MODELING AND NANOTECHNOLOGY


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SIMULATION EXPERIMENT OF A CONTROL OPTION TO IMPROVE TRAFFIC SAFETY AT A INTERSECTION

Abstract. The article considers the construction of a micromodel using the Anylogic software for analyzing the organization of traffic at an unregulated intersection and considers a variant of improving the organization of traffic. The conditions for the use of traffic light regulation at the intersection were checked. For the proposed option, a logical algorithm of the agent model is built and visualized. The developed technique for modeling conflict-free pedestrian and traffic flows at an intersection is proposed for use at other similar intersections.

Keywords: intersection, micromodel, Anylogic, pedestrian crossing, traffic light control.

Introduction
The growth of cities and the increasing need of the population for mobility caused the need to take measures to regulate traffic not only in the central part of the
city, but also in the suburbs. It is no coincidence that in 2013 the European Union published a document called the Sustainable Urban Mobility Plan and thus began serious work to address the problems of urban transport. Ensuring the rapid and safe movement of the population is a key priority.

The rapid development of information technology, as in all areas, has a significant impact on the solution of transport issues. Using modern software, it becomes possible to simulate transport and assess mobility. Numerous software tools are used to simulate transport processes (GPSS World, PTV, Anylogic, Flexsim, etc.). Among the software tools offered for designing micromodels of traffic control in cities, Anylogic looks more attractive due to its capabilities. Through the program, it is possible to implement agent-based modeling, which allows you to enter specific parameters of traffic participants. These parameters include factors such as vehicle speed, acceleration and deceleration, length, speed of pedestrians, and even the mathematical pattern of their movements.

These simulation programs are extremely effective for objects whose operation is very difficult or expensive to test in real life. In addition, the software itself allows you to correct and calibrate the final model. It should be noted that the system model is often simpler than the actual system itself. One of the main reasons for this is that the model does not take into account parameters that do not affect a particular system. The main stages of building a model are the adaptation of the real system to the model, the choice of abstraction level and the choice of the model language. Once the model is built, you can test the upgrade options by creating different scenarios. Once the optimal solution is found, it can be proposed for use in a real system [1].

At the intersection of two or more roads, i.e. at intersections, there are points of conflict between vehicles and the flow of pedestrians. Such conflict points create the possibility of delays and accidents. Thus, at each intersection, regular monitoring of the organization of traffic is required.

**Literature analysis**

An intersection or interchange is a part of the transport network used by a certain number of vehicles at a given time interval in accordance with the queuing
scheme used for crossing. Delays and queues are key features of such an intersection, which helps to analyze and design an intersection for a particular service level [2].

Capacity at unregulated intersections is calculated based on different approaches. Basically, these are deterministic and probabilistic methods. The first method was developed in Germany and takes into account gaps, which is also used in the US and Europe. The basic principle of this method is to calculate the carrying capacity of the vehicles on the secondary road and on the intermediate times. The second method is an empirical regression method and is based on the use of a regression function for indicators obtained from a large number of observations. When determining the capacity in this way, the geometric design of the road, visibility, the total number of vehicles and the number of turning vehicles are taken into account [3].

In a study by Suprabeet Datta et al., turn-in delays are assessed through microscopic analysis, taking into account unruly driver behavior. In a study conducted at 13 unregulated intersections, the speed of vehicles that caused a conflict situation on the right and left turns, the turn time depending on the class of vehicles were determined. In addition, the influence of oncoming vehicles on turn delays was evaluated. The authors tried to prove that the proposed method allows estimating 52% of delays [4].

In another article, Suprabit Datta notes that the lack of "Give way" and "Stop" signs at intersections causes problems at unregulated intersections. To build mathematical models, the author used the number of vehicles that can meet at conflict points, and their speed. Delays at 13 selected intersections were examined and validated by PARAMICS after real-time video calibration [5].

Abhishek addressed the issue of ensuring a constant maximum speed on the secondary road at an unregulated intersection relative to traffic on the main road. The study analyzes the behavior of traffic participants based on the theory of queuing [6].

There are studies at non-regulated intersections using modern approaches to traffic management, for example, Mohammad Ali Sahrai modeled delay
management at unregulated intersections using an artificial neural network [7].

Adebayo B. Bakare compared the methods for determining capacity at unregulated intersections in Sweden and the United States and noted the advantages and disadvantages of the Swedish method based on queuing theory and the American method of determining the estimated capacity based on empirical experience [8].

**Research Methodology**

In large cities, road junctions, especially unregulated intersections, are considered problem areas in terms of road safety. Under certain conditions at intersections, an adjustment of the traffic light mode is applied. If this is impractical, alternative methods of regulation are used. In any case, it is necessary to predict in advance and analyze in detail the situation at the intersection. With the help of modern software, especially simulation modeling, the task has become much easier. The creation of computer simulation models makes it possible to predict and evaluate the conditions that may arise at a particular intersection. Therefore, using the Anylogic 8.7.10 simulation software, an assessment of the current situation at the intersection of Nikolai Baibakov and Seyid Hussein streets in the Sabunchu hospital area (Baku city) was carried out, the proposed calculation options were substantiated and both options were visualized.

Firstly, the problems that arise in the current traffic situation at the intersection were analyzed, the conditions for using traffic light regulation in the node were checked to improve traffic, and a simulation model of the proposed regulation option was created and substantiated.

