Distributed optical fiber acoustic sensing system for perimeter security

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Abstract: *Distributed fiber optic sensing is known for the few last decades. One of the most interesting area in security field is Distributed Acoustic Sensing (DAS). Nowadays, DAS systems have deployments in many different areas like pipeline monitoring, seismic activity monitoring, or perimeter security monitoring. They can use existing optic fiber networks and create a distributed sensor from this fiber which can monitor areas all acoustic events along the fiber. This paper deals with the evaluation measurement with a commercial DAS system used for perimeter security. The system was evaluated on university optical fiber test polygon and three different events were classified–man jumping, man walking and car driving along the fiber route. Based on the measurement and another post-processing also the speed of movement can be determined.*
Keywords*: DAS, DISTRIBUTED ACOUSTIC SENSING, PERIMETER SECURITY, OPTICAL FIBER, SECURITY*

1. Introduction

One of the first thing which must be ensured in objects and areas with restricted access is security, mainly perimeter protection. Several different technologies can be used for this purpose, like CCTV cameras, PIR sensors, piezo sensors, etc. This approach requires many point sensors. For longer distances also e.g. microwave cables can be used. But for longer distances (above 10 km) all these solutions are ineffective in term of cost. For longer distances systems based on standard telecommunication optical fiber DAS, which requires only a single optical fiber can be used as a suitable solution.

DAS uses phase-sensitive optical time-domain reflectometry (OTDR) to measure backscatter Rayleigth signal generated by short coherent pulses of light injected into a single-mode fiber. The technique of OTDR is well-known in telecommunication and is used for trace analysis and for detecting faults cased e.g. by fiber cuts or bad connections. In case of phase-sensitive OTDR an ultra-narrow linewidth laser source is used. The response measured by reflectometer is a product of Rayleigh backscatter that appears on the inhomogeneity of fiberglass not only from mechanical defects, but it is also sensitive to changes generated by mechanical and acoustic vibrations from the outside environment [1, 2].

In the following section measurement topology and used system description are presented. Section 3 presents results of different scenarios including classification and determination of speed of walking and car moving.

2. Measurement system

For the measurement commercially available system ODH-F from OptaSense was used. The maximal achievable length of one trace (system enables connection of 4 traces ant switching between them) is 50 km with a sample rate up to 50 kHz (sample rate is determine by the distance) [3]. In our case the total distance was approx.. 1.6km, sampling rate was 10 kHz and special resolution 1.2m

Figure 1 *DAS Integrator unit by OptaSense [1].*

Test polygon is located outside faculty building of the Brno University of Technology. Optical cable is buried under ground approx. in one meter depth in HDPE 40/35 tube. Distance from the sidewalk is approx. 1 m which means that distance from a road is approx. 2 m. Topology of test polygon, including sidewalk, road and fiber is shown in Fig. 2 with a marked part of optical fiber. DAS unit is situated in the rack room in the building, where the end of measuring fiber is.

Figure 2 *Position of optic fiber.*

3. Measurement results

In this part 3 different scenarios for used in perimeter security are presented. Simulated events are typical incidents in security and simulate intrusion into protected area – walking of person, jumping, and driving car at the access road at different speeds. From measurement data moving speed of objects over the fiber cable can subsequently be calculated.

Waterfall graphs (Figs. 3, 5, 6, 7 and 8) represent intensity in time on the y-axis separately for each distance segment plotted on the x-axis. Intensity is shown as shades of grey, where darker shades appertain higher measured intensity.

The first scenario represents the jumping of a person weight 70 kg from the fence. Jumping is shown in Fig. 3 respectively in graph Fig 4. You can see in graph in Fig. 3 two points of rebound and impact on the sidewalk. These massive peaks can be easily detected by threshold and notice security service by auxiliary system. The same person from the first scenario was walking on the sidewalk, around one meter far from the optic fiber.

