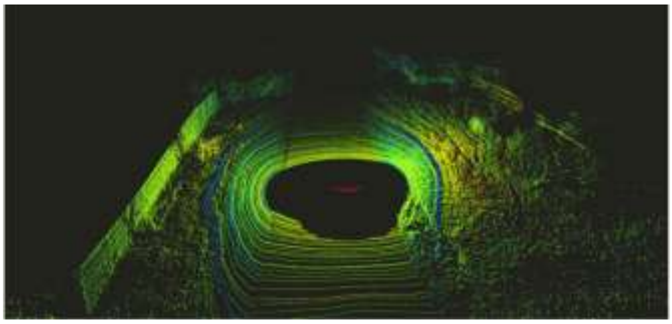

Figure 1: LIDAR image output after placing itin a car.

6. Principles of LIDAR

Imaging

The primary principle used in LIDAR imaging is time-of-flight (TOF).Here, depth is measured by counting the number of time delays in circumstances in light emitted from a source. There are three approaches to this base:

6.1 Pulsed Approach

Lidar allows the creation of a 3D point cloud of a part of the environment of the unit. Hence, the range or distance to the destination object is measured based on the round-trip delay of light waves that travel to the destination object. This may be achieved by modulating the intensity, phase, and frequency of the transmitted signal and measuring the time required for that modulation pattern to appear back at the receiver. Here the range is determined by multiplying the speed of light in a medium, by the time a light pulse takes to travel the distance to the target. Since the speed of light is a given constant while we stay within the same optical medium, the distance to the object is directly proportional to the traveled time. The measured time is obviously representative of twice the distance to the object, as light travels to the target forth and back, and, therefore, must be halved to give the actual range value to the target.

$$R = \frac{c}{2} t_{oF},$$

Figure 2: Pulsed Approach, where R is the range to the target, c is the speed of light (c=3_108 m/s) in free space and toF is the time it takes for the pulse of energy to travel from its emitter to the observed object and then back to the receiver.

6.2 Continuous Wave Amplitude Modulated (AMCW) Approach

A second approach is based on amplitude modulation of a continuous wave (AMCW), so the phase of the emitted and scattered detected waves are compared, allowing us to measure distance. In this pulsed case, as the emission is continuous, which makes the amplitude of the received signal to remain below the eye-safe limit at all times. The AMCW approach consists of using the intensity modulation of endless lightwave rather than the optical maser pulses mentioned before. This principle is known as CW modulation, phase-measurement, or amplitude modulated continuous-wave (AMCW). It uses the phase-shift evoked in Associate in Nursing intensity-modulated periodic signal in its roundtrip to the target so as to get the vary price. The optical power is modulated with a relentless frequency fM, generally of some tenths of Mc, therefore the emitted beam could be a curved or sq. wave of frequency fM. When reflection from the target, a detector collects the received lightweight signal. activity of the gap R is deduced from the part shift occurring between the mirrored and therefore the emitted signal.

$$\Delta\Phi = k_M d = \frac{2\pi f_M}{c} 2R \Rightarrow R = \frac{c}{2}\frac{\Delta\Phi}{2\pi f_M},$$

Figure 3: Continuous Wave Amplitude Modulated

(AMCW) Approach, where R and c are, again, the range to the target and the speed of light in free space; kM is the wavenumber associated to the modulation frequency, d is the total distance travelled and fM is the modulation frequency of the amplitude of the signal.

6.3 Continuous Wave Frequency

Modulated (FMCW) Approach

Inexorably, a third approach is defined by frequency-modulated continuous-wave (FMCW) techniques, enabled by direct modulation and demodulation of the signals in the frequency domain, allowing detection by a coherent superposition of the emitted and detected wave. For a static target, the jitter between the collected light and the reference causes a constant frequency difference fr, from the mixed beams. This concedes the instantaneous frequency that vary under a linear law, fr is directly proportional to tOF and hence proportional to the target range also.

$$f_r = slope \cdot \Delta\tau = \frac{B}{T} t_{oF} = \frac{B}{T}\frac{2R}{c} \Rightarrow R = f_r \frac{cT}{2B},$$

Figure 4: Continuous Wave Frequency Modulated

(FMCW) Approach, where B is the bandwidth of the frequency sweep, T denotes the period of the ramp, and equals the total travelled time toF.