**Building a simulation model for traffic control at an intersection**

Crossings of roads, traffic and pedestrian flows at the same level are called intersections. However, in some cases, the concepts of a transport hub, road junction, area, etc. are also used. According to the rules of the road, the rules for crossing intersections are as follows:

- a driver turning right or left must give way to pedestrians and cyclists crossing the carriageway;
- if there are traffic jams at the intersection, forcing the driver to stop and
preventing the movement of other vehicles, the driver is prohibited from entering such intersection.

Traffic at the intersection is organized in two ways with regulation and non-regulation. An unregulated intersection is an intersection where there is no traffic controller, a traffic light is not installed or turned off, or a flashing yellow light signal is on [9]. Unregulated intersections are divided into 3 parts according to the method of organizing traffic: unorganized, with priority and roundabouts.

Crossroads, unregulated by technical means, are created at the intersections of minor streets and roads with very low intensity. The traffic priority at these intersections is based on the principle of "no obstacles on the right". At such intersections, the speed depends on the side visibility distance. Particular attention should be paid to intersections with a side visibility distance of less than 20 m. Priority signs should be used here. At the intersection of Nikolai Baibakov and Seyid Hussein streets in the Sabunchi settlement, regulation is carried out on a priority basis (Figure 1).

Fig. 1. Traffic jams on Nikolai Baibakov Street during peak hours

In a simulation model built on the values obtained as a result of real-time live observation of traffic and pedestrian flows at the considered intersection, density can be observed. Since there is no pedestrian crossing around the intersection, pedestrians cross the road from different places and are exposed to certain risks. Modeling the current situation at the intersection allows you to visualize the complexity of the emerging traffic mode (Figure 2).
Various scenarios can be proposed to reduce congestion at the intersection in question. First of all, it is necessary to check the feasibility of using traffic light regulation at intersections.

Regulated intersection - an intersection, the traffic sequence at which is determined by traffic lights or traffic controllers.

The use of traffic lights at intersections is carried out under certain conditions. The requirement for a traffic light is determined by analyzing the existing safety factors, as well as by the following conditions [10,11]:

1. According to the intensity of the eight-hour movement
2. According to the intensity of the four-hour movement
3. Traffic intensity during rush hours
4. According to the intensity of pedestrian traffic
5. By the presence of the transition of schoolchildren
6. By the presence of a coordinated regulatory system
7. Accident statistics
8. By road network
9. By the presence of an intersection close to an intersection of the same level

At the intersection we are considering, pedestrians have to wait a long time to cross the road. In addition, this transition is not secure. If there are schools around the intersection, it is advisable to create an adjustable crossing when the maximum number of students crossing the road in 1 minute is more than 20. In this case, only
the intensity of high school students should be taken into account.

Observations of the hourly traffic intensity at the considered intersection show that it is expedient to use traffic light regulation here. Thus, the intensity of pedestrian traffic at the intersection during peak hours was 190 people per hour. In addition, 2 school buildings are located around this transport interchange. Since the intensity of pedestrian flows and the movement of schoolchildren is quite high at the intersection, it is advisable to use traffic light regulation.

To ensure the sequence of the transition of pedestrian and car flows, we will build a statechart (Figure 3).

![Statechart Diagram](image)

Fig. 3. **Organization of transport and pedestrian crossings at a regulated intersection**

The following codes are used to ensure movement in accordance with the forbidding and green traffic lights:

- Pedestrian 1 and car 1 - stopLine2
- Pedestrian 2 and car 2 - stopLine 3
- PedAreaDescriptorE - pedCountbefore++; pedCountbefore--;
- PedAreaDescriptorI - pedCountForward++; pedCountForward--;
- PedAreaDescriptorG - pedCountBackward++; pedCountBackward--;

Using the tools Car Source, Car Move To, Car Dispose, PedSource, Ped Move To, Ped Go To, Ped Sink, a logical diagram of the movement of vehicles and
pedestrians at the intersection is created (Figure 4).

To simulate the movement of pedestrians in the model, the Pedestrian Type function is selected from the Pedestrian Library and various agents for pedestrians (doctor, nurse, policeman, worker, soldier, engineer, etc.) are selected in the window that opens. A color parameter is added to the window that opens to select an agent.

Parameters for vehicles are also selected from the road library.

To assess the situation that will arise as a result of the use of two-phase traffic light control at the intersection, the mode of operation of traffic lights at the intersection is determined based on a well-known technique, according to the intensities of vehicles under existing conditions [12]. The window for entering the values of the duration of traffic lights into the program is shown in Figure 4, the logical diagram of the movement of vehicles and pedestrians at the intersection is shown in Figure 5, and the created micromodel of the intersection is shown in Figure 6.

Fig. 4. Window for entering the traffic light operation mode into the model

Fig. 5. Traffic flow diagram at the intersection
Fig. 6. 3D image of the intersection after applying the traffic light

As can be seen from the figure, the use of traffic light regulation at the intersection leads to an increase in the safety of pedestrians at the intersection, and a decrease in traffic congestion.

**Conclusion**

The development of micromodels with the help of simulation programs for solving problems related to the organization and safety of traffic at intersections, where pedestrian and traffic flows increase, allows you to quickly and efficiently solve these problems and test various scenarios. Before considering the application of complex design solutions at the considered intersections, it is important to check the effectiveness of simple solutions (for example, the use of traffic lights) that are easy to implement in the Anylogic environment. For example, for the intersection we are considering, the effectiveness of the proposed scenario (the use of traffic lights) can be justified both visually and by statistical indicators.

**References:**

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