Intelligent System of Visual Simulation of Passenger Flows

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Abstract. Existing information systems in the field of passenger transportation are investigated, where the key task is to evaluate passenger flows. Possibilities, accessibility, principles and principles of optimization of information systems of passenger transportation of public transport are analyzed. It is established that the visualization of passenger flows is one of the important tasks of optimizing routes and improving the quality of passenger transportation by public transport. An intelligent system of visual simulation of passenger traffic is proposed, which, based on the operation of the neural network, allows optimizing the work of passenger transportation by public transport.

Keywords: intelligent system, passenger flow, visualization, simulation, public transportation

1 Introduction

Today one of the most important problems in smart city developing is public transportation, which in turn is not sufficiently guided by modern intelligent systems. The main and most important unit in the field of public transportation is a passenger who needs urban or long-distance transportation. The large number of passengers who use public transport and make their own movements with it help to form the concept of passenger flows. Passenger flows depend not only on the features of the route, but also on certain major points of the largest passenger flows in the city. Passenger flows are the most important aspect that must be discouraged when creating new routes and connections, updating or modifying existing ones.

At the moment, it is precisely this problem of research and visualization of passenger flows that has not been resolved, indicating its relevance.

The aim is to create intelligent system for visual simulation of passenger flows in order to solve the current problems in the study and analysis of passenger flows by using visualization.

Visual simulation of passenger flows will help solve the following tasks:

1. Visually see problem areas on routes.

2. Clearly identify major stops with the highest passenger flows.
3. Decide quickly on the need for route upgrades.
4. Obtain passenger flows forecasts for the quantitative and qualitative change of vehicles.

The object of the study is the process of creating an intelligent system of visual simulation of passenger flows in the field of public transport.

2 Analytical Review of Sources

2.1 Analysis of Recent Research and Publications

The author in [1] analyzes scientific developments in the field of information support to optimize networks of public transport routes in large and very large cities, where he developed a method of obtaining a matrix of correspondences containing all kinds of urban displacements to the purposes with precision detailing to a specific stop. The identified goals and directions can be used for further research of information support of optimization tasks of public transit routes in large and very large cities.

In order to improve the organization of passenger service on the route, the authors of [2] proposed to use a rational distribution of vehicles to take into account their passenger capacity during the period during which the transportation is carried out. When using rolling stock with a small number of seats in [2] considered that such an increase in the number of transport leads to congestion of urban transport system and increasing excess emissions of harmful gases into the atmosphere. The research has also developed measures to increase the efficiency of rolling stock use to improve passenger service.

The problem of assessing the quality of passenger transportation by public transport within the city with different numbers of vehicles on the route is devoted to work [3].

The authors [3] analyzed the existing methods of assessing the quality of urban transport and identified among the criteria quality indicators: pedestrian movement, waiting time, travel time and dynamic transport capacity factor. The simulation model of change of the complex indicator of quality of public transport in the city developed in [3] established a stable dependence of this indicator on the number of vehicles on the route. This made it possible to determine such a rational number of rolling stock that would maximize the efficiency of urban transport for a given quality level.

To predict passenger traffic in [4], the authors used the smart city principle for public transport management, which was realized through the use of long-term short-term memory (LSTM) based on a recurrent neural network architecture. The proposed hybrid optimized network model gives additional performance improvements of 4% - 20% compared to non-hybrid models, indicating the feasibility of using the proposed hybrid optimized LSTM network based on the estimation of the accelerated Nester adaptation moment (Nadam) and the stochastic gradient descent algorithm SGD when modeling passenger flows.

In [5], the authors proposed a simulation model of the distribution of passenger traffic on transport networks, taking into account the timetable and delay of trains. As a result of modeling, the authors of [5] formulate statistical indicators, including the volume of passenger traffic of each vehicle and the stops that are animated by the software of the software. The model proposed in [5] provides a quantitative example to illustrate developed software. The authors [6-31] estimate man-made damage in the passenger transportation, and modeling the fuzzy knowledge base for IT evaluation.

2.2 Analysis of Existing Software Products

Possibilities of visualization of passenger traffic in the sphere of public transport are provided by the company "A + C Ukraine", as well as a three-month visualization of data on the sale of electronic ticket in the city of Zhytomyr from the site http://texty.org.ua/. A + C Ukraine does not disclose its methods and concentrates on individual cities or routes, does not cooperate with international standards for route reporting, and prefers to develop solutions individually for each situation. The greater concentration of this company is focused on the organization of information gathering and to a lesser extent on visual simulation, the only one presented by this company in open access, an example of the work is shown in Fig. 1.