7. Combining of LIDAR and Robots

The main application of LIDAR involves the generation of huge 3-dimensional maps, which can be further used to navigate the car or robot appropriately. The mapping and navigation of an environment, using LIDAR can be further used to know ahead of time the bounds of a lane, or that there is a stop sign or traffic light 500m ahead. This kind of predictability is exactly what a technology like automatic cars require.

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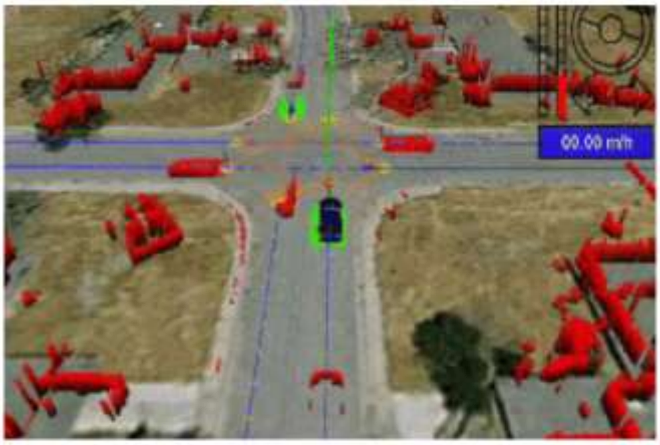

Figure 5: LIDAR IMAGING

8. Experimental Model

The output of LIDAR is a 3D image of depth and distance of objects present between the source and the destination. Today, all the robots are evolved around coding. Thus, the robotic prototype will be coded such that, when the LIDAR senses any obstacle it will be coded to stop and move in the direction without obstacle. Today, the technology is so advanced that the direction of movement of the pedestrian can also be detected, so that the robot can acknowledge if it has to wait for the pedestrian to cross or to move along the direction of the pedestrian. The combination of amazing navigation, predictability and high-resolution object tracking has meant that LIDAR is the key sensor in automatic cars

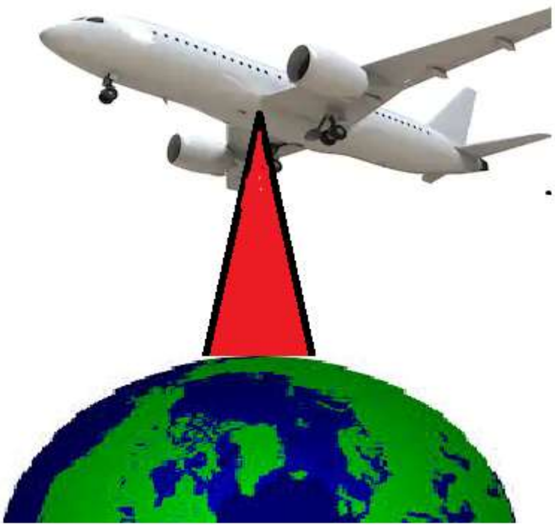

Figure 6: LIDAR technology used in aeroplanes to view 3-dimensional images of the earth

8.1 Vehicles

LIDAR has been used to create Adaptive Cruise Control *(ACC) systems for automobiles. Systems such as those by Siemens and Hella use a LIDAR device mounted in the front of the vehicle to monitor the distance between the vehicle and any vehicle in front of it. Often, the lasers are placed onto the bumper. In the event that the vehicle in front slows down or is too close, the ACC applies the brakes to slow or stop the vehicle. When the road ahead is clear, the ACC allows the vehicle to speed up to speed preset by the driver. LIDAR is also being incorporated into a development called Pre-Scan where a laser scans the road surface several hundred times a second. This information is then fed to the cars on-board computer and processed in a fraction of a second which adjusts the individual suspension at each wheel. The aim of this technology is to achieve the smoothest and safest ride possible by preempting the wheel and tyres reactions to imperfections in the road surface or warn about obstacles and pot holes.

8.2 The Future Of LIDAR

The 2 advantages with a real focus of decrease in cost and increase in range Cost Decrease: The lowest cost system is actually achieved using surround view sensors like LIDAR because rotation reuses the lens, lasers and detectors across the field of view, versus using additional sensors each containing individual lenses, lasers and detectors. This reuse is both the most economical, as well as the most powerful, as it reduces the error associated with merging different points of view in real-time — something that really counts when the vehicle is moving at speed. Resolution and Range Increase: The huge jump in the number of applications for LIDAR has brought with it a flood of talented founders and teams starting companies in the space.

