Development and research of the information system for monitoring the condition of the road surface using mobile devices to optimize logistics and repair costs

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***Abstract*— The work is dedicated to the implementation of information system for monitoring the quality of the road surface condition, and the development of software to interact with the system and the network of mobile devices for data collection. The architecture of the prototype of a hardware device intended for collecting statistical data on specialized transport is proposed. The results of the prototype work on some sections of roads are shown. This work was supported by RFBR grant №16-37-00240.**

Keywords*— monitoring, road surface, pit, unevenness, mobile application, geolocation, map, data collection, data analysis, gyroscope, accelerometer.

I. INTRODUCTION

According to statistics, the greatest number of road accidents happens due to unsatisfactory condition of the road surface. In this regard, more and more important is the control of the condition of the pavement. The urgency of the study is also determined by the Novosibirsk city's need for a strategic planning tool for road-repair work, in connection with the participation of the region in the pilot project for the integrated development of the transport infrastructure "Safe and high-quality roads" [1]. The main objectives of this program are to bring to 2018 the normative state of at least half of the agglomeration roads (by the year 2025 there should be at least 85% of such roads), a decrease by 2018 in the number of places where traffic accidents are concentrated on the roads of the metropolitan area to half 2025, the number of hazardous areas should be reduced to 10% of the level of 2016). The developed system allows real-time monitoring of the current quality of the road surface and the dynamics of the formation of irregularities in certain areas.

II. FORMULATION OF THE PROBLEM

The purpose of this work is to create an information system that allows you to monitor the dynamics of the formation of irregularities at different times of the year on different sections of roads.

This system allows you to predict the formation of new irregularities by collecting statistical data on the nature of the irregularities (0-3, 0 - no unevenness, 3 - deep pit). It helps to get more correct information about traffic jams on the roads, promptly perform repair of the road surface, and significantly reduce the waste of funds for car repairs, as its technical condition depends on the condition of the road surface covered. To achieve the goal, the following tasks are set: to implement a set of libraries implementing the algorithm for collecting and analyzing statistical data on the nature of irregularities, rationing data from different devices, developing a mobile application using the created set of libraries to predict the condition of the road surface, developing a hardware device that collects statistical data.

III. FEATURES OF THE PLATFORM

General algorithm of the service:

1. Collection of data on the irregularities detected by the device;

2. Accumulation of received data on the server;

3. Data processing in a given period of time;

4. Display of the road surface condition taking into account the received data.

Data collection is carried out in two ways: by mobile devices by those who move by personal transport and with a hardware device designed for official and public transport. At the moment, a certain algorithm for detecting irregularities in the course of the mobile application has been developed.

The mobile application works directly with the accelerometer of the mobile device, which returns values characterizing the slope of the three axes - x, y, z. For the standard when launching a mobile application, coordinates of the current position of the phone in the vehicle are taken in the state of motion when the engine is running. This point is the center of the reference sphere, in comparison with which the unevenness is estimated from the received coordinates from the mobile device. If the point is beyond its boundaries, then this case is considered as a pit / roughness on the road.

The server sends: the ID of the road segment and the type of irregularities, information about which was generated on the client side of the service.

It is important to pay attention to the fact that the current algorithm in its work should not differ when used on different mobile devices, in various vehicles. For this, there

is an algorithm for normalizing the data of each accelerometer on each device. The algorithm is described in more detail below (Figure 1).

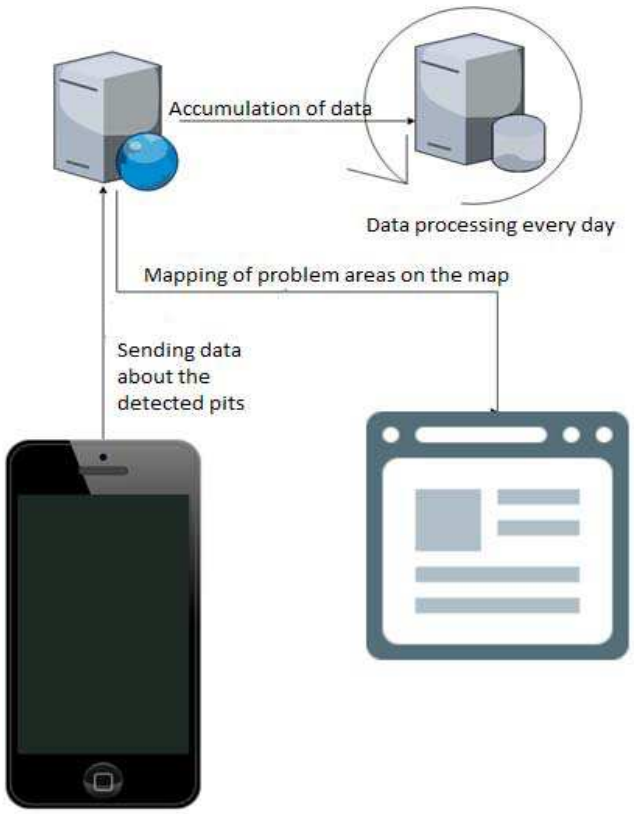

Fig 1 General scheme of the service

The distance between the centers of the sphere is calculated by the formula:

$$D = \sqrt{(x_1 - x_0)^2 + (y_1 - y_0)^2 + (z_1 - z_0)^2}$$

D is the distance between points; x_0, x_1 are the coordinates of Ox of the first and second points, respectively; y_0, y_1 are the coordinates of Oy of the first and second points, respectively; z_0, z_1 are the coordinates of Oz of the first and second points, respectively.