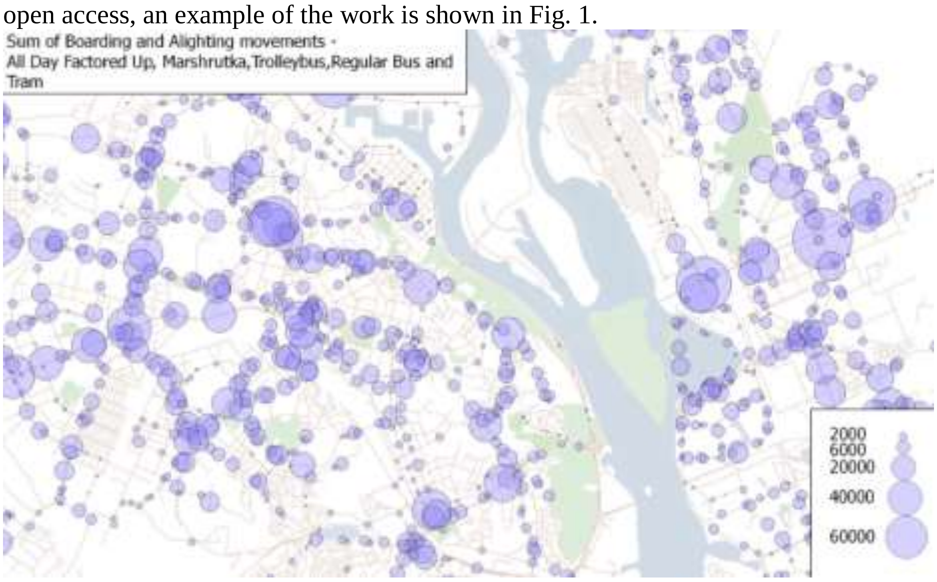

Fig. 1. Software from A + C Ukraine

As for the visualization of data from the electronic ticket from the site http://texty.org.ua/, it has not been updated since January 2019 and provides visualization only for a period of three months. It is worth noting that the e-ticket data is already partially distorted, because not all passengers buy a ticket immediately after entering the transport for various reasons, and not all passengers buy the ticket at all. This system does not use data from real passenger traffic and provides only a schematic picture of the tickets paid, without taking into account the current traffic load on the race.

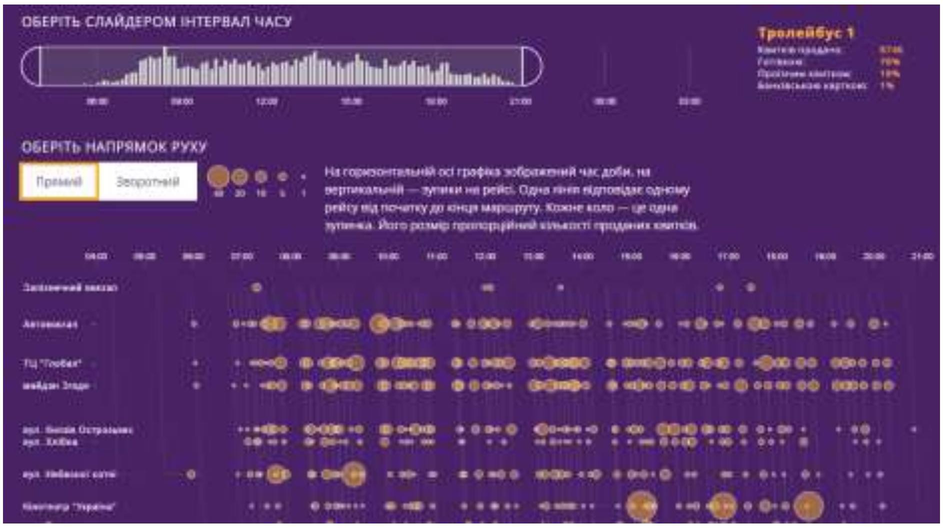

Fig. 2. Website texty.org.ua

3 Systematic Analysis of the Proposed Intelligent System for Visual Simulation of Passenger Flows

The developed intelligent system works with the most up-to-date data, downloading it at the user's request from the servers of the city. From the diagrams in Fig. 3 and fig. 4 shows that the proposed intelligent system is very flexible to use and does not require a long wait for updating and downloading of data for visual simulation or analysis. Most processes with large datasets are performed only once at initial startup or forced upgrade. In the future, this data is cached and does not require further updating. The creation of additional files for filling occurs in a fully automatic mode, where the user needs to fill in the data either in accordance with a specified template, which is created specifically to unify the process of interaction between different systems, or in accordance with the international standard GTFS.

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To facilitate the understanding of the main parts of the intellectual system, a description of the behavior of the projected system is presented in the form of an activity graph, which is depicted using the activity diagram, which is shown in Fig. 3 and the state diagrams in Figs. 4.