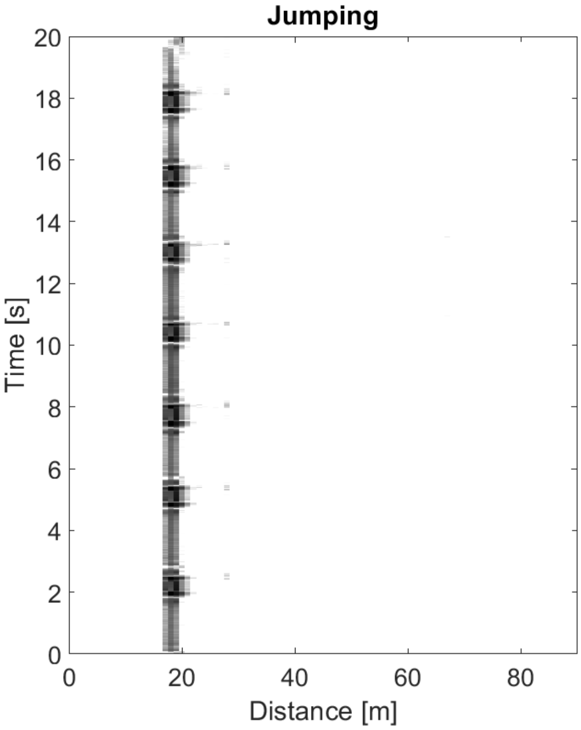

Figure 3 *Jumping of person near fiber.*

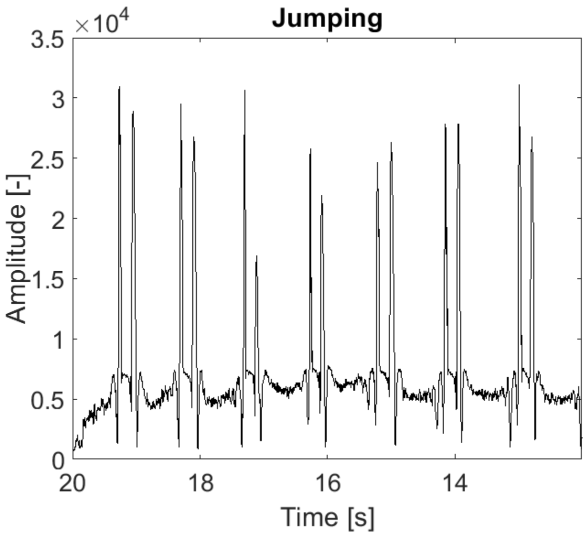

Figure 4 *Jumping drawn in time.*

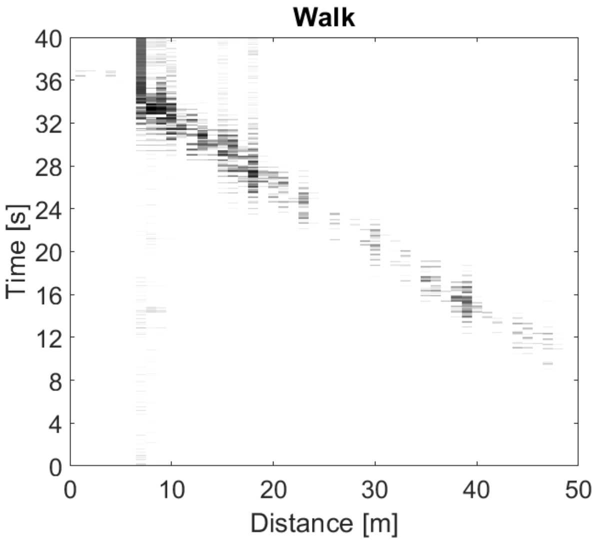

Figure 5 *Walking by fiber.*

Graphs in Fig. 6, 7 and 8, show a car on the road passing along the fiber at different speeds. The weight of the car was approximately 1200 kg, 3 meters far by optic fiber. The scales of graphs are the same, so slope represents differences in speed of moving object. Tested were 3 different speeds, 30, 50, and 80 km/h held by cruise control and compared with GPS.

