

TECHNICAL SCIENCES

USING DIGITAL FILTERS OF GNSS-MONITORING DATA IN THE PORTABLE APPLICATION "STAMM"

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Abstract

GNSS monitoring has become widespread in transport, significantly increasing the efficiency of its use. Moreover, the data received through communication channels, as a rule, is stored by online services and can be further used to solve a variety of tasks. Monitoring service providers provide an opportunity for users to freely upload reports generated on the basis of monitoring. However, the use of this data comes with a number of limitations. First of all, this is due to errors in determining the current speed of the car, which is due to the peculiarities of satellite navigation technology. Therefore, monitoring data are subject to preliminary processing in order to exclude or correct anomalous observations caused by measurement error. The portable application "Stamm" presented in the article contains tools for smoothing incorrect measurements.

Keywords: digital filters, driving cycles, satellite monitoring, GPS-Glonass navigation

Introduction

The processing of GNSS online monitoring data (Global Navigation Satellite System) includes the collection, analysis and interpretation of information received from satellite navigation systems. This is mainly information about the coordinates and speed of objects, tied to the exact time counts. The reverse channel of the system also provides for the transmission of arbitrary data. This may be data from various sensors related to the technological process of the object of monitoring.

Specialized programs and algorithms are used to process GNSS online monitoring data, which allow you to accurately determine the coordinates of objects and monitor their movement. This is important for many industries, such as transport, geodesy, construction, etc. Processing GNSS online monitoring data is a necessary tool for accurately determining the location of objects and monitoring their movement. This makes it possible to increase work efficiency, improve safety and reduce the cost of transportation and other operations.

Methods of correcting the error of GNSS navigation

To ensure high accuracy of GNSS online monitoring data, correction methods are used to eliminate errors and distortions that occur during data transmission and processing. Some of these methods include:

1. Signal correction: This method is used to eliminate errors associated with signal distortion during its transmission through the Earth's atmosphere. For this purpose, data on the state of the atmosphere obtained with the help of additional instruments are used.

2. Differential correction: This method is used to eliminate errors related to various factors, such as multipath propagation of the signal and incorrect location of satellites. For this purpose, data obtained with the help of additional receivers at nearby points is used.

3. Carrier frequency phase correction: This method is used to eliminate errors related to the phase change of the carrier frequency during its transmission

through the Earth's atmosphere. For this purpose, data on the state of the atmosphere obtained with the help of additional instruments are used.

4. Ephemeris correction: This method is used to eliminate errors related to the incorrect location of satellites at the time of signal transmission. For this purpose, data on the exact location of satellites obtained with the help of specialized stations are used.

All these correction methods make it possible to increase the accuracy of the GNSS data of online monitoring and provide more reliable control over the movement of objects.

The error in determining the coordinates of GPS (Glonass) systems can be caused by various factors, such as:

1. Signal distortion during transmission through the Earth's atmosphere, which may lead to inaccuracies in determining the distance to the satellite.

2. Multipath propagation of the signal, when the signal is reflected from various surfaces and reaches the receiver with a delay, which can also lead to inaccuracy in determining the distance to the satellite.

3. Incorrect location of satellites, which may lead to inaccuracy in determining the coordinates of the object.

4. Errors in ephemerides that describe the exact location of satellites at the time of signal transmission.

5. Incorrect receiver setup or data processing.

To eliminate these errors, the correction methods described above are used. It is also important to choose the location of the receiver, taking into account the minimization of possible interference and signal distortion.

Thus, the accuracy of determining coordinates and speed using GNSS navigation depends on several factors, such as the number and location of satellites, the quality of the receiver and error correction methods. Glonass and GPS systems ensure the accuracy of determining coordinates at a level from several meters to

several tens of meters, depending on the number of satellites used and signal reception conditions. In terms of speed, Glonass and GPS systems allow you to determine the speed with an accuracy of several meters per second. However, additional sensors such as speed sensors, accelerometers, and gyroscopes can be used to measure speed more accurately. In general, the accuracy of determining coordinates and speed is quite sufficient to control the mode of operation of vehicles. However, the extensive database of high-speed profiles of cars formed during the monitoring process can also be used for scientific research. For example, to determine typical speed profiles or driving cycles of cars and special equipment [1-6].