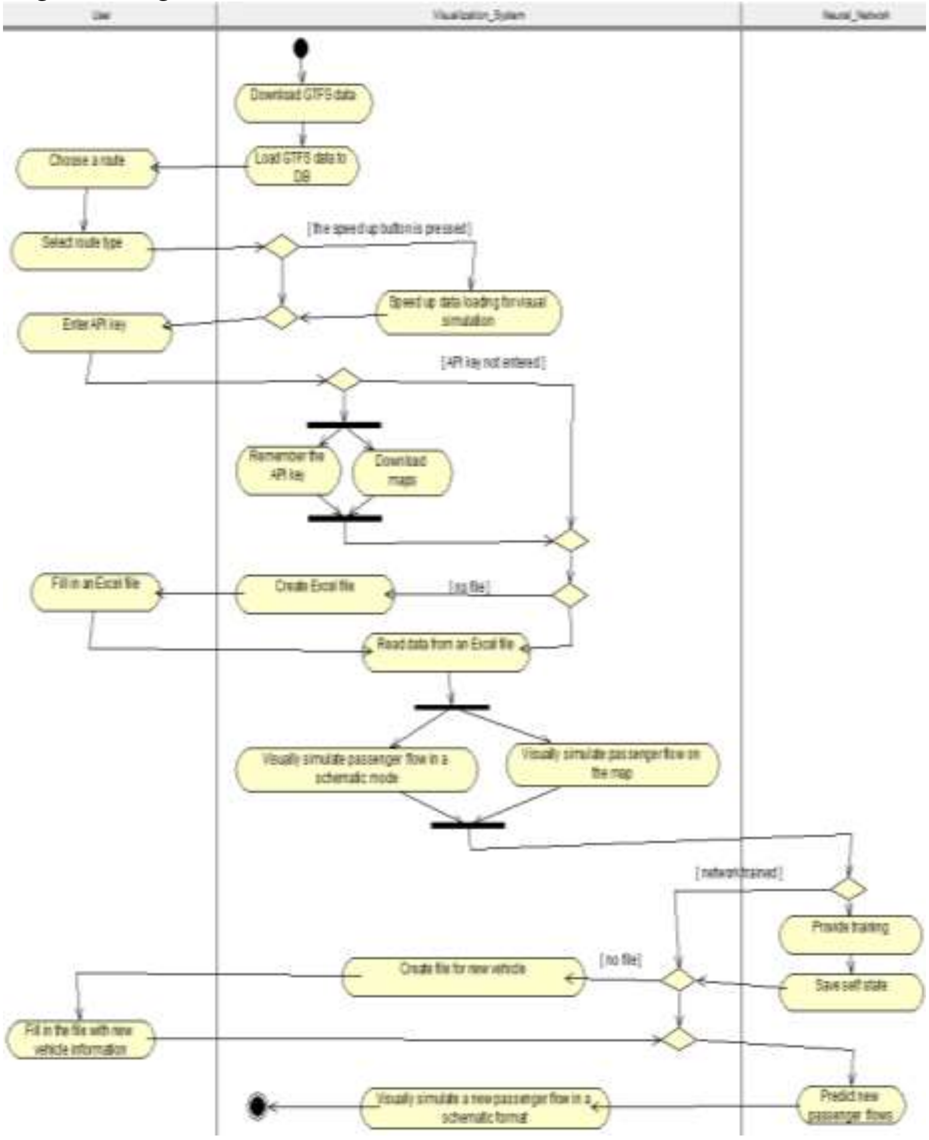

Fig. 3. Diagram of activity of the intelligent system

The neural network can be trained and retrained at the request of the user, which reduces the running of calculations for the next visual simulations. There are also two different modes of visual simulation: 1. With schematic representation of the route and stops on it. 2. Real image of the route with real scale on the map.

Map mode also displays a simulation of moving traffic throughout the day, displaying all passengers who are waiting for or are already in transit and are moving between stops.