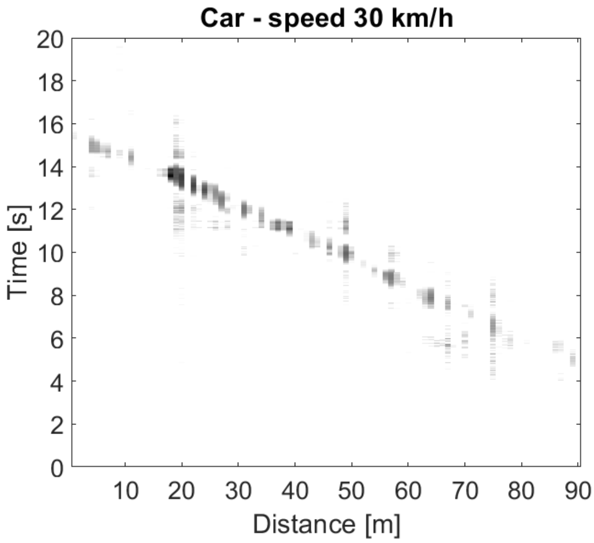

Figure 6 *Car by fiber at 30 km/h.*

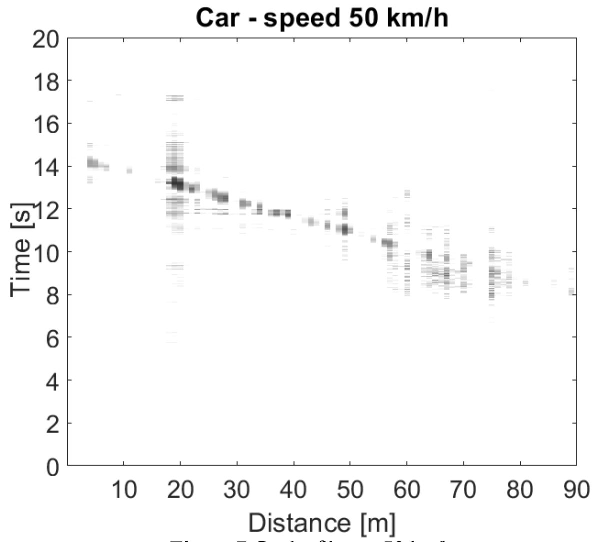

Figure 7 *Car by fiber at 50 km/h.*

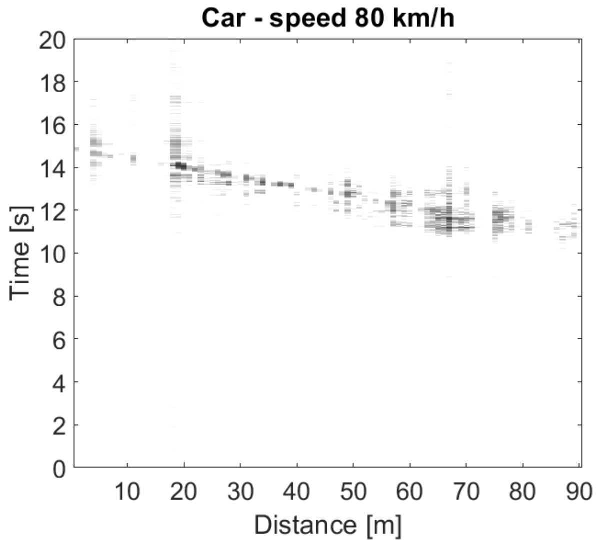

Figure 8 *Car by fiber at 80 km/h.*

Distance values and crossing time of the measured section are received from plots in Fig. 5-8 and are for better comparison shown in the table 1. Based on time and distance the speed can be calculated. The speed values evaluated from DAS system are almost identical to the speed measured by GPS.

Table 1 *Comparison of speeds between real and calculated from DAS.*

Type	Speed GPS [km/h]	Duration [s]	Distance [m]	Speed calculated [km/h]
Car	30	11	90	29,45
Car	50	6,5	90	49,85
Car	80	4	90	81
Walk	6	29	50	6,2

4. Conclusion

This paper described the application of DAS for use in security field. Two different events were evaluated. After processing measurement data, a security system can offer an alarm state for each segment of fiber.

From the measurement results the speed of moving objects were calculated and compared with reference GPS measurement. Values received from the DAS correspond with GPS based values.

5. Funding

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6. References

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