$$x = \frac{x_{Current}}{x_{Max}};$$

$$y = \frac{y_{Current}}{y_{Max}};$$

$$z = \frac{z_{Current}}{z_{Max}};$$

To work with the service it is enough to install the application on a mobile device that has an accelerometer. This application collects data in the background. No specific devices and specially trained personnel are required when working with the system.

In addition to the application for mobile devices, a hardware device was done that performs analysis of statistical data. It is based on a miniature single-board Raspberry Pi Model B of the first generation. To determine the geographic coordinates, the GPS module GY-NEO6MV2 was used, the MPU6050 accelerometer module allows to determine three coordinates of the device position in space, and sending the data to the server is realized using a 4G modem.

The software part of the hardware device is based on the Linux Raspbian distribution (Debian for Pi), Python scripts that collect accelerometer data on the i2c bus, and also data from the GPS. The device uses a ported algorithm with iOS and Android to collect statistical data.

The service consists of several parts:

A. A web application running on Python + Flask on the Apache + mod_wsgi web server;

B. Mobile application for data collection and partial analysis on the client side;

C. A hardware device for data collection in service and public transport.

One of the most preferred options for data exchange is the JSON format, due to its prevalence. It was used in this service.

A ready-made web application is available at: yam.mynstu.xyz (Figure 2)

At the moment, it is possible to get data from the server:

• about the state of the road according to the coordinates of any point on this road. If there are intersections on the road, then it can be divided into several parts. It is necessary to consider this when requesting the service [3];

• about a specific period of time [4];

• about the belonging of the street to the district [5].

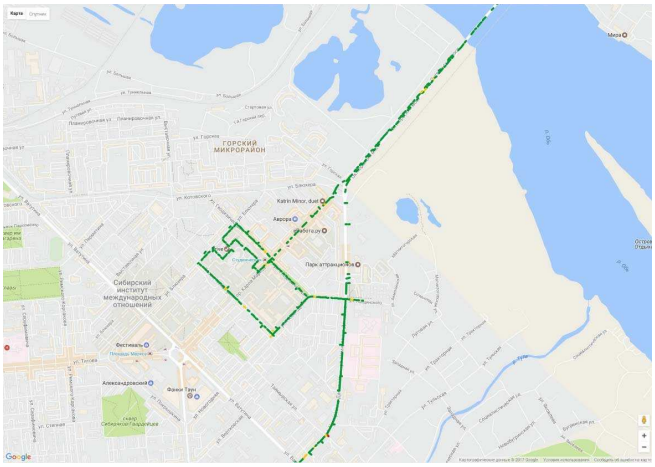

Fig 2 Results of the developed system

This information system has a wide range of applications. In addition to quality control of the pavement, its timely recovery, the system can estimate the quality of the repairs done, based on the fact that the time on the road surface began to appear unevenness. It is planned to implement the service of constructing the optimal route and

generating information about traffic jams in the settlement, taking into account the data on pits / unevenness on the road surface.

The developed prototype of the monitoring system was tested in the Leninsky district of the Novosibirsk region using mobile devices iPhone 6s, 5s, Nexus, and also with the help of vehicles GAZ31105, GAZ 3102 and VAZ 2105.

IV. Plans for Development

At the current stage, the algorithm that classifies the unevenness is debugged, as well as their correct display on the site. The next steps in the development of this system are the expansion of the monitoring zone, the visualization of other regions of the country, and the increase in the accuracy of the determination of pits and irregularities, the filtration of "noise".

REFERENCES

[1] "Official site of the city of Novosibirsk". [Electronic resource] // 2017. Access mode: URL: http://novo-sibirsk.ru/major/news_1153/71024/

[2] "YamoAnaliz" [Electronic resource] // 2017. Access mode: URL: https://yam.mynstu.xyz

[3] "YamoAnaliz". Characteristics of the road by coordinates. [Electronic resource] // 2017. Access mode: URL: yam.mynstu.xyz/get_road_for_point?Lat=82.897642&lng=54.988244

[4] "YamoAnaliz". Statistical data for a specific period of time (from 01/01/2017 to 01/02/2017). [Electronic resource] // 2017. Access mode: URL: https://yam.mynstu.xyz/yam/data/between_dates?from=01.01.2017&to=28.02.2017

[5] "YamoAnaliz". Affiliation of the street to the district. [Electronic resource] // 2017. Access mode: URL: https://yam.mynstu.xyz/yam/street_intersection/2124