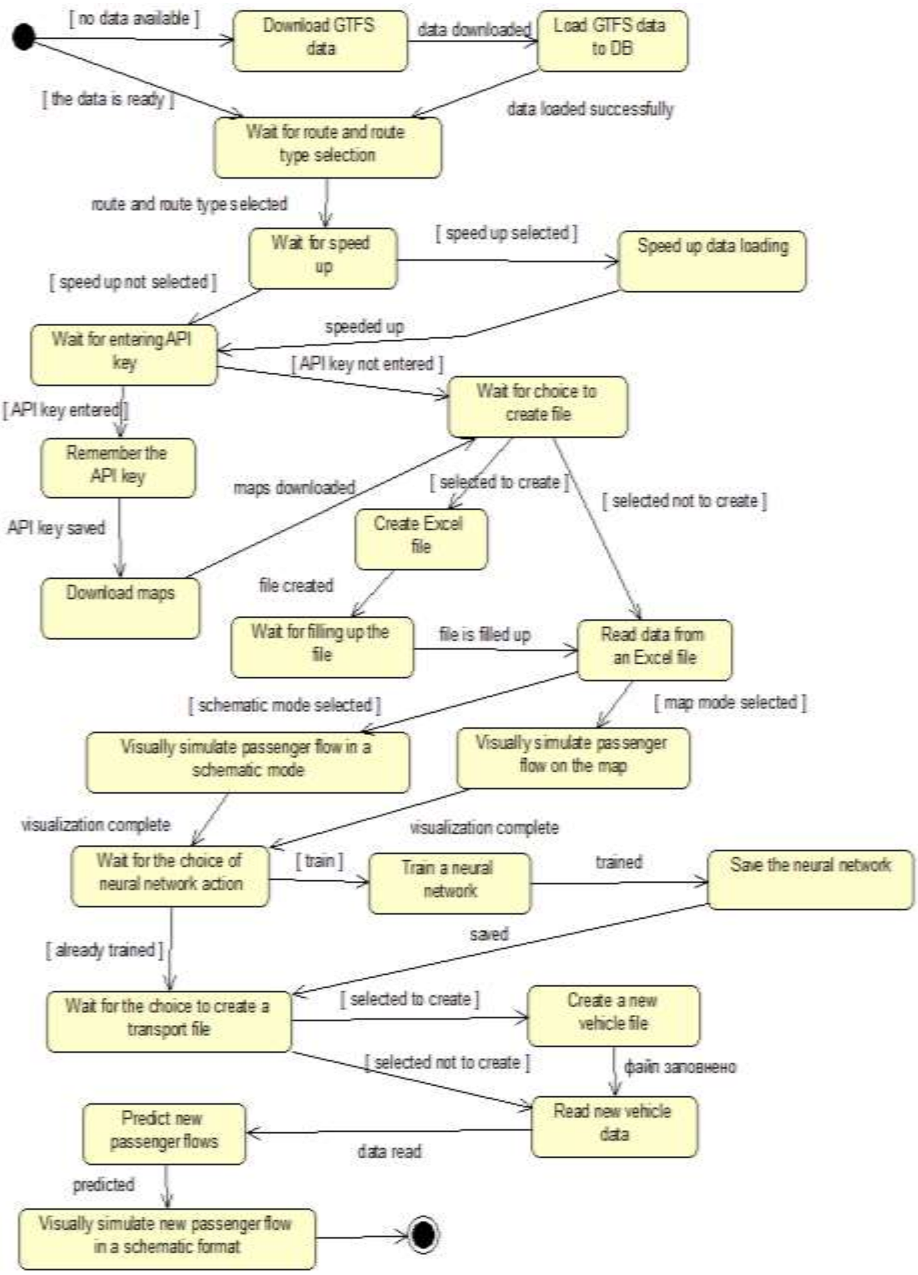

Fig. 4. State diagram

To understand the interaction of the user, the intelligent system and other components in Fig. Figure 5 shows a diagram showing that the system is constantly accessible and can be updated from the servers of the city where the most up-to-date information about all routes is located.

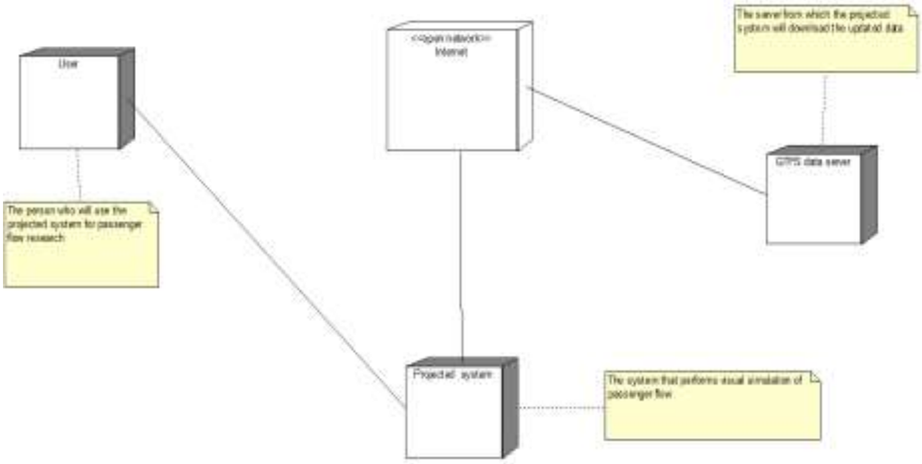

Fig. 5. Deployment chart

3.1 Description of the finished software

The main screen of the software is the interface shown in Fig. 6. The whole interface is made according to the CE (Chain Elements) principle, which indicates this type of interface when the user cannot click on buttons that are responsible for processing data that does not yet exist, instead the user only has access to the buttons that are currently available to use. And only after using the active buttons the user will gradually be able to access the following buttons. That is, the user at any time can be sure that if the button is active, then the action it describes will be executed exactly, of course, unless there is some unforeseen situation, which will be reported separately. According to this principle, in the presence of data, we can only update the data and choose the route and its type. Also, the application interface is made in the dark mode, which is now very popular for all software products or websites, which, in turn, is more pleasing to the human eye and not too bright.

