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Long Range LiDAR Characterisation for use in a Smart Cane System for the Visually Impaired and Blind

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1. Introduction

Obstacle detection has become a very important area of interest for the automotive industry due to the move towards autonomous vehicles. Since the environment the vehicle has to navigate is ever changing the current best system for obstacle detection is to combine a number of sensors. This means that for the varying weather and lighting conditions the best sensor can be used to provided obstacle detection and avoidance information. The INSPEX H2020 project goal is to use a similar system of multiple sensors to provide personal obstacle detection for visually impaired and blind (VIB) people. Figure 1 shows the INSPEX ambition. Power, weight and size reduction will be key to achieving this goal. In this paper the initial prototype is characterised and improvements beyond typical reduction of key parameters is considered. The INSPEX system will integrate a short range LiDAR (distances up to 5m), an ultrawide band (UWB) RADAR (distances up to 5m), ultrasound (distances up to 2m) and a long range LiDAR (distances up to 10m). The sensors will be miniaturised and the power consumption reduced so that they can be incorporated into a white cane. In this paper the first prototype for the long range LiDAR sensor is characterised for various lighting conditions and distances. The results show that for distances of 3m and 5m consistence obstacle detection can be achieved even in bright lighting conditions but for distances beyond this the detection can be inconsistence and is highly dependent on the lighting conditions.

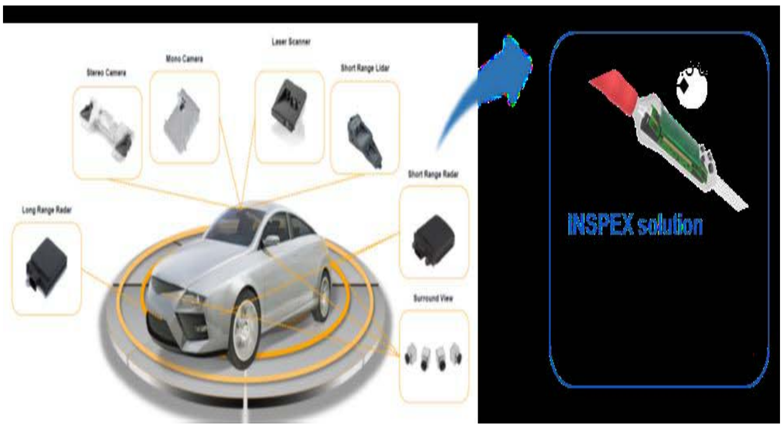

Figure 1: INSPEX Ambition

2. Long Range LiDAR

2.1 Long Range LiDAR Description

LiDAR operates by emitting a light pulse and using a time to digital converter to measure the time between emission and detection of the reflected beam. The initial prototype (shown in Figure 2) is powered using mains electricity and contains additional electronics for debug and test purposes. This increases the size and weight and will be eliminated in the design for the next system. This LiDAR was developed by SensL using a 905nm wavelength laser diode. The laser operates on a pulse of 105ns with a power of 7W so although it is very high power the short pulse length means that it confirms to class 1 laser and is eye safe. The design includes an FPGA to produce a histogram of the distance results to provide accurate distance information within 1cm. The current prototype is very large (119mm x 77mm x 55mm) but significant reductions can be made by optimising the electronics and reduces the size of the optics.

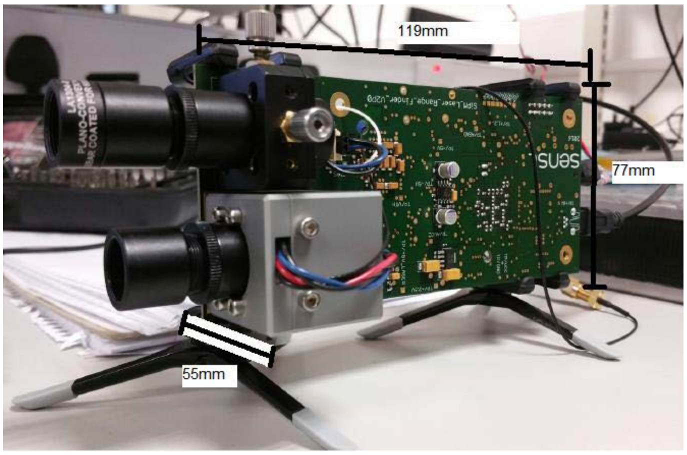

Figure 2: Long Range LiDAR initial prototype

2.2 Long Range LiDAR Characterisation

The characterisation of the LiDAR was done in various environments (indoor and outdoor), lighting conditions (dark, bright, overcast, indoor) and weather conditions (light rain, sun, and mist). Since the system is not packaged for use in wet conditions the system was covered in a plastic box. This showed that there was no detectable attenuation when a clear plastic obstruction was placed in front of the lens. Figure 3 shows an example of the types of obstacles used to characterise the system. Typical results for the characterisation are shown in Figures 4 and 5. For indoor conditions and dark lighting detection is consistent up to a distance of 5m from the obstacle. For distances from 5m to 10m detection is not as consistent but is achieved in dark conditions which is shown in Figure 5. Figure 4 shows that for bright conditions detection is also achieved for short distances (up to 5m). However, detection was not achieved for longer distances in bright light and outdoor lighting. This will need to be addressed in future design for the system as outdoor environments will be the main area of use for the smart cane INSPEX system.

