Target Detection in Low Visibility Condition and Artificial Lighting Using a Laser Sensor

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Abstract: – The Lidar (LIght Detection And Ranging) sensor produced by Siemens uses five infrared beams to detect targets up to a distance of approximately 250 m. The paper describes the tests witch has been develop using our new software in order to visualize the detected targets. We used our program in the detection of different types of targets, placed at different distances and in different combinations. An important goal was to see how various meteorological conditions affect or do not affect the target detection. Other types of experiments were focused on low visibility conditions, different lighting conditions (natural, artificial, day, night).

Key-Words: - sensor, Lidar, target, programming, test, experiments.

1 Introduction

The United States National Highway Traffic Safety Administration (NHTSA) studies have contributed to the growing importance of driver assistance systems because they have demonstrated the use of vehicle dynamics control systems can significantly reduce the number of car accidents not involving other participants in road traffic. The growing demand for comfort and the increasing average age of motorists also are factors behind the development of driver assistance systems. The aid [1] of electronic assistants make it possible to compensate for minor physical handicaps, so disabled or elderly persons may enjoy individual mobility. Moreover, the system can help assist any driver who can make the odd mistake now and again.

The active cruise control (ACC) is one of those systems that is being developed mainly for highway driving [2].Obstacle avoidance is one of the most critical technologies needed for autonomous vehicles, due to the safety reasons, both for occupants and other road users (like vehicles, pedestrians, etc...). Research is under way to find solutions to this critical issue, based on range data [3], [4], most often fused with visual data [5]. The innovative Lidar based Adaptive Cruise Control detects the car in front, determines its speed and keeps the right distance to it with braking or engine operations and relieves the driver if concentration slows down. The research on the field of autonomous vehicles has been mainly oriented in lane detection and obstacle detection, mostly using either LRF or vision systems. In [6] and [[7] the object detection is similarly performed using a laser scanner. Sparbert and co-authors [6] used for the lane detection the same laserscanner as for obstacle detection, taking the features of road margins into account, while in [7] the road is detected and classified through the white lane markers, using a vision system.

The main objective of this paper is to present the conclusions of our tests using our solution for computing and showing results of target detection using a 3D sensor. The sensor used is a Lidar range finder lidar. It is used to measure the distance from the lidar instrument to different types of targets. This paper analyzes the limitations and disadvantages of the lidar .

2 General characteristics of the lidar sensors

In general there are two types of lidar systems: micropulse lidar systems and high [8] energy systems. Micropulse systems have developed as a result of the ever increasing amount of computer power available combined with advances in laser technology. They use considerably less energy in the laser, typically on the order of one watt, and are often "eye-safe" meaning they can be used without safety precautions. High-power systems are common in atmospheric research, where they are widely used for measuring many atmospheric parameters: the height, layering and densities of clouds, cloud particle properties (extinction coefficient, backscatter coefficient, depolarization), temperature, pressure, wind, humidity, trace gas concentration (ozone, methane, nitrous oxide, etc.).

There are several major components to a lidar system:

1. Laser — 600-800 nm lasers are most common for non-scientific applications. They are inexpensive and can be found with sufficient power but they are not eye-safe. Eye-safety is often a requirement for military applications. 1550 nm lasers are eye-safe but not common and are difficult to get with good power output. Airborne lidars generally use 1064 nm lasers, while some bathymetric systems use 532 nm lasers in order to penetrate water. Laser settings include the laser repetition rate (which controls the data collection speed) and pulse length (which sets the range resolution).
2. Scanner and optics — How fast images can be developed is also affected by the speed at which it can be scanned into the system. There are several options to scan the azimuth and elevation, including dual oscillating plane mirrors, a combination with a polygon mirror, a dual axis scanner. Optic choices affect the angular resolution and range that can be detected. A whole mirror or a beam splitter are options to collect a return signal.
3. Receiver and receiver electronics — Receivers are made out of several materials. Two common ones are Si and InGaAs. They are made in either PIN diode or Avalanche photodiode configurations. The sensitivity of the receiver is another parameter that has to be balanced in a LIDAR design.
4. Position and navigation systems — Lidar sensors that are mounted on mobile platforms such as airplanes or satellites require instrumentation to determine the absolute position and orientation of the sensor. Such devices generally include a Global Positioning System receiver and an Inertial Measurement Unit (IMU).