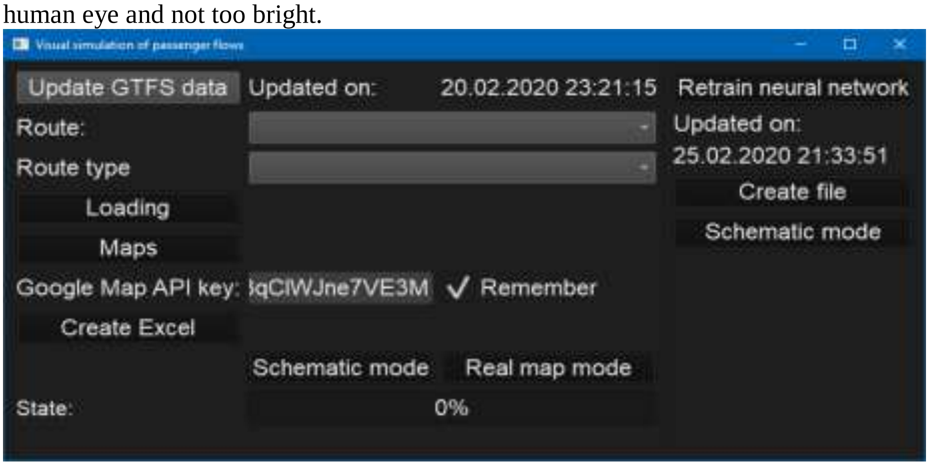

Fig. 6. The main interface

And in the absence of data, it will only be available to download the new data shown in Fig. 7.

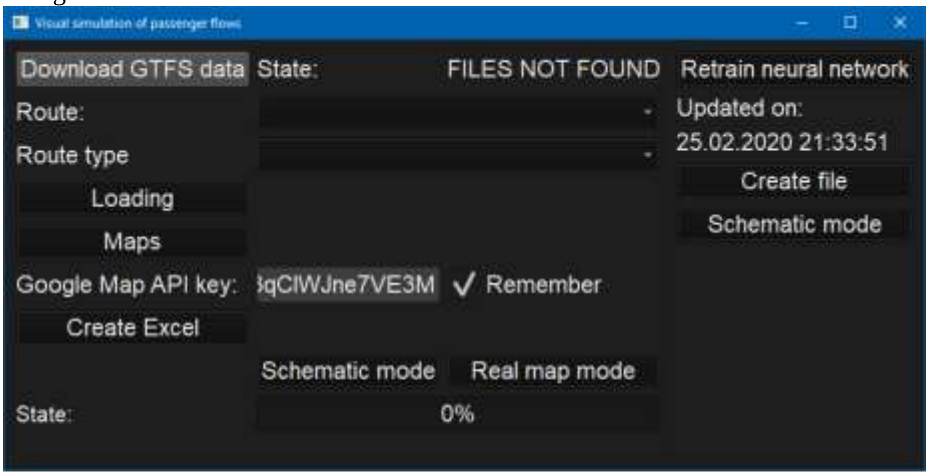

Fig. 7. Main interface without GTFS data

After selecting the route and its type, all other buttons and fields will be activated, and the type of download will be "fast" or "slow", that is, whether the program already has cached data, or whether to create a new cache for future runs. Immediately displays whether there are downloaded maps or not. In general, the application does not require maps, if the user does not have an API key for Google Maps, or does not want to use maps, the mode will be displayed without a card in the background, but with all proportions and scales. The main program window showing all the new features is presented in fig. 8.

