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Method of Video-Measurements of Traffic Flow Characteristics at a Road Junction

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Abstract

In the theory of traffic flows the main characteristics are: intensity, speed, and density. They make it possible to use hydrodynamic models. In connection with the development of modern highways and road networks, traffic flows behavior is becoming more and more complex and diverse. In particular, the B.Kerner studies have shown that the laminar solution of hydrodynamic models is poorly correlated with experimental data. Our research team is developing tools for intelligent monitoring of traffic flows on fragments of the road network with different geometries. The paper presents a project of a client-server system, which allows obtaining, in real-time, information regarding the basic characteristics of traffic flows at the junction of any configuration using mobile devices. The automation of obtaining characteristics is based on the application of image recognition algorithms (virtual detection method).

Keywords: Traffic Flow; Computer Vision; Traffic Model; Mobile Application; Client-server Architecture; Virtual Detection Method.

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Introduction

The group of Professor A.P. Buslaev since the end of the last century is engaged in the development of the theory of transport flows, optimal control taking into account traffic jams and load modes of engines in different road conditions (Lukanin et al, 1998; Lukanin et al, Part I, 2003; Lukanin et al, Part II, 2003). Deterministic-stochastic models of mixed traffic flows are used for more accurate propagation based on mathematical modeling.

Modern Problems of the theory of transport flows include approaches to the modeling of pedestrian flows (Kozlov et al, 2011), as pedestrians are an important part of road traffic.

In the past decade, general tasks of pattern recognition for transport research have been set. In particular, (Buslaev et al, 2010) raised the task of recognizing a person at full height and modeling the dynamics of his movement, to ensure safe traffic.

In one of our works approaches to recognition of road signs, traffic lights, and markings from a carboard, in particular, a pedestrian "zebra" by video sequence were considered (Yashina et al, 2011). This video sequence was captured from a smartphone and then processed using OpenCV. Initially, the mobile application was developed for the mobile platform Windows Phone, but later it was decided to transfer the project to the Android operating system, due to its greater distribution and greater choice of smartphones with different camera parameters.

For research carried out in the daytime in the sun, it is relevant to consider the shadows of cars. They are monotonous, can be easily seen on the asphalt, and with the help of the algorithm of restoring 3D objects by shadow (Buslaev et al, 2009; Buslaev et al, 2010), we will be able to find the shadow and highlight the car itself.

This paper presents a project of a client-server system, which allows obtaining, in real-time, information regarding the basic characteristics of traffic flows at the junction of any configuration using mobile devices. The automation of obtaining characteristics is based on the application of image recognition algorithms (virtual detection method).

Monitoring and Optimization of Traffic Intensity Measurements

Since the 2000s, the Department of Higher Mathematics, headed by A.P. Buslaev, has been engaged in research on traffic flows.

Adjustment of model parameters is carried out with the help of results of road traffic flow characteristics carried out at certain measuring points. One of the possible technologies is schematically depicted in the Figure 1.