The LIDAR sensor produced Siemens AG consists of infrared emitters [9],[10],[11], a photodiode as a receiver for the bundled invisible infrared light and the evaluation electronics. The sensor continuously measures the propagation time of the transmitted infrared rays. The time the light needs to travel from the sensor to the vehicle ahead and back again is measured. Based on these propagation times, the electronics calculate the distance to the next vehicle ahead. The electronic image differentiates between various objects, which means it can distinguish cars, trucks or motorcycles from stationary objects.

Laser [12] radar depends on knowing the speed of light, approximately 0.3 meters per nanosecond. Using that constant, we can calculate how far a returning light photon has traveled to and from an object [13]:

$$D = \frac{c \cdot tof}{2} \qquad (1)$$

where D = distance; c = speed of light (~300km/s); tof = time of flight

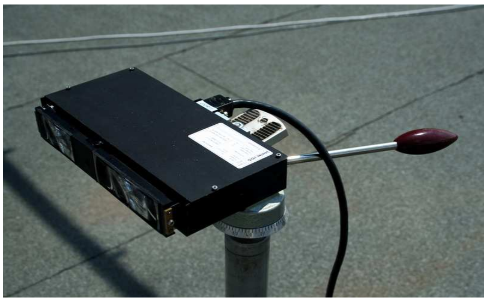

Fig. 1 The Lidar sensor

In table 1 are summarized the lidar sensor characteristics.

Table 1 Lidar sensor performance and technical data

Sensor performance	Sensor highlights
• 5 infrared laser beams (one main plus 2 x 2 to cover cut-ins) • locate edges of the vehicle • Visibility measurement • Car detection up to 250 m • Distance control range: typical 100m -180m	• Enhanced performance, low cost - compared to radar sensors • Sweep function: reliable information and lane prediction • Optimized vehicle integration concept: Mounting behind the windshield
Technical data	
• Weight: < 500g • Size: 220x110x30 mm • Temperature range: -40°C to + 85°C • Cycle time: 40ms • Horizontal opening angle: 30° (15° ± 7.5°) • Vertical opening angle: 6° total	• Distance accuracy: ± 10 cm • Speed accuracy: ± 0.1 m/s • Angular accuracy: ± 0,1° • Microscanning-zone: 0.5 ° • Microscanning-frequency: 2 Hz

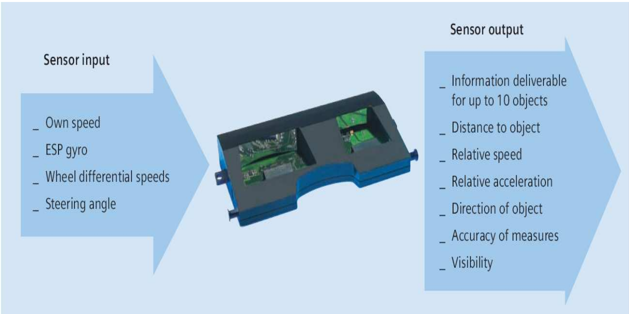

Fig. 2 The Lidar sensor inputs and outputs

3 Tests regarding the influence of meteorological conditions on target detection

In our previous work [14] a new software was developed in order to visualize the detected targets, to analyze the data and create graphical tridimensional representation of the targets. Tests were conducted in order to understand the influence of different meteorological conditions and also the influence of the artificial light on target detection on the highway.

The following tests were conducted and their results are shown in the next fgures.