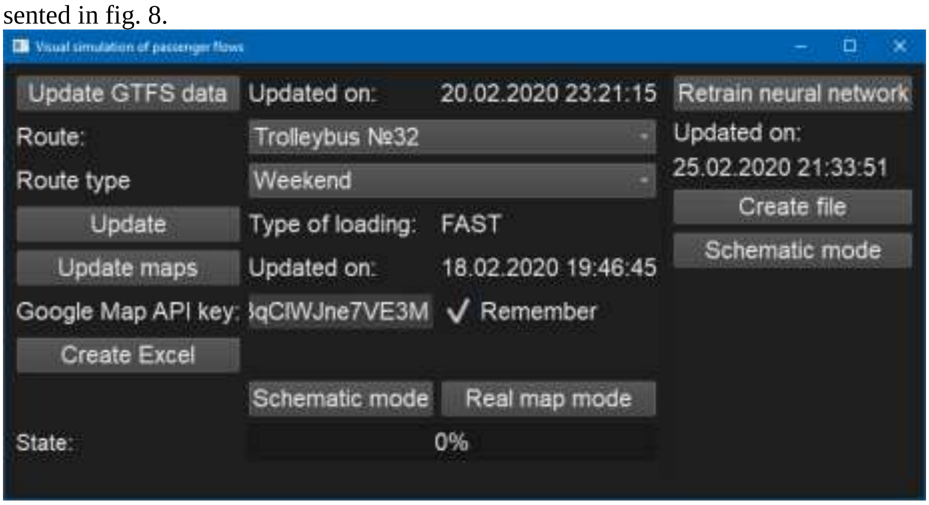

Fig. 8. Main interface with all active buttons

The Create Excel buttons create a file to fill with passenger traffic for each transport on the route. An Excel file is selected based on several factors, such as:

1. Passenger traffic data can only be collected by people who stop and count it manually.

2. With the help of special sensors mounted on the doors of vehicles, which in turn will be able to export the collected data to an Excel spreadsheet.

After successfully filling the Excel file with the number of passengers at stops, you can choose any mode, either schematic or on the map.

In schematic mode, stops are marked one by one according to their location on the route in the forward and reverse directions, there is a scroll up and down mouse to view all stops and arrow navigation to select the next or previous time intervals.

If you use the D key, you can get to see the general information all day, not hourly.

Each stop is signed by the name and number used at the actual stops in the city on the respective signs. The following is a summary of how many passengers went in and out at a stop over a given period, the sum of all flow passengers at a stop. The size and segments of a circle are dynamically determined. The larger circle indicates the greater number of people who came in and left at this stop. The segments are highlighted in different colors to reflect the attitude of those who have entered and those who have left.

Between the stops, the dynamic width of the line and the number indicate the passenger flow, that is, how many people were transported during this hour on this race between stops.

This mode's interface uses different colors to indicate different meanings and features. This is done to make the program interface as intuitive as possible without reading the documentation shown in Fig. 9.

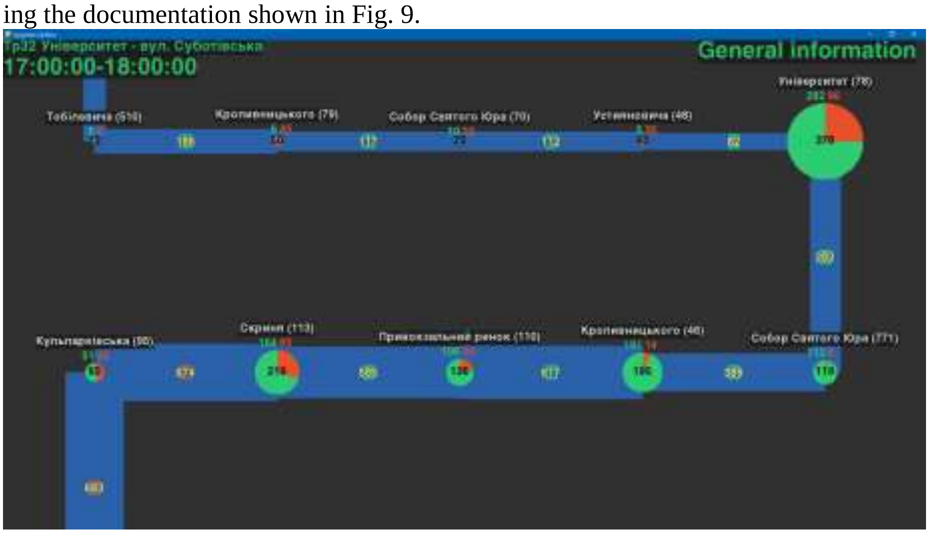

Fig. 9. Schematic mode

In this mode, you can also click on the stop and get more information, an example of a window is shown in fig. 10.

The races also support the function of an additional data window, which shows the maximum capacity of the race for several parameters, and of course all overloads are depicted clearly by the color change, which is shown in Fig. 11.

General information about the route is displayed by clicking on the button "General information" and an example of the window is shown in fig. 12.

