White paper:

Traffic monitoring with TeraRanger One distance sensor

Abstract

The applicability of using a TeraRanger One sensor for traffic monitoring has been assessed. Distance values have been recorded from a bridge over a highway, and vehicles passing through the field of view of the sensor have been detected, enabling the estimation of the average vehicle size. This validates the use of TeraRanger One sensors for traffic monitoring applications that involve vehicle flow at intersections, vehicle size statistics, or even vehicle speed estimation, but the potential use cases beyond traffic monitoring are many. This white paper is provided as an example to show how a low-cost yet fast distance sensor can be used to provide an additional level of intelligence to support Internet of Things, Smart City and many other applications.

1 Introduction

According to the United Nations[1], the global population will grow up to 9.6 billion by 2050, out of which 6.3 billion will live in urban areas. As cities become more complex and their resources management more challenging, smart and sustainable approaches will be required to keep cities habitable and efficient.

Digital technology and the Internet of Things will enable transport optimization[2], among which we can find real-time traffic data or smart street lamps as just two examples. Due to their unique characteristics of weight, speed, and size, TeraRanger sensors can play a major role in making smart cities a reality by, for example, contributing to traffic monitoring.

[1] https://www.weforum.org/global-challenges/projects/future-of-urban-development-services/

[2] https://www.weforum.org/agenda/2016/02/4-ways-smart-cities-will-make-our-lives-better/

2 Experimental setup

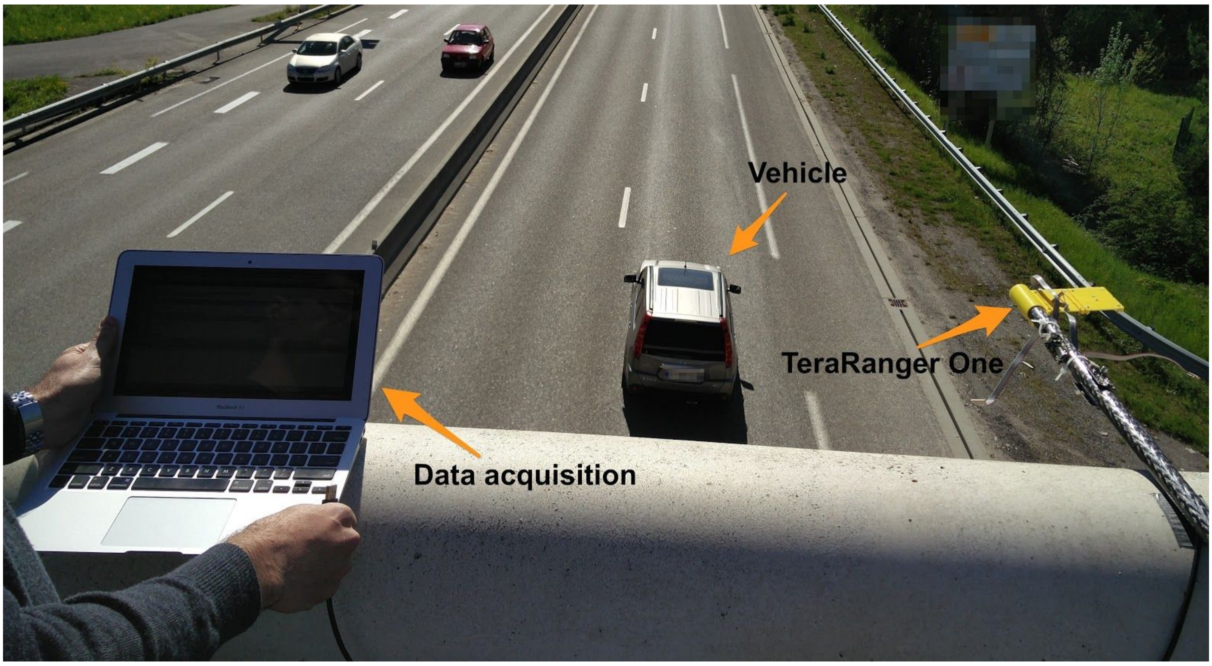

Figure 2.1: Experimental setup

A TeraRanger One Type B sensor was attached to the end of a pole and suspended from a bridge over a highway at a distance of approximately 7.5m from the ground, as depicted in figure 2.1. A laser pointer was used to confirm the height of the bridge. Distances were monitored with a TeraRanger One for sequences of eleven vehicles passing through the field of view of the sensor, and the duration of the experiment was timed using a mobile application stopwatch. The data value stream was recorded for further analysis using a MacBook Air and Arduino software with a 115200 baud configuration. The experiments were carried out on in sunny conditions between 5:20pm and 5:40pm, at an irradiance of 250 W/cm2 and a temperature of 22.2 ◦C.

