Processing and analysis of accelerometer data for the task of recognizing the state of the surface by mobile platform

Yegor Boyarchikov yegor.boyarchikov@tul.cz, Ing. Tomáš Martinec, Ph.D TUL

The author provides an overview of the existing methods of data processing, which could be used for the objective of surface defects identification. All of the algorithms were tried on real test datasets. Further research suggests the application of the most suitable approaches in autonomous mobile platforms projects.

Key words: Z-THRESH, Z-DIFF, G-ZERO, road defect identification, autonomous mobile platform

Introduction

Surface state monitoring is a difficult and complex issue. Installation of the large number of static sensors is probable solution but very expensive. If we speak about relativelly big areas of the surface, application of the static methods for the road state analysis also seems unsuitable. For example, rod and level mehod is one of the well known methods for the static road state analysis [1]. The huge size of the road network makes application of static methods challenging in terms of cost and labor. This task can be solved by adding inexpensive and easy-to-install data collection equipment, which will simplify the process of road quality monitoring. Researchers already were trying to solve these problems. “Vehicle Intelligent Monitoring System” was developed. An accelerometer, a microscope, a GPS and laptop PC are installed in an ordinary road patrol car, but this system has advantages and disadvantages[2]. VIMS was designed at the beginning of the century. This work is intended to use previous experience and improve it with present approaches. The project will be carried out in stages. At the first stage, it is supposed to work out the data collection, to study and select the optimal method of data processing. At further stages, it is planned not only to detect surface defects (large and small dumps, cracks and other defects) but also to bind them to GPS coordinates.

Methodology

Despite the actuality of the issue, the amount of the articles dedicated to the question of the surface monitoring defects identification relatively small. The following abstract contains a description of the several algorithms, which could be used for accelerometer data processing. The main objective is the identification of road defects, cracks, and dumps [3].

Z-THRESH – the first and the simplest algorithm which could be used for the road defects identification. This approach is based on the Z-axis data processing. Function for the Z-axis data classification is a border function that contains the desired value (Image.1). Based on this value algorithm performs classification of the road defect. For example, it is possible to identify dump, crack or sequence of the defects.

Image 1: Z-THRESH algorithm for road defect identification.

Z-DIFF – a more advanced type of algorithms for road defects identification. This method is also based on Z-axis data processing. The classification function of the Z-DIFF algorithm is a border filter. This function performs a classification of the difference between two subsequent values (Image.2). This approach allows for identifying fast changes in acceleration on a vertical axis. Based on this it is possible to identify the type of the defect and classify the type of the surface.

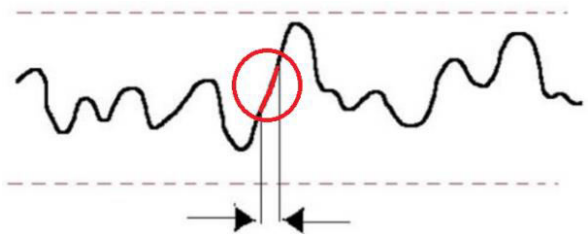

Image 2: Z-DIFF algorithm for road defect identification.

G-ZERO is an algorithm for surface defect identification. While using visual data analysis tools and searching for specific data patterns researchers found that there exist certain events characterized by measurement tuple. During the experiments, it was discovered that in a moment of passing dump or crack values of the accelerometer demonstrate definite dynamics. The empirical analysis of the data had led to the following conclusions: 1) such data tuples could be acquired when the vehicle was in a temporary free fall, for example, entering or exiting a pothole; 2) such data tuples could be analyzed without information about exact Z-axis position of the accelerometer. The researchers named this algorithm G-ZERO (Image.3) after the main feature of the detected event.

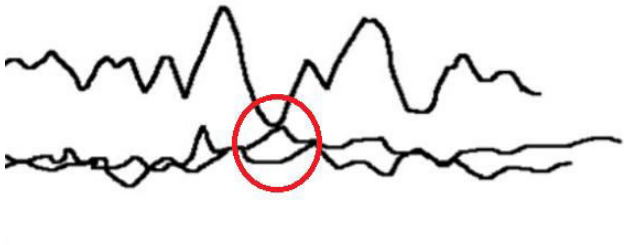

Image 3: G-ZERO algorithm for road defect identification.

Results and discussion

During the research, it was decided to implement the described algorithms. Implementation of them has provided an opportunity to perform testing with real data, which were collected by Bosch BMA 280 accelerometer. Each of the described algorithms has demonstrated advantages and disadvantages.

Z-THRESH is a relatively simple algorithm. According to the author's opinion, this is the only advantage. The main weak point is a necessity to know of approximate area type. Based on this knowledge the researcher is able to configure border, to provide better identification of the defects.

Z-DIFF is an algorithm which also indicates changes in the vertical direction. This point makes it similar to the previous algorithm. The algorithm requires determination of the Z-axis position similar to the previous approach this is also a disadvantage from the author's point of view. Comparing with Z-THRESH this approach lets us to identify fast changes in the curve, it obviously increases the quality of defect detection that is an advantage definitely.

G-ZERO has a set of advantages. For us is important to reach the highest amount of defect identifications during accelerometer data processing. Evaluating algorithm does not require positioning and uses information from all of the axes. Based on the previously described facts, it is clear, that the approach is one of the most effective tools in spite of relatively difficult implementation.

Conclusions

In this project, the author provides a brief description of the algorithms for further implementation in the mobile autonomous platform design project.

Acknowledgment

This work was funded by the Student Grant Competitions (SGS) program at the Technical University of Liberec in 2019.

References

[1] Sayers, M., Karamihas, S.: The Little Book of Profiling: Basic Information about Measuring and Interpreting Road Profiles. University of Michigan. Transportation Research Institute, UMTRI (1996)

[2] Takashi Furukawa, Japan 2012 "VIMS Manual." VIMS Consortium, Nagasaki University

[3] B. Lanjewar, Jyoti Khedkar, Rahul Sagar, Rasika Pawar, Kunal Gosavi. Survey of Road Bump and Intensity Detection algorithms using Smartphone Sensors. IJCSIT, Vol. 6, 2015