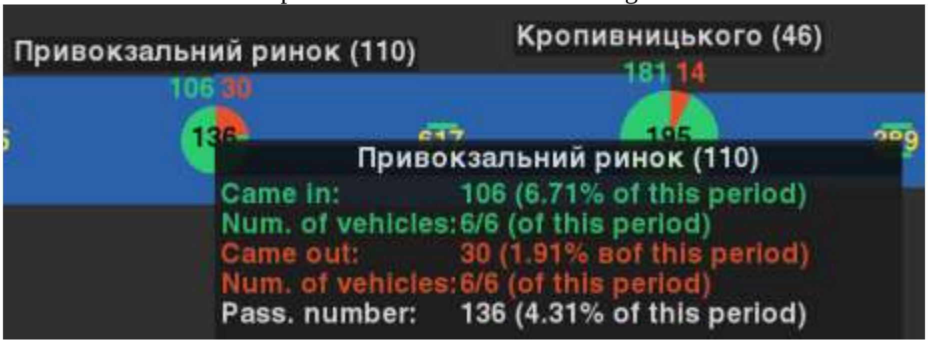

Fig. 10. Stop data window

Fig. 11. The distillation data window

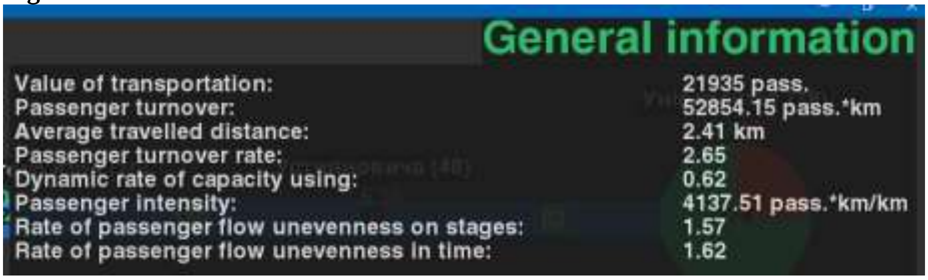

Fig. 12. General information window

Another available mode is the visual simulation mode on the map (Fig. 13), where according to the received data on the time of transport and passengers accurate simulation of traffic during the day with stops and picking up and disembarking of passengers. This mode is best suited to understanding where real congestion can be found on the map, or certain places that attract people to the city. Since the screen shows the exact time of day, you can also see how much traffic is currently on the route, what is happening to them, perhaps the vehicle at lunch, or moving too slowly than expected.

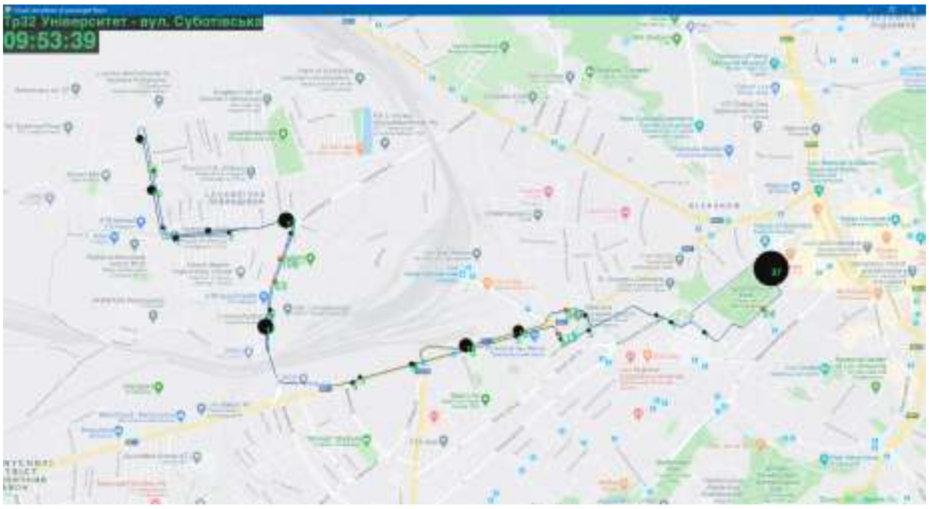

Fig. 13. Map mode

This mode also supports zoom in and out, slowing down the simulation 2 and 3 times (Fig. 14, 15) from normal. You can pause the simulation on the space key and examine this point in time. Red is indicated by the active vehicle on the route, yellow - if at lunch. At each stop, the number of passengers waiting for transport is indicated and the size of the circle that indicates the stop, the more people, the larger the circle, dynamically depends. The size of the circle increases dynamically between arrivals of transport, also at landing and disembarkation.

Movement in all directions is by arrows, zoom - mouse wheel. The standard animation speed is that 1 minute of virtual time is simulated in 1 second of real time, the speed can be reduced 2 and 3 times by the PageDown key, and the speed increase by the PageUP key.