a) White metal board at 18m from Lidar. Conditions: fog

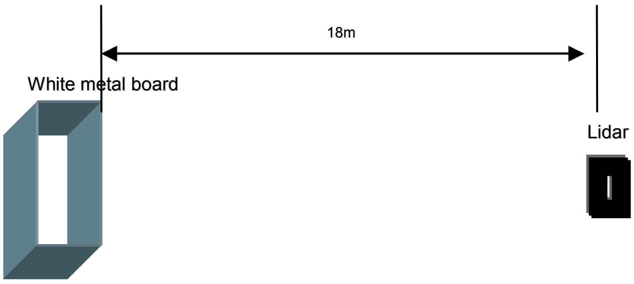

Fig 3. White metal board at 18m from Lidar and fog

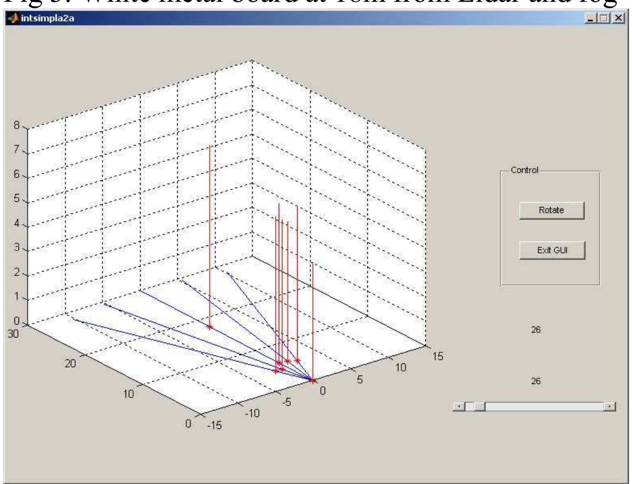

Fig 4. Results: White metal board at 18m from Lidar and fog

b) White metal board at 18m from Lidar. Conditions: fog and dark (experiment was conducted during night time)

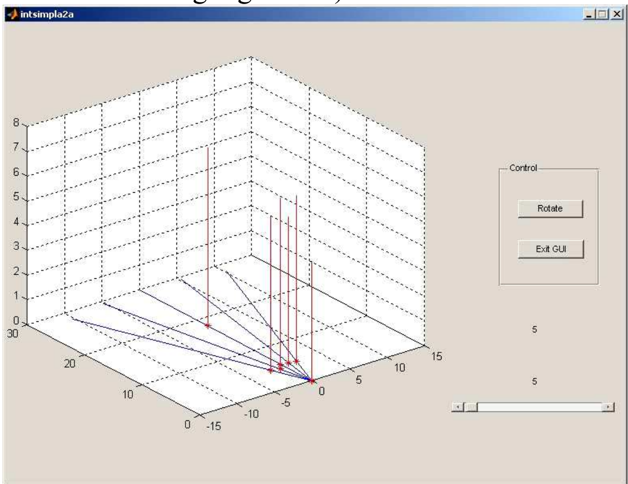

Fig 5. Results: White metal board at 18m from Lidar and fog during night time

c) White metal board at 18m from Lidar and water spray at 2m from Lidar.

Fig 6. White metal board at 18m from Lidar and water spray at 2m from Lidar.

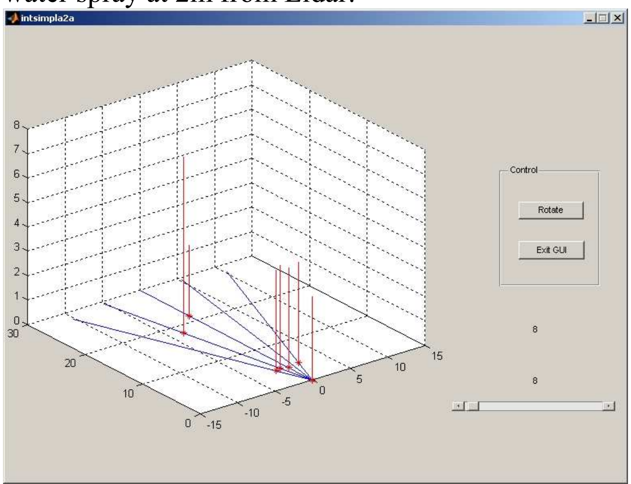

Fig 7 Results: White metal board at 18m from Lidar and water spray at 2m from Lidar

d) Conditions: snowing, Lidar through open window, towards edge of the roof (12m from lidar).

