TRANSPORT SYSTEMS

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INTELLIGENT MOBILE INFORMATION SYSTEM FOR UNDERGROUND

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Abstract**—***Ways to improve ease of subway passengers is considered. Environmental parameters for prediction problems are studied. Choice of machine learning methods is made. The accuracy of the prediction is estimated.*

Index Terms—Navigation; mobile devices; subway; machine learning, artificial neural networks.

I. INTRODUCTION

A lot of people are living in modern cities. High population density makes it necessary to use different modes of transport for reaching your destination as soon as possible, in addition to their own vehicles. In many cities over one million people use the subway system of underground communications. This mode of transportation is in great demand among the population due to its advantages, such as high bandwidth, predictable routes, comfortable microclimate conditions regardless of the time of year, the adaptation of the repetition rate of transport units under load conditions on the transport network, etc. Among the shortcomings of this way of transportation, you can find the absence of visual cues about the location of the train inside the tunnel traffic in most parts of the route, which in combination with the condition of a long trip may predispose carriers to the loss of focus for the moment of the train arrival.

Despite the fact that all metro station are voiced, and some subway cars are equipped with monitors that display current information about the movement of the train, including the name of the next station on the route, there are a significant number of passengers who, for some reason, are missing these factors. For such passengers pass the necessary stops is quite usual, and in conjunction with the habit to count the time of arrival to your destination without the usual travel by land transport of lead time, it brings additional inconvenience in the form of delays and the need for increased attention to the route, or the rejection of the use of free time during the trip for other tasks. For passengers the possibility of the presence of receiving notice of the need to prepare for the exit of the subway car could be a useful tool.

II. PROBLEM STATEMENT

There are known sensor readings $x_{ij}\,(i=\overline{1,n},$ $n-1,\ n,\ n-$ number of sensors, $j=\overline{1,m_i},\ m_i - j$th sensor reading).

It is required to identify the station to which the train is approaching until it stops.

III. HARDWARE CHOICE

Having considered the decision failed to find one who could provide such functionality and be ready for use. As a result, it was decided to develop a means to solve the task.

Since the user should be notified, as well as to provide data on the environmental conditions classification tools and decision-making, then to solve this problem it is necessary to use tools that can perform a variety of devices, having in its composition of different sensors, have computing resources and have sufficient mobility. Taking into account the fact that the list of devices that have these features, the most popular among the population use mobile communications with any software to simplify called smartphones, for the implementation of the objectives of passengers means of solving the problem of notification of the need to prepare for the exit of the train metro decided to start developing apps for smartphones. Since dominant at the moment smartphone operating systems are operating systems iOS and Android. The last one are represented by a large number of models and are more available to passengers who choose the subway as the primary means of moving around the city. So it was decided that the first implementation of the program the product will be aimed at users of smartphones running the Android operating system.

To provide users with timely notice of the need to prepare for the exit of the subway train, the system must be able to determine the current location of the passenger traffic on the route, the start point of the route and the arrival of the target station. To perform all three tasks the system can use heuristic algorithms, combined with decision support systems on the basis of which will form the route options. However, realization of these objectives require significant effort and time to optimize the costs of the entire system, as well as to obtain speedy working prototype, the problem of determining the initial and final points of the route request made by user requested to specify these parameters manually. Thus, much of the design and development of the first phase focused on the problem of determining the current position of the passenger on the part of the route.

Present mobile devices are available in a wide variety of hardware for the collection of environmental parameters. To select the optimal set of sensor data to the information system organized selection significant parameters generated available sensors based on expert opinion, backed by visualizing the distribution of sensory data.

Since some types of sensors are present only in a small range of models of mobile devices, such sensors have been excluded from the set of forming significant sensory data as well as the absence of the input to the trained neural network, in most cases, it has unpredictable consequences, and therefore require the preparation of a separate version neural network for each sensor configuration of mobile devices. Thus, for example, atmospheric pressure sensors, and light level were excluded.

From the list of sensors available in the vast list of mobile devices in the list of priority candidates were the following sensors:

– accelerometer;
– magnetometer;
– gyroscope;
– sensor of the level of radio signals.

For evaluation of the permissibility of the data application of a certain sensor, the authors developed a simple application to collect data from a primary sensory above four sensors built into mobile devices.

On the basis of the prepared sample in the first phase assessed data distribution character in relation to the train of the route with reference to the timeline. In this step, evaluation was performed based on visual estimation distribution using imaging techniques.