When using the monitoring database, it is necessary to take into account data stream compression algorithms when storing information about the speed of vehicles on GNSS online monitoring servers, they are used to optimize the use of data storage and reduce the load on the network and reduce the amount of data transmitted without loss of information quality.

One of these algorithms is the delta coding algorithm, which is based on preserving the difference between successive values of vehicle speed. This allows you to reduce the amount of data transmitted if the speed of the vehicle does not change significantly. Another algorithm is the Huffman algorithm, which is used to compress text data. It can also be applied to vehicle speed data if this data is presented as text strings.

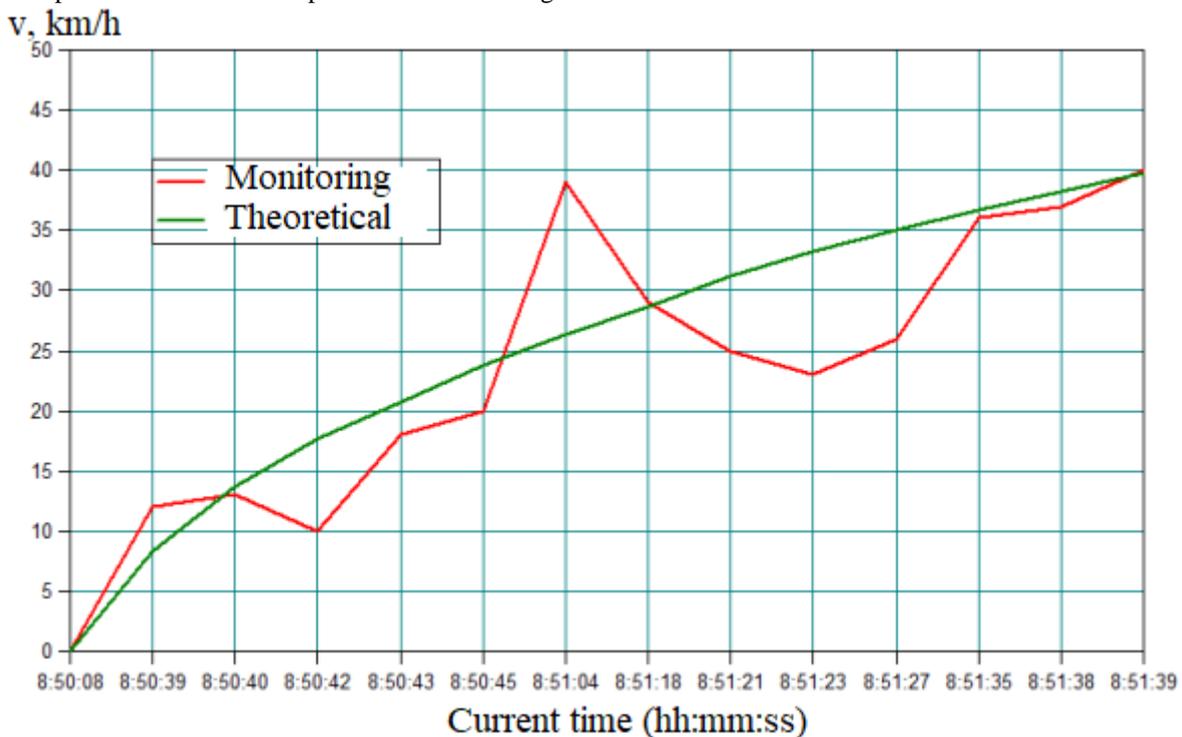
Data compression algorithms such as LZ77 and LZ78 can also be used, which are based on finding duplicate fragments in the data stream and replacing them with references to previous occurrences. This reduces the amount of data transmitted if the speed of vehicles is repeated at certain time intervals.

However, if there is an error in determining the current coordinates using GNSS for the reasons noted above, the use of stream compression algorithms can multiply this error. But even the speed profiles obtained with the minimum speed update frequency of one second at the moment require pre-processing. (Pic. 1), and it can be both positive and negative.

