Imitation modeling as a forecast of transport flows self-organization

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Abstract. The problem of reorganizing the road traffic at the time of repair roads is always worthwhile, since the roads are constantly becoming unusable and there is a need to maintain them in proper condition. Frequent repairs are caused by an increase in the number of cars on the roads, as the road surface wears out faster because of this. During repair, the entire repair section often overlaps, and due to the redirection of traffic flows, the load on the adjacent sections changes. This paper analyzes the method of predicting the traffic situation, in which the load on the road network increases due to changing traffic conditions. The application of the simulation method can significantly simplify the task of predicting the behavior of drivers in traffic, as well as help to develop in advance measures to prevent congestion and accidents.

1. Introduction

The application of the simulation method can significantly simplify the task of predicting the behavior of drivers in traffic, as well as help to develop in advance measures to prevent congestion and accidents.

To solve the problem of predicting the movement of traffic flows, a simulation method is used. Models are created in the program PTV VisSim [1-3].

The VisSim program is designed to build, research and optimize virtual models of physical and technical objects, including control systems. VisSim is an abbreviation of the expression Visual Simulator – a visual, perceptible, medium and simulator.

In the description and subsequent construction of the model in the VisSim environment, there is no need to write down and solve differential equations, the program will do it itself according to the structure of the system proposed by the researcher and the parameters of its elements. The results of the solution are displayed in a visual graphic form. Therefore, the program can also be used by those who do not have deep knowledge in mathematics and programming.

The initial data for the creation of the average model are the following data:

- sub base in the form of an image or a drawing;
- intersection parameters;
- the nature of traffic and pedestrians and other data;
- time of traffic light cycles;
- priority rules;
- availability of parking and stops.
Using the PTV Vissim 9 (Student) program, a fragment of the road network is modeled, which includes N. Suslova, Vaneev, Vasyunin, Kornilov and Ivliev streets. The study was conducted at the beginning of the 2018.

![View of the street road network’s (SRN) satellite (Yandex maps, dated 03.21.18)](image1)

**Figure 1.** View of the street road network’s (SRN) satellite (Yandex maps, dated 03.21.18)

A speed limit has been introduced for all sections, the number of lanes, their width and number [2], which form the vehicles approaching the intersection, are taken into account. In real driving conditions, some drivers form two instead of one row. Violations are modeled by adding a strip. The routes of the route vehicles, the stops and the interval of movement are set. Conflict points and directions of movement along the lanes are made in accordance with traffic rules and signs [1]. The ratio of freight and passenger vehicles in the stream (2% and 98%, respectively) was introduced.

![Traffic light cycle at the Vaneev street–Suslova street junction.](image2)

**Figure 2.** Traffic light cycle at the Vaneev street–Suslova street junction.

Public transport routes are modeled separately, with their stopping points and timetables. Each traffic light is governed by its traffic light cycle, the phases are set separately. When drawing up cycles, the
degree of observance of the traffic light signal is set. Non-observability of signals from drivers up to 2%, from pedestrians up to 25%. Figure 2 presents an example of the traffic light cycle.

At some crossings, not all drivers and pedestrians are waiting for the traffic light to allow, then we set a slightly lower degree of observance on them. At a pedestrian crossing opposite the exit from the parking lot near the shopping arcades at the Vasiunin street, the observance of pedestrians is 92-93%, the drivers at the same exit are 98-99%. Departures from parking on the Firebird shopping center – pedestrians – 85%, cars – 95%. At a pedestrian crossing at the intersection of the Kornilov street – Suslova street, when passing through the Kornilov street, the observance of the traffic light signal at pedestrians is the smallest among all the intersections under consideration and is 74%.

Next we modeled the situation with the repair work. The main work in this block is the reorganization of public transport routes. Then we changed the routes of vehicles. As a result, it was obtained that along the Nadezhda Suslova street the flow actually decreased to 0, and the flow on the streets of Boris Kornilov street and Vasiunin street increased significantly.

On the Suslova street a turn was organized from the Vaneev street, because part of the drivers, not noticing the signs informing about the repair, still drive into the blocked area. Also, there is a potential route for detouring a blocked plot through courtyard territories, but the model did not reflect this entire route, but only its beginning.

Figure 3 presents the crossing of the Suslova street-Kornilov street with barriers.