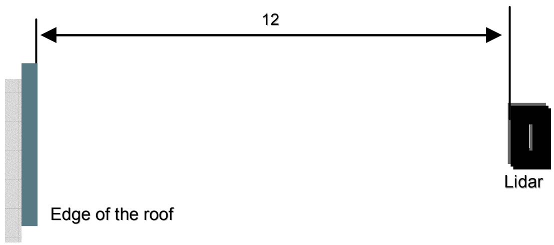

Fig 8. Lidar through open window, towards edge of the roof

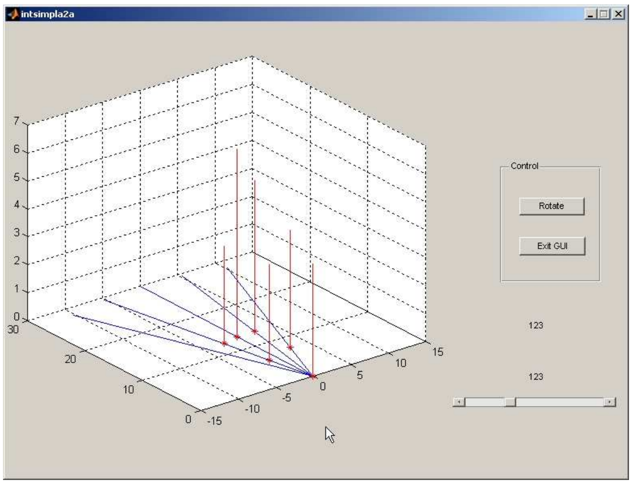

Fig 9. Results Snowing, Lidar through open window, towards edge of the roof.

e) Very Strong car light pointed into Lidar, very close (10cm) (nothing in the background)

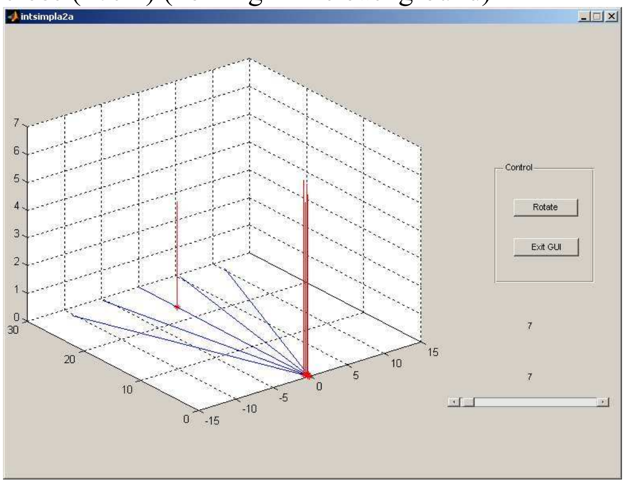

Fig 10. Results for a very strong car light pointed into Lidar

f) Lidar pointed towards sun. Conditions: fog

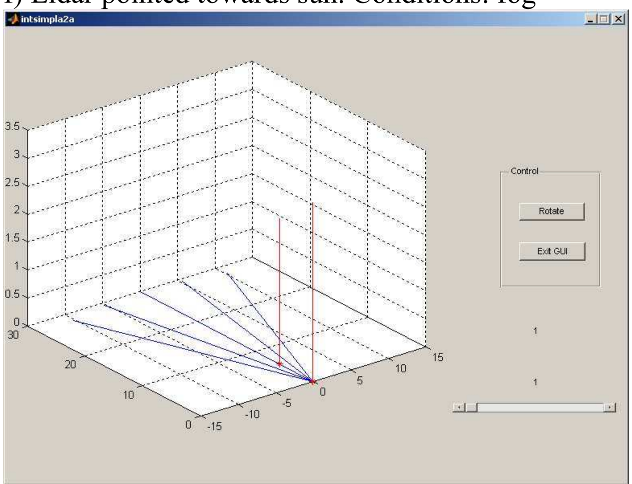

Fig 11. Results Lidar pointed towards sun. Conditions: fog

4 Conclusion

The results of tests lead us to the following conclusions regarding the influence of different factors:

Day or Night Not affected. The Lidar works during the day or at night.

Sunlight and Reflections/Angle of Measurement
Sometimes. A strong sunlight reflection off a highly reflective target may "saturate" a receiver, producing an invalid or less accurate reading. Pointing the Lidar towards the sun in open air in foggy weather resulted in the appearing of a target at 5m from the Lidar. (see Fig.11)

Dust and Vapor
Yes. Laser measurements can be weakened by interacting with dust and vapor particles, which scatter the laser beam and the signal returning from the target. Fog was of great influence.(see fig. 4), and it appeared as several different moving targets

Temperature and Temperature Variations
No effect. Experiments were conducted both in summer and winter, thus the variations were from over 20deg to close to 0deg. Laser measurements are based on the speed of light and are unaffected by temperature variations.

Weather
Fog, rain and snow were seen as targets by the Lidar,(fig.4,7,9) so meteorological conditions do influence the measurements.

As future work other types of experiments will focus on reflectivity of the oject (different materials and different colors).

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