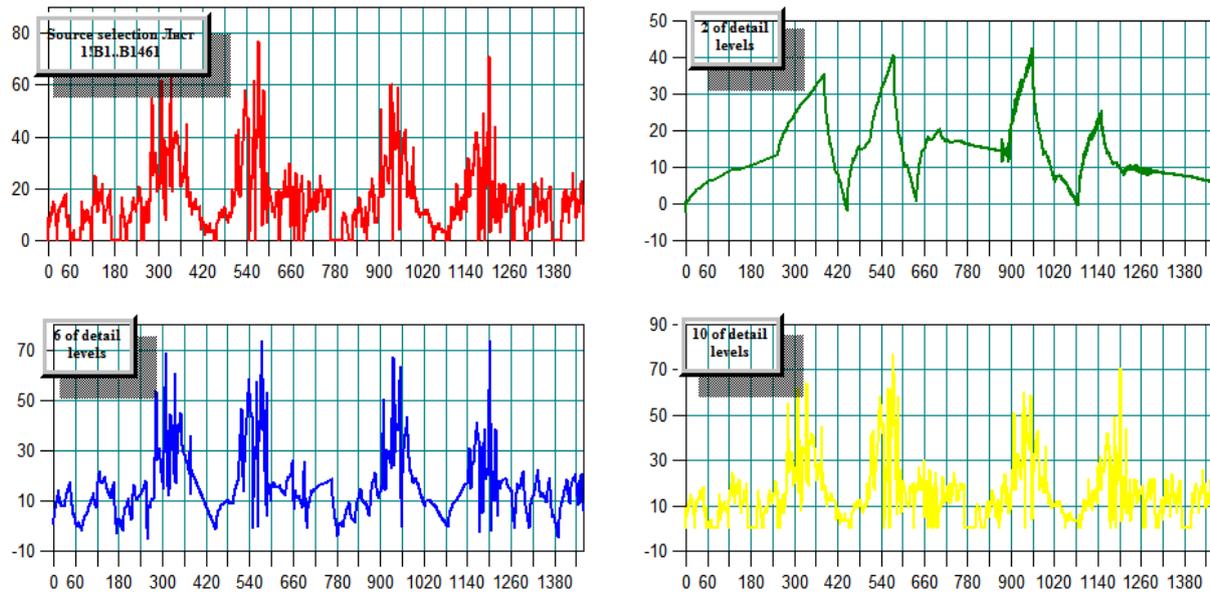
The figure shows jumps in the calculated speed values relative to the assumed real ones. Thus, smoothing of numerical values is necessary to eliminate outliers.

Correction of the initial monitoring data

To do this, you can use data coarsening using spectral data analysis tools, for example, compare the source data from the GNSS monitoring server (Pic. 2 at the top left) and the data obtained using the Wavelet transform (Pic. 2 at the bottom left) available in the Stamm 4.2 program [2, 7]. It is obvious that the approximation of GNSS monitoring data with a given detail makes it possible to smooth out emissions over the entire field of the velocity profile.



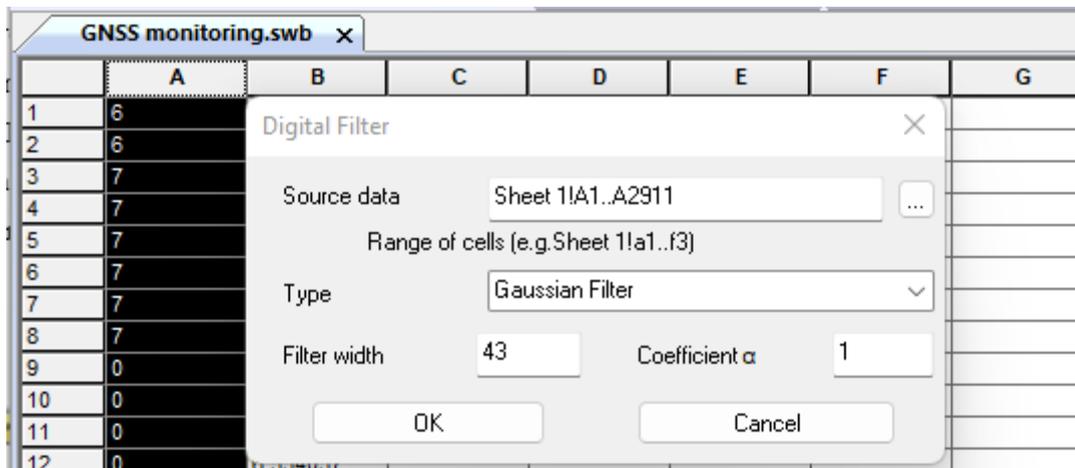
Pic. 1. The curve of the speed change during the acceleration of the car