The first phenomenon that attracts attention is the occurrence of congestion on sections of roads where traffic jams were not usually observed. In the model, this picture may initially seem critical and suggest the idea that the road network does not cope with non-standard loads. Also in the Vasyunin Street there are a lot of buses and minibuses, so there are lines at some stops. Here one of the limitations of the program becomes apparent: buses stop at exactly the designated stops of the route vehicles, while in real conditions this rule is not always respected.

In order to objectively assess the changes occurring in the movement of traffic flows, we use the function of the VisSim and take several measurements. For the analysis of installed meters of the length of the mash and time counters in transit vehicles.
Based on the obtained values of “maximum mash length”, Tables 1 and 2, the traffic jam at the Suslova street –Kornilov street intersection slightly decreased (counter 1). The traffic jam at the traffic light at the exit from the parking lot of the shopping mall (counter 3) increased one and a half times. Through this place there is the entire stream, redirected from the Suslova street. Values "mash length" reflect a similar situation.

| Counter number | Average mash length | Maximum mash length |
|----------------|---------------------|---------------------|
| 1              | 10.55               | 37.04               |
| 2              | 4.16                | 32.85               |
| 3              | 5.03                | 41.75               |

Table 2. Length of congestion after reorganization.

| Counter number | Average mash length | Maximum mash length |
|----------------|---------------------|---------------------|
| 1              | 4.10                | 26.17               |
| 2              | 7.04                | 82.44               |
| 3              | 10.54               | 67.47               |

The travel time from the Ivliev street –Suslova street intersection to Sovetskaya Square was practically unchanged before and after the reorganization, from which it can be concluded that the increased flow could not significantly delay the transport. And the way from the Ivliev street –Suslova street intersection to the Suslova street –Vaneev street increased 2 times. The path to the reorganization was approximately 980 meters, after the reorganization 2500 m. Accordingly, the increase in travel time is due to an increase in the route, rather than a more busy SRN.

| Counter number | vehicles (all) | vehicles (min) | vehicles (max) | travel time (average) | travel time (min) | travel time (max) |
|----------------|----------------|----------------|----------------|-----------------------|------------------|------------------|
| 1              | 21             | 19             | 2              | 179.21                | 173.48           | 233.67           |
| 2              | 25             | 17             | 8              | 246.14                | 209.33           | 324.36           |

Table 4. Travel time after reorganization.

| Counter number | vehicles (all) | vehicles (min) | vehicles (max) | travel time (average) | travel time (min) | travel time (max) |
|----------------|----------------|----------------|----------------|-----------------------|------------------|------------------|
| 1              | 4              | 2              | 2              | 342.78                | 242.43           | 443.14           |
| 2              | 8              | 5              | 3              | 269.70                | 233.73           | 329.66           |

Based on the two measurements taken, several conclusions can be drawn.

At first, as is obvious, small traffic jams in the street road network inevitably arise and the path of cars from point a to point b increases.

Secondly, we received that in this system of streets the reorganization of traffic flow is very successful.

Thirdly, it can be concluded that the network in question is capable of withstanding an even greater transport load, and in the near future it and its elements (roads and intersections) will not have to be modernized.

In the process of modeling, an important role is played by the correct collection of initial data and a complete mapping of the road situation, including traffic violations. Occasional particular cases of driver or pedestrian behavior, such as not giving a driving advantage or not observing banding, are defined by
separate lanes, conflict zones, which overload the program. It is difficult to organize overtaking or advancing, as in a real situation each driver determines for himself the possibility or impossibility of overtaking in different ways. In spite of the fact that in real conditions drivers refuse to perform a maneuver, the program sets a flow regime in which all possible maneuvers and rebuilds are performed. Cars in the animation drive too close to each other, which is not recommended, because you can provoke other road users to create an emergency. The student version of the program has a number of limitations, due to which it is impossible to reflect the entire road situation.

The program is suitable for obtaining the most likely option for the reorganization of traffic and pedestrian flows; it reflects a clear and illustrative traffic pattern.

References
[1] 2019 Rules of the road as of 2019 (Moscow, Eksmo)
[2] GOST standard R 50597-93 Highways and streets. Requirements for the operational condition, acceptable under the terms of road safety (Moscow, Eksmo)
[3] Vorobev A I, Gavrilyuk M V, Pletnev M G 2016 Methodical instructions for laboratory work on the course "Intelligent Transport Systems" (Moscow, MADI)
[4] Strohalev V P, Tolkacheva I O 2008 Imitating modeling (Moscow, MSTU n a Bauman)