3 Methodology

Raw data obtained from the TeraRanger One sensor was treated to analyze the evolution of vehicle height as a function of time. This included removing outliers and setting the distance value to 7.5m when the sensor reached its detection limit, as in these particular testing conditions (tarmac) the limit and the height of the bridge were very similar. Therefore, the height h measured from the ground was calculated using the distance d obtained by the TeraRanger One sensor:

$$f(x) = \begin{cases} 0 \; if detection limit reached \\ d - 7.5 \; Otherwise \end{cases} \tag{3.1}$$

Data acquisition frequency of TeraRanger One Type B sensors self-adjusts to provide optimal results depending on the external conditions, and therefore the average reading frequency can be estimated using the elapsed time of the experiment and the number of data values streamed. This information has been used to generate the graphs in section 4, as a means of creating a powerful visual aid.

4 Results

Two sequences were recorded using the TeraRanger One sensor. The height measured from the ground together with some examples of the corresponding vehicle are represented in figures 4.1 and 4.2 for each experiment.

There is a clear correspondence between the passing through of each vehicle and the observed peaks in the graphs. Two extremely sharp peaks that cannot be considered noise do not find a correspondence with any vehicle, and should be related to the detection limit of the sensor. The average TeraRanger One sensor data acquisition frequency f, the average vehicle height and the average vehicle frequency across the bridge f vehicle, are summarized in table 4.1.

Table 4.1: Summary of average values obtained during both experimental sequences.

f TeraRanger One (Hz)	10.4 ±1.6
h vehicle (m)	1.58 ± 0.23
f vehicle (vehicles / min)	21

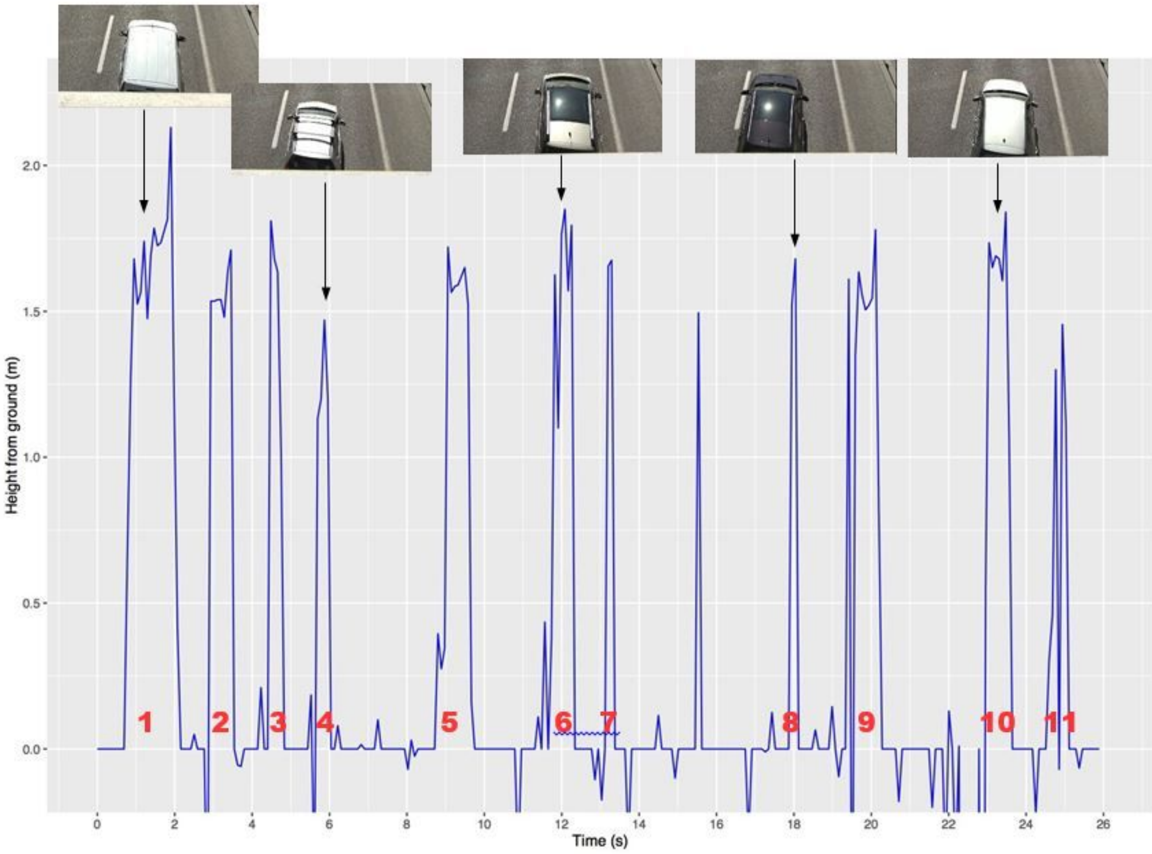

Figure 4.1: Height from the ground as a function of time for sequence #1. A total of eleven vehicles were recorded.