Figure 3: Example of Obstacles tested

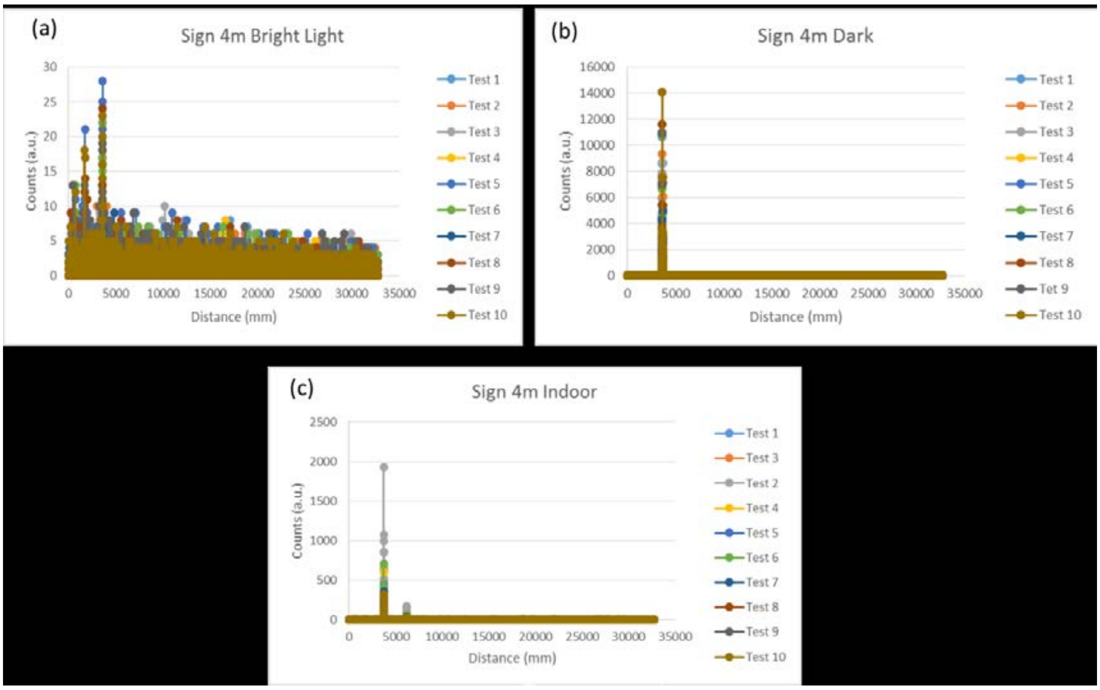

Figure 4: Detection of Sign at 4m Distance for (a) bright light, (b) darkness and (c) indoor lighting

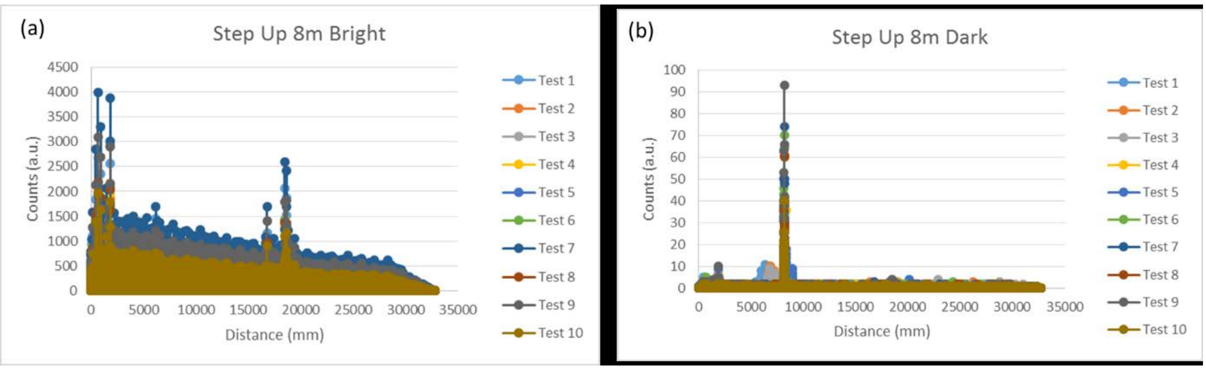

Figure 5: Detection of Step Up at 8m distance in (a) bright light and (b) darkness

2. Conclusion

The system operates as expected up to 5m in both indoor and outdoor conditions. At distances greater than 5m, obstacle detection was achieved indoors reliably. However, in outdoor conditions detection at 10m was affected by the ambient light and measurement could be achieved but not under all conditions. For outdoor conditions the detection angle needs to be reduced so that obstacle detection can be obtained reliably for a distance of up to 10m. The size and weight of the device must also be addressed for use on a cane as there is limited real estate, power requirements and weight are very important when a device is to be held. The initial results are very promising however and it is envisioned that the next generation will have a significant reduction in foot print and improvement in the optics for outdoor use.
In the next design of the system these short comings will be addressed and the entire system size will be reduced to better fit into the smart cane system. Also to be addressed is the high power consumption of the current design and also the use of mains power. A battery will be used to power the next LiDAR device so that portability will be addressed. The requirements for the INSPEX system means that there are a number of areas to be addressed but this characterisation has provided a good description of the current design and identified the areas where improvements are required.

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