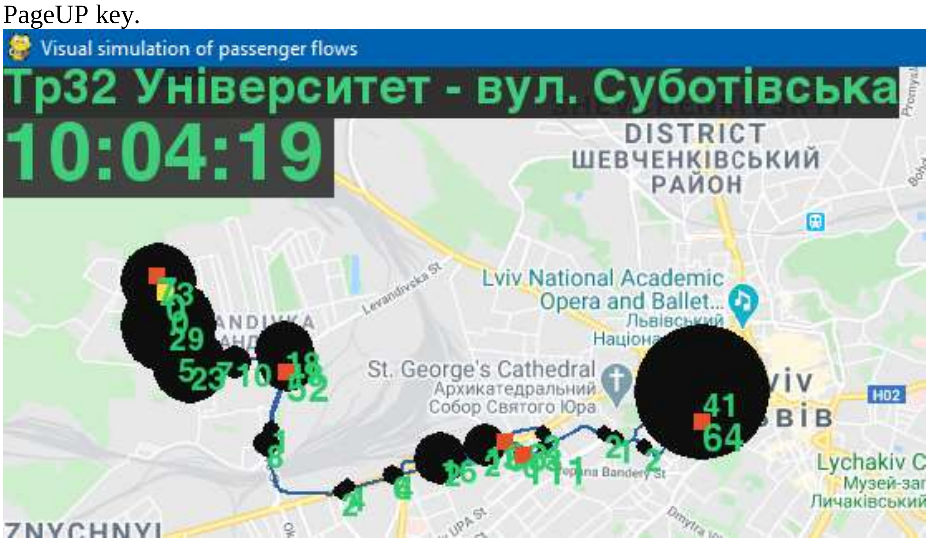

Fig. 14. The smallest zoom

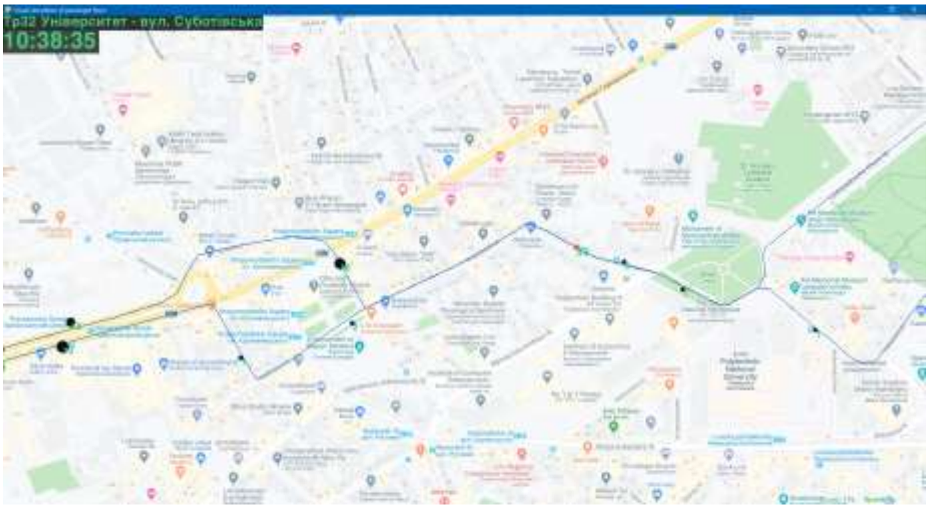

Fig. 15. The greatest zoom

Regarding the interaction with transport forecasting, there is a separate block on the right side of the main menu (Fig. 8), in which you can train the neural network, after which it will be saved and will not require retraining. The program also creates a template file for the submission of information in GTFS format, which should fill the user with a new additional transport schedule. Pressing the "Scheme Visualize" key asks for the capacity of the added transport in the window in fig. 16, the passenger traffic data is recalculated and it is displayed in the schematic display mode (Fig. 17).

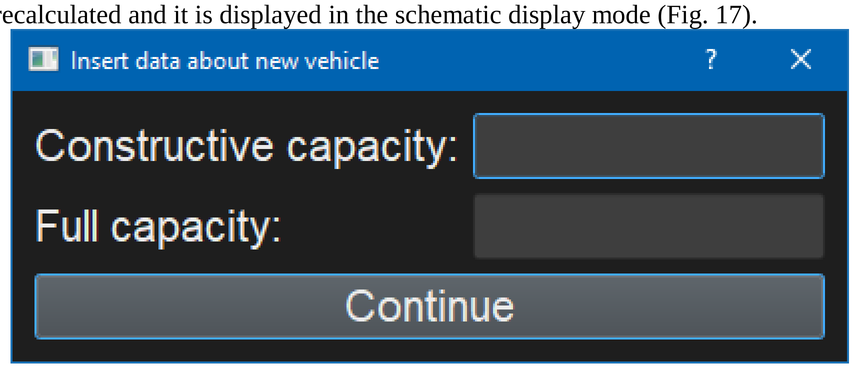

Fig. 16. Window for entering capacity

Fig. 17. Changed passenger flows

4 Conclusions

The paper investigates a number of existing passenger software products on the market. It is established that the key task of public transport information systems is to evaluate passenger traffic. Their possibilities, accessibility, principles and principles of optimization of passenger transportation are analyzed. It is established that the visualization of passenger flows is one of the important tasks of optimizing routes and improving the quality of passenger transportation by public transport. An intelligent system of visual simulation of passenger traffic is proposed, which, based on the operation of the neural network, allows optimizing the work of passenger transportation by public transport.

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