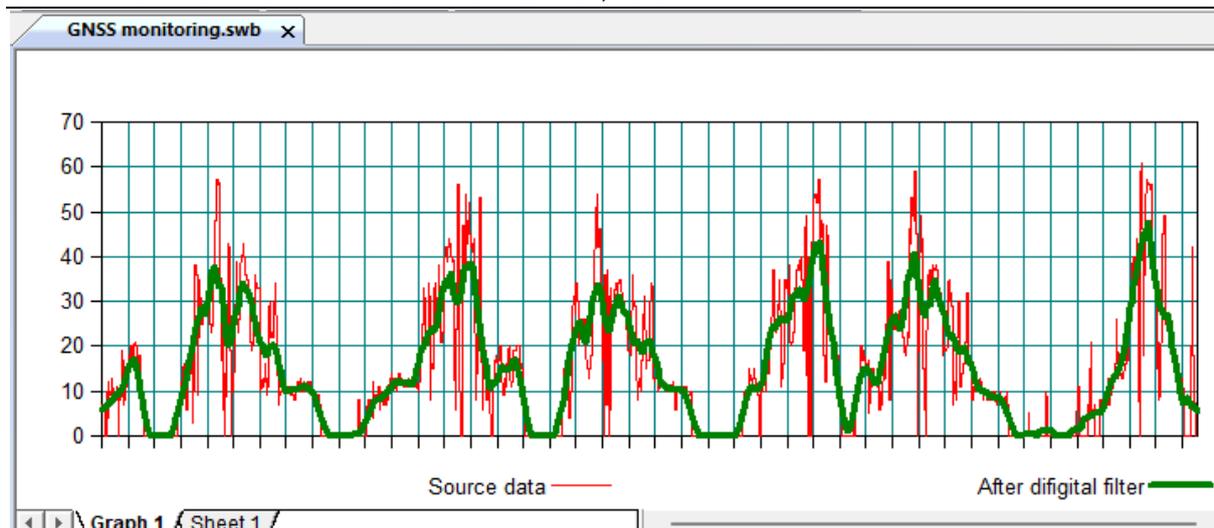
Pic. 2. A velocity profile subjected to a Wavelet transform. Stamm 4.2

However, the approximation of the entire velocity curve at once, as a rule, does not completely eliminate the errors caused by the imperfection of the coordinate determination technology (Pic. 3). In the figure, you can see that there is a presence of negative values in the data smoothed by this method. In addition, to restore the data processed using the wavelet transform, additional computing power costs associated with a large number of coefficients of theoretical dependence comparable to the size of the original sample are required. The features of the wavelet approximation also impose strict restrictions on the sample size.

In the latest version of the program, the author added the function of digital filters. In fact, this is also an approximation, but performed on a narrow area determined by the width of the filter. The difference lies in the fact that the application of the filter "replaces" incorrect data and you can get a corrected selection, for example, in the adjacent column of the workbook of the Stamm program. By controlling the type of digital filter and its settings - width and coefficients, you can achieve the desired degree of "correction" of the data (Pic. 3). The effect of the filter on the original sample can be estimated using the graph obtained in the appendix (Pic. 4).



Pic. 3 Applying a digital filter to the original sample



Pic. 4 Application of a digital filter with a window width of 43

Results and discussion

The use of digital filters allows you to clear the initial sample received from the GNSS monitoring server from abnormal values, the type of filter and its settings should be determined based on the data compression algorithms used on the server and the quality of GPS equipment, Glonass terminals. The given example of data correction made it possible to achieve almost complete compliance of the "Stop" phase with real traffic conditions.

Conclusions

The proposed methods and approaches for processing experimental data obtained by exporting reports from GNSS monitoring servers will improve the quality of the sample and remove anomalous observations that distort the studied patterns. In addition, the use of digital filters does not require further reuse of computer computing power. An important feature of the Stamm application, along with the noted functions of preprocessing, data analysis and visualization, is its mobility. The program does not require the installation and use of any additional libraries or files, since it is a mobile application capable of being executed from any available medium [7].

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