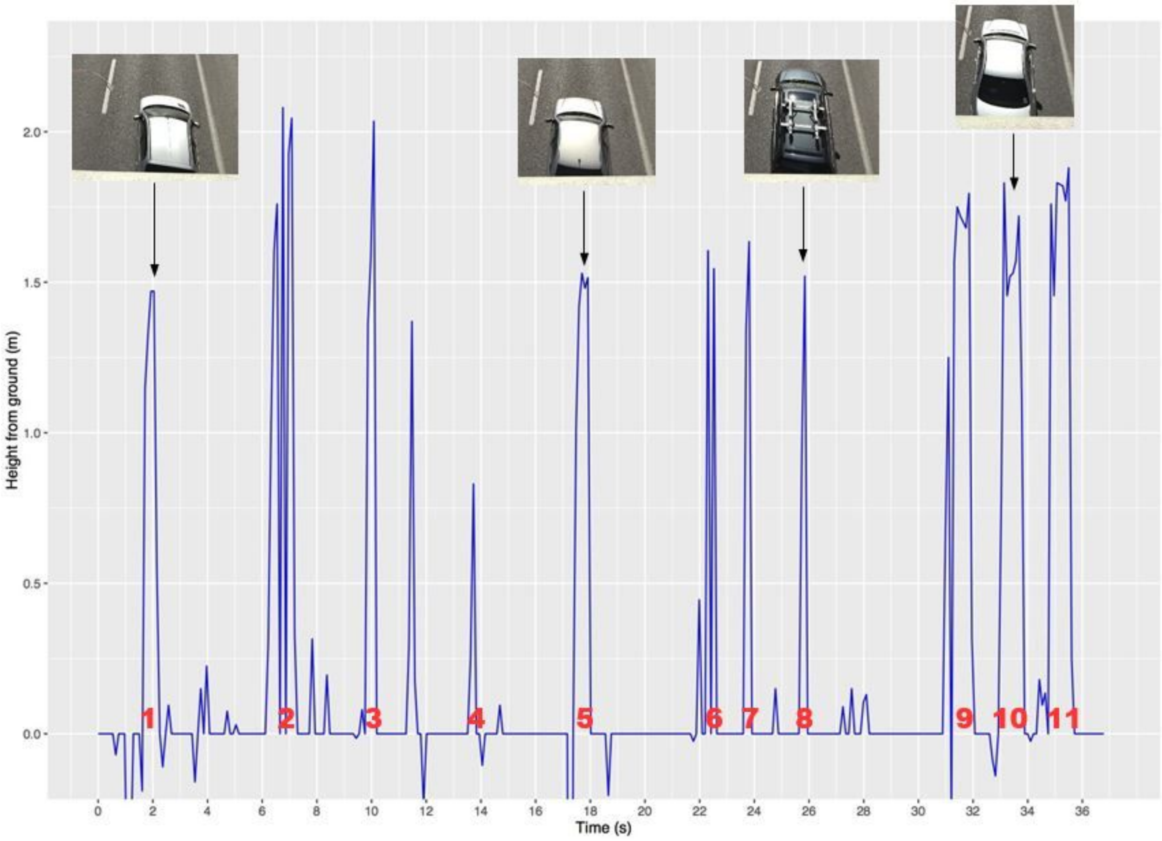

Figure 4.2: Height from the ground as a function of time for sequence #2. A total of eleven vehicles were recorded.

5 Applications in traffic monitoring

TeraRanger One sensors can be used in applications aimed at monitoring traffic flow at intersections, bridges, or traffic lights by analyzing the number of detected vehicles during a given period. The possibility of streaming the data would provide real-time traffic data and height information collection of vehicle size statistics which may have an impact on road maintenance planning.

Furthermore, two aligned TeraRanger sensors separated a known distance apart could be used for speed estimation purposes, as their signals could be synchronized a known amount by using a TeraRanger Hub. In this simple yet elegant way, the time difference between detection could be used to calculate the speed of the vehicle.

6 Conclusion

Situated on a bridge at 7.5m height from the ground, a TeraRanger One has been able to clearly detect individual vehicles travelling on a highway (legal speed limit of 110 kph) underneath. This validates the use of TeraRanger One sensors in traffic monitoring applications.