The most consistent results were obtained from the acceleration sensor. Since the raw data of the sensor comes to the three axes [1], then in order to obtain a more universal parameter simple transformations were applied. For these purposes, the accelerometer data were reduced to a single value as the sum of vectors, and the presence of gravitational influence mathematically possible. As a result of equation to obtain a combined parameter of the accelerometer is as follows:

$$A_u\left(a_x, a_y, a_z\right) = \frac{\left(a_x^2 + a_y^2 + a_z^2\right)}{g^2}. \quad (1)$$

A plot of the universal parameter accelerometer times is shown in Fig. 1.

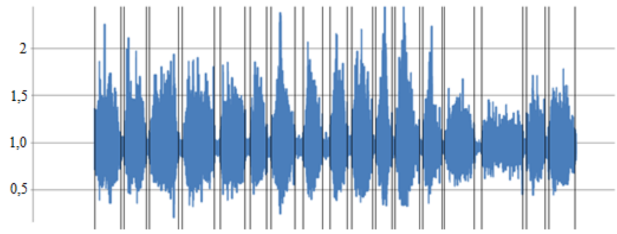

Fig. 1. The accelerometer data distribution on the time scale

Parameter values obtained at the portions corresponding movement of the train was obviously higher than that for the portions corresponding to a state of rest. This assumption is confirmed by the calculation of the variance on the corresponding portions. Calculations have shown that the dispersion values at the portions corresponding movement was up to 17 times greater than the dispersion values at the respective portions rest. Similar actions were applied to the data of the other three sensors. For values of magnetic field intensity universal value it was developed using the equation:

$$M_u\left(m_x, m_y, m_z\right) = \sqrt{m_x^2 + m_y^2 + m_z^2}. \quad (2)$$

A graph of the magnetic field is shown in Fig. 2 where you can observe a certain regularity. This pattern is a sharp increase of the magnetic field values at the beginning of the movement of the train in most cases. This can be explained by energizing the windings of electric motors, installed in subway trains.

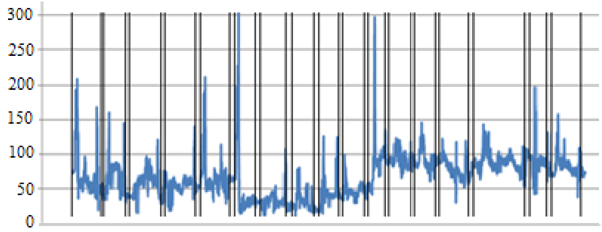

Fig. 2. Distribution of the magnetometer data on the timeline

The presence of such a pattern allows the use of these data, together with the accelerometer data. However, these data must be further processed by entering the filter that transmits only the peak values of the magnetic field.

Investigation of signal intensity value distribution mobile radio device shows the presence of a certain regularity (Fig. 3). This pattern is evident in the fall of the signal level at certain sections of the route. In most cases, it is correlated with the train being inside of a tunnel. Such behavior of the parameter can be explained by the fact that the tunnels are located deep underground, and the signal from terrestrial cell towers is weakened by soil layers.

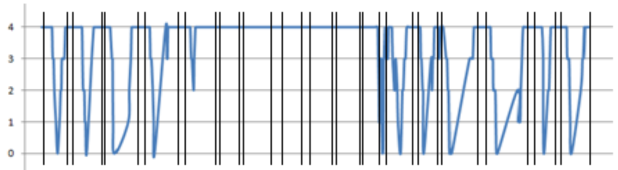

Fig. 3. Distribution of radio signal level on the timeline

Studying of the gyroscope data showed insufficient representativeness of the sample data, which can be obtained from the sensor. In addition, a correlation of the angular acceleration of the state of the data train is difficult to justify.

According to studies about characteristics of the data received from the mobile sensor, it was decided to include three essential characteristics feature: linear acceleration, magnetic field intensity and the intensity of radio signals. To investigate the influence of these features on the classification accuracy of the article the authors divided the array into two groups, which are studied separately. The first group included all three data sensors and the second data only accelerometer and magnetometer. This article describes the results of evaluation of neural network, the input of which is fed data from the second group of features.

IV. Problem Solution

The solution, which is necessary to determine the functional dependence of the class of phenomena from a certain set of parameters can be performed by various methods, including different methods of statistical analysis and machine learning. However, based on a variety of devices on which you plan to use the developed solutions, the need for system scalability, ability to adapt the classifier to the new data it was decided to begin the study of the implementation of tasks of machine learning methods, based on the use of artificial neural networks.