Higher resolution output and increased tracking range (200m in some cases) will provide better object recognition and tracking NOTE: The statement on resolution is mentioned by Velodyne in an interview https://www.youtube.com/watch?v=tZ8WbSNsNaU.

9. Pending Issues

While the deployment of lidar imaging systems for autonomous vehicles seems unstoppable, and major automotive manufacturers are starting to select providers for data collection units and introducing them in commercial vehicles, the final technology implementation is still uncertain in several relevant details. The selection of the most appropriate technology and scanning strategy among the different competing alternatives in terms of cost and functionality still needs in depth work, and becomes one of the most visible examples of the current uncertainty in the industry.

However, beyond the final technology of choice, there are still several relevant issues that need to be worked out for the full implementation of lidar imaging systems in commercial vehicles. Here we present a list of pending issues to be solved, in particular considering automotive.

A complete list of all potential pending issues is impossible to compile, but we propose what seems to us some very relevant problems for lidar deployment, most of them general to all types of measurement principles and implementations.

10. Why not RADAR?

Radar (radio direction and ranging), very similar to SONAR, that was associated the technology developed throughout an notorious warfare (WorldWar 2). Rather than using light or sound waves, it instead utilizes radio waves to live distance. Today's world has a tendency to build use of a great deal of measuring instrument (using metropolis sensors) on Homer, and it's a triedand- tested technique that may accurately discover and track objects as way as 200m away. The RADAR system works in much the same

way as the LiDAR, having an unique feature being that it uses radio waves instead of laser or light waves. In the RADAR instrument, the size of the antenna doubles up as a radar receiver as well as a transmitter. Nonetheless, radio waves have scant absorption compared to the light waves when contacting objects. Thus, they can work over a relatively long distance.

The most well-known use of RADAR technology is for military purposes. RADARS are often equipped in case of Airplanes and battleships to measure altitude. They can also be used to detect other transport devices and objects in the vicinity.

11. Adverse Circumstances

Every coin has two sides, this technology also comes with a few distinct disadvantages. The LIDAR system can readily detect objects located in the range of 30 meters to 200 meters. But, when it comes to identifying objects in the vicinity, the system is a big letdown. It works well in all light conditions, but the performance starts to dwindle in the snow, fog, rain, and dusty weather conditions. It also provides a poor optical recognition. That's why, self-driving car manufacturers such as Google often use LIDAR along with secondary sensors such as cameras and ultrasonic sensors. The RADAR system, on the other hand, is relatively less expensive. Cost is one of the rea sons why Tesla has chosen this technology over LiDAR. It also works equally well in all weather conditions such as fog, rain, and snow, and dust.

However, it is less angularly accurate than Li-DAR as it loses the sight of the target vehicle on curves. It may get confused if multiple objects are placed very close to each other. For example, it may consider two small cars in the vicinity as one large vehicle and send wrong proximity signal.

Unlike the LiDAR system, RADAR can determine relative traffic speed or the velocity of a moving object accurately using the Doppler frequency shift.

12. Conclusions

Lidar imaging systems are a novel type of sensor enabling complete 3D perception of the environment, and not just the conventional 2D projection obtained from a camera. Within this paper, we have tried to describe in detail the different configurations of lidar imaging systems available for autonomous vehicles. Despite the discussion becoming biased towards cars because of the rising activity in the field, similar considerations to the ones presented here may be stated for maritime or aerial vehicles. We reviewed and compared the three main working principles underlying all lidar measurements, to then overview the main strategies involved in imaging, grouped into scanners (mechanical, MEMS and OPAs) and detector arrays (flash and TOF approaches). Afterwards, we tried to overview the principal considerations related to sources and photo-detectors used in lidar imaging systems units at present, showing its advantages and disadvantages. We finished with some of the most relevant pending issues which lidar imaging systems in vehicles need to overcome to become the reality everyone is expecting.

13. Acknowledgements

When a LIDAR is mounted on a mobile platform like satellites, airplanes or vehicles, it's necessary to see absolutely the position and also the orientation of the detector to retain useable knowledge. world Positioning Systems give correct geographical info concerning the position of the detector associate degreed an Inertia activity Unit (IMU) records the precise orientation of the detector at that location. These 2 devices give the tactic for translating detector knowledge into static points to be used in a very kind of systems.

14. Appendix

Figure 7: Simple representation of LIDAR used in cars

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