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DATA PROCESSING SYSTEM FOR SMART CITY BASED ON NEURAL NETWORK

This work is devoted to the problem of automatic road quality control, which can be used by road repair services. This paper provides a survey of some known techniques and algorithms of detecting potholes on the road and describes our own method, using trained neural network based on data gained from accelerometer. It will be shown our concept of system for detecting potholes on the road, which can be used, as a part of the IoT system. It uses data from an accelerometer for finding road bumps using neural network.

Keywords: Internet of Things, SmartCity, Potholes detection, Accelerometer, CNN.

Fig.: 2. Tabl.: 0. Bibl.: 8.

Relevance of the research topic. The ability to control the quality of the road surface as an element of Smart City system would be an extremely useful to prevent further damage for road surface and safe a lot of money for repairing.

Target setting. The main aim is to provide our own method, using trained neural network based on data gained from accelerometer to classify road surface quality.

Actual scientific researches and issues analysis. In general, there are several approaches to solving this problem, which are presented in open sources. We can mention both algorithmic and theoretical purposes, but they all have some critical disadvantages. Some of them are needed for qualified personnel for data collection and analysis, and mostly all this approaches do not cover the driver's driving style, because the most important quality indicators can also be considered, abrupt braking or acceleration, the treatment of which can’t be tracked using an accelerometer.

Uninvestigated parts of general matters defining. In this paper, the possibility of creating a full-fledged system for finding pits on the roads using accelerometer data based on convolutional neural networks, in contrast to the generally accepted approach in the use of recurrent neural networks for time series analysis. It was also possible to integrate it into a large-scale Internet of Things system.

The research objective. In this paper the main purpose was to offer our way for solving the problem of finding road defects with the help of modern linear acceleration sensors for monitoring the quality of road sections. To solve this problem, we considered and analyzed the algorithms for assessing the quality of the road surface and marking road sections by quality and create own algorithm based on neural network solutions. We offer a hardware that allows real-time detection of defects on the road surface and in a special way to mark such road sections.

Materials and methods of research. First of all, hole system is divided into two parts like on figure 1. The first part is a device for collecting linear acceleration data. It was proposed to use the lis3dsh accelerometer and the stm32f407vg microcontroller as hardware for this part. Their choice is due to low energy consumption and high popularity in the Internet of Things, as well as the availability of convenient software for their programming and debugging. It should also be noted that you can easily use devices of other lines stm32 with minimal reconfiguration of configuration files.

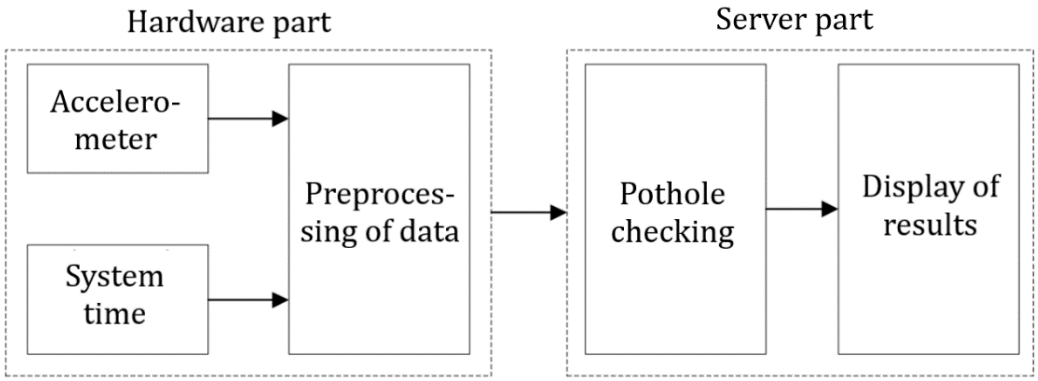

Figure 1. System architecture

The second part of the overall system is the server, which collects data from all devices connected to it by the communication protocol, and is responsible for the secondary processing and subsequent classification of the quality of the road surface. It is worth noting that this approach allows you to scale the size of the system, add other peripherals. In this work the own dataset was collected. To do this, a test run was performed on sections of road of different quality. The csv file with three parameters, each of which represents the rate of linear acceleration in one of the axes, is considered as a dataset. The total size of the training dataset is 3600 frames. Each frame is a matrix of 3 * 64 in accordance with the number of records for 2 seconds. For this work was made our own model of CNN network. In total it can classify a road quality level on 4 types:

1. Smooth road
2. Curb, lying policeman, railway crossing
3. Small pits
4. Large pits (deeper than 2 cm, more than 20 cm in diameter)

Research results. Testing of our device was held on the road section which has some different roughness such as (large potholes, small potholes, pothole clusters, gaps, pavements and rail crossings). It helps to find profits and disadvantages of methods we used. As a result, a neural network was obtained, which classifies the quality of the road surface with an accuracy of 85.2%. The graph of accuracy indicators obtained depending on the number of epochs is shown in Fig. 2.