A necessary first step was the choice of the topology of the neural network. Since the nature of the alleged dependence wore a hypothetical character, the choice of topology has been reduced to a choice between the two groups of topologies: forward propagation neural networks and recurrent neural networks. In the first case, the benefits of topology are:

– ease of implementation;

– flexibility in the number of possible modifications within a single topology;

– there is no need to store the state of the different iterations, which is expected to improve the system performance parameters when used in a mobile device of limited hardware resources.

Expected disadvantages of the topology of neural networks in the framework of solving the problem was the lack of the possibility to apply the methods of forecasting time series, which could give a more accurate prediction value.

In order to determine the most successful with the configuration of lower refractive errors of classification system under development, it was decided to compare the characteristics of classifiers based on different network topologies. This comparison is planned for the next stages of the study. In this article we consider the implementation of mobile information systems based on neural network of direct distribution.

Since the network neurons is generally nonlinear elements, then, consequently, neural networks are non-linear systems suitable for solving nonlinear classification, principally due to the presence of non-linear characteristics. In this case the main advantage of the trained artificial neural network is a generalization that allows to provide the ability to recover missing data, and to predict their performance. In the mobile information system developed by the input data for the neural network are values obtained from sensors that are built-in into the hardware of the mobile device. These parameters are represented by a vector in a certain parameter space, which is recorded by a given algorithm in the neural network. The system prediction using neural network station where passengers need to get off the train, an important advantage is the automatic adjustment of the level of accuracy of the classification station, and further definition of the destination station and the ability to predict this level. However, it is also necessary to carry out the automatic synthesis of neural networks themselves (the number of neurons, the types of activation functions and the weighting coefficients), which can be carried out effectively by the methods of structural parametric design technology of artificial systems for various purposes. These methods allow for directional choice of optimal configuration and parameters of the neural network.

To carry out structural and parametric synthesis of neural network adopted a set of tools of machine learning TensorFlow, developed by Google Inc. The result obtained by synthesis using an iterative neural network configuration estimate of classification accuracy on a test sample of sensory data.

V. The Structure of the Neural Network

After identification of a set of data, as well as the topology of the network, the next step is the development of the structure of the neural network and its further training.

Since the chosen topology was backpropagation neural network, developed network comprised input layer neurons, several hidden layers and an output layer. The input neuron layer was three, which formed a feed stream of values that have been obtained from sensors and pretreated. An array of hidden neurons consisted of two layers of neurons of neurons in every hundred. The output layer neurons consisted of two neurons, forming a two-element array and which contain a probability value array classifying input data into one of two classes: the train movement and rest.

Activation function [2] was chosen sigmoid following form:

$$y = \frac{1}{\left(1 + e^{-x}\right)}. \quad (3)$$

An optimizing algorithm based on gradient descent methods [4]. Multivariable logistic function was used to obtain complementary probability distribution. The volume of training sample was about forty-five thousand tuples of sensor data.

IV. Results

The result of solving the problem was the training of artificial neural network whose parameters can be used to reconstruct the neural network to end user devices. The highest classification accuracy when using the developed neural network of the learning network with the number of periods equal to 25 and was almost 89%.

V. Conclusions

Despite the relatively low error rate, the practical application of the trained neural network is currently not recommended without increasing the accuracy of the classification, and, in turn, predict the time to reach the destination station. To accomplish this goal, additional stages of the study.

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О. І. Чумаченко, І.В. Рощинський. Інтелектуальна мобільна інформаційна система пасажирів метрополітену

Розглянуто способи підвищення зручності користування метрополітену пасажирами. Проведено дослідження параметрів навколишнього середовища для задач прогнозування. Виконано вибір методів машинного навчання. Проведено оцінку точності прогнозування.

Ключові слова: навігація; мобільні пристрої; метрополітен; машинне навчання, нейронні мережі.

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Е. И. Чумаченко, І.В. Рощинский. Интеллектуальная мобильная информационная система пассажиров метрополитена

Рассмотрены способы повышения удобства пользования метрополитена его пассажирами. Проведено исследование параметров окружающей среды для задач прогнозирования. Выполнен выбор методов машинного обучения. Проведена оценка точности прогнозирования.

Ключевые слова: Навигация; мобильные устройства; метрополитен; машинное обучение, нейронные сети.

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