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Software and hardware solutions for the road surface state classification

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The author provides an overview of the own vision of possible harware and software methods which could be applied in the field of surface defects identification. Approaches described in the abstract were experimentally tested in real conditions.

Key words: Road surface state classification, data analysis, ESP32, data classification, autonomous mobile platform

Introduction

From the first sight, road quality data analysis may seem relatively trivial task. However, this area contains several subtasks that are not obvious, but require attention. The author has personally encountered with the need to solve such subtasks.

According to the author's opinion, subtasks can be divided into two groups. The first group - tasks related to the hardware part. The second group includes tasks associated with the software part.

Taking look closer at the tasks of the first group. Firstly, this type of tasks includes the task of choosing a suitable element base: sensors, controllers, methods of information exchange between modules of the system. The next important issue is system configuration. How many of these or those modules can provide a sufficient level for the correct operation of the system. Another task: the task of mounting system modules on the mobile platform. Perhaps the task seems to be secondary, but the correct position of such system elements as accelerometers makes it possible to ensure at high level such system parameters as fault tolerance, relatively acceptable noise level in the primary data, as well as reduce the number of modules used, which may lead to the reduction of the system's cost.

Turning to the second group of subtasks. Software related subtasks. More specifically, the solution of these subtasks determines how efficiently the filtration of useless data, the speed of analysis of the cleaned data and the quality of the analysis will take place. Questions mentioned above are the main tasks of this subsection.

Methodology

We will describe the methodology for applying certain solutions in the same sequence as above: first, we will touch upon the hardware part, and then the software one.

ESP32 controllers (Image.1) and MPU6050 sensors (Image.2) were used as the main elements of the system.

Image 1: ESP32

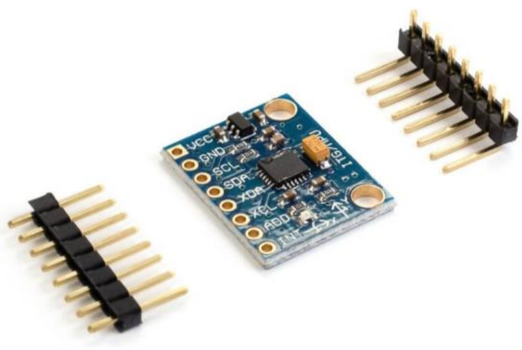

Image 2: MPU6050

These elements meet all the requirements imposed on them by the author of the article. Some characteristics of the ESP32 controller [1] are given in (Table.1) and for the MPU6050 sensors in (Table.2).

Table 1: ESP32 characteristics

Core name	Tensilica Xtensa 32-bit LX6 microprocessor
Cores amount	2
ROM	448 KiB
SRAM	520 KiB

Table 2: MPU6050

ADC Resolution	16-bit
Voltage	3-5V
Acceleration range	± 2 ± 4 ± 8 ± 16g
I2C protocol support	+

The next question is the placement of system elements directly on the platform. An example of placement can be seen in (Image.3).

Image 3: External part of the system

This method, shown in the image above, is relatively optimal. Ideally, the sensors are planned to be placed directly near or on the suspension elements connected to the wheels. This approach allows obtaining the most truthful and not distorted by additional influences data, as well as to minimize the number of sensors and reduce the cost of the system.

As for the controllers, these parts of the system can be placed inside the platform; the influence of the external environment will lead to the failure of them. Since the cost of controllers is relatively higher than the cost of sensors, a high probability of failure will lead to unnecessary expenses and an increase of the system's cost.

However, to improve the accuracy of the primary (manual) data processing for the purpose of their subsequent use for training the system, video recording of experiments was used. In (Image.3), you can observe a camera placed in close proximity to the sensor so that both the sensor and the surface are in the frame at the moment the corresponding wheel travels over it. This solution allows to accurately determine and compare the data on the chart and the real situation at a particular point in time.

It should be noted that in the process of developing data analysis mechanisms, different algorithms were used, from such as the gradient descent method [2], to such as the Nelder-Mead method [3].

Results and discussion

During the experiments, the main hardware elements of the system (ESP32 and MPU6050 sensors) were tested, the optimal positions for their installation on the platform were determined.

As for the software part, the methods of optimizing of the received data, filtering and subsequent processing were tested.

Conclusions

Nowadays, the setup of the system is almost completed, a set of hardware elements have been formed, and the issues of placing the elements of the system on the platform have been worked out.

In terms of the software part, software development continues based on existing methods, since the task is specific and, unfortunately, cannot be solved by existing tools.

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