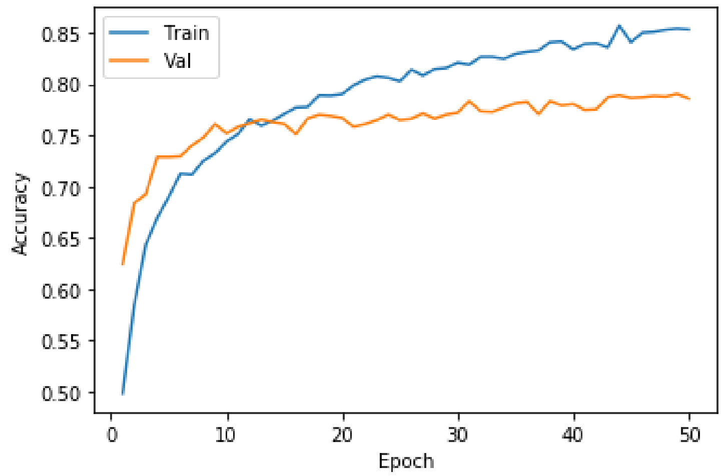

Figure 2. Neural network accuracy depending on the number of training epochs

Conclusions. This paper describes a system for identifying potholes on roads using developed device as part of the IoT system. This system was developed based on an overview of such examples, their advantages, and their disadvantages. Using a neural network solutions help to find more features that can't be found using human eye. Such system concept in the future may become part of a larger project, and increase its functionality. In the future, it is possible to improve the process of detecting holes by increasing the dataset to make network familiar to different manners of driving.

Based on the obtained result, we can clearly say that the system has certain advantages over analogues that exist in the world. First of all, the created model has a low level of energy consumption, competitive for similar microcontroller systems and much more prevalent in comparison with the systems as used by mobile devices. Disadvantages include the attachment to the correct position of the sensor, but this problem is solved by rigid fixation, or by adding a method to recalculate the acceleration relative to the static coordinate system.

References

1. Komninos, N. Intelligent Cities: Innovation, Knowledge Systems, and Digital Spaces; Taylor & Francis: Abingdon, UK, 2002.

2. R. Bishop, “A survey of intelligent vehicle applications worldwide”, IEEE Intelligent Vehicles Symposium (IV 2000), Dearborn, MI, USA, May, 2000, pp. 25-30.

3. Devapriya, W.; Babu, C.N.K.; Srihari, T. Real time speed bump detection using Gaussian filtering and connected component approach. In Proceedings of the World Conference on Futuristic Trends in Research and Innovation for Social Welfare (Startup Conclave), Coimbatore, India, 29 February–1 March 2016; pp. 1–5.

4. Mohamed, A.; Fouad, M.M.M.; Elhariri, E.; El-Bendary, N.; Zawbaa, H.M.; Tahoun, M.; Hassanien, A.E. RoadMonitor: An intelligent road surface condition monitoring system. In Intelligent Systems’ 2014; Springer: Berlin, Germany, 2015; pp. 377–387.

5. Y.-c. Tai, C.-w. Chan, and J. Y.-j. Hsu, “Automatic road anomaly detection using smart mobile device,” in Proceedings of the2010 Conference on Technologies and Applications of Artificial Intelligence (TAAI2010), November 2010

6. De Zoysa, Kasun, Chamath Keppitiyagama, Gihan P. Seneviratne, and W. W. A. T. Shihan. “A public transport system based sensor network for road surface condition monitoring.” In Proceedings of the 2007 workshop on Networked systems for developing regions, pp. 9. ACM, 2007.

7. Jakob Eriksson, Lewis Girod, Bret Hull, Ryan Newton, Samuel Madden, and Hari Balakrishnan. 2008. The Pothole Patrol: Using a Mobile Sensor Network for Road Surface Monitoring. In Proceedings of the 6th International Conference on Mobile Systems, Applications, and Services (MobiSys ’08). ACM, New York, NY, USA, 29–39.

8. Marius Hoffmann, Michael Mock, and Michael May. 2013. Road-quality classification and bump detection with bicycle-mounted smartphones. In Proceedings of the 3rd International Conference on Ubiquitous Data Mining-Volume 1088. CEUR-WS. org, 39–43.

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