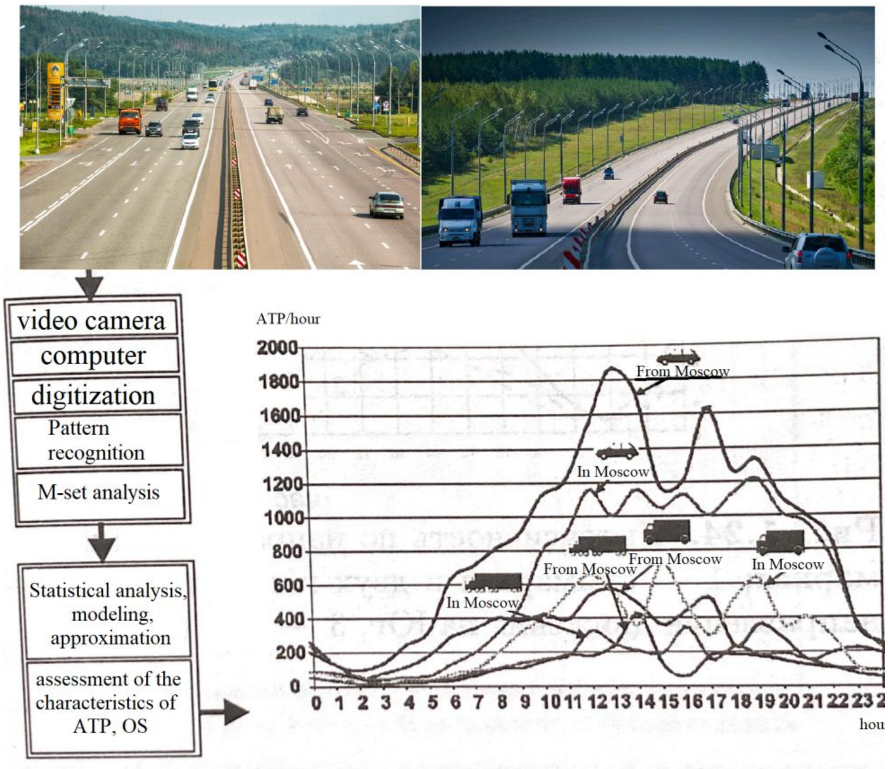

Figure 1. Highway video monitoring scheme

Figure 2 shows the dependencies of intensity on the day of the week, typical for the roads of the Moscow region. The data were obtained with the help of video footage taken by the Department of Mathematical Modeling of the Moscow Automobile and Road Institute (MADI) on 35 kg of M2 "Crimea" highway.

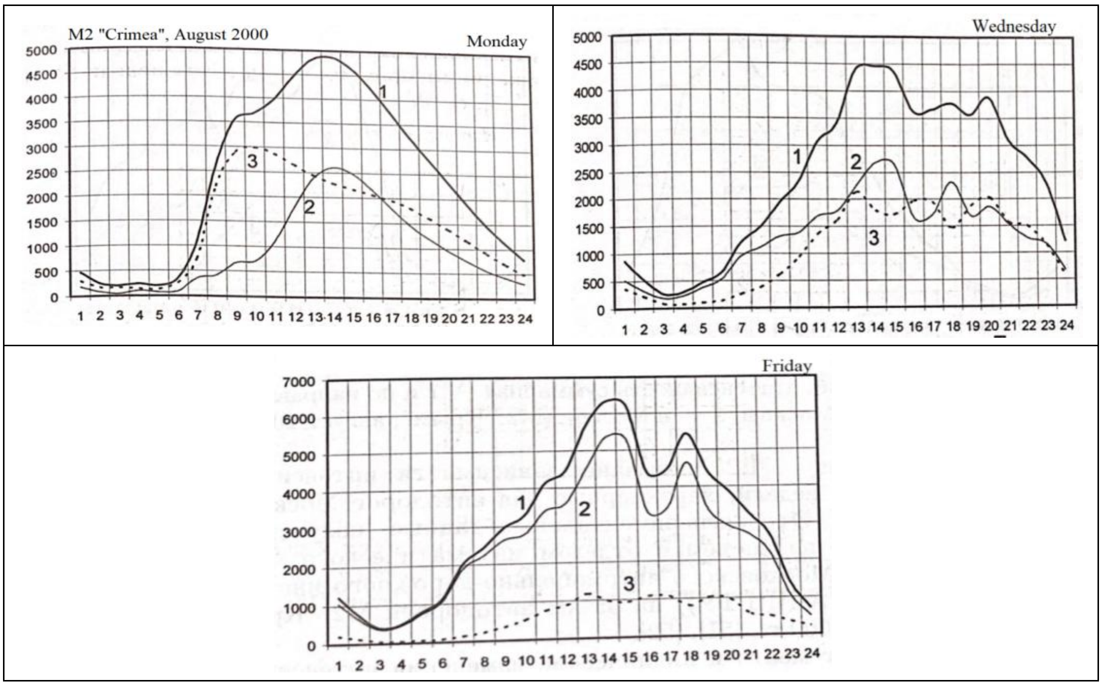

Figure 2. Intensity graphs: 1 - total intensity in two directions; 2 - the direction of movement on us; 3 - the direction of movement from us

Monitoring of traffic flows at interchanges is an important problem in traffic flows study. A very large part of traffic accidents takes place at a road junction and with increased traffic intensity there are often situations when the traffic participants do not have time to finish the maneuver in the allocated time. Based on the intensity data, we can conclude that there is an excessive load on any of the directions at the intersection.

In the theory of traffic flows the main characteristics are: intensity, speed, and density. They allow the use of hydrodynamic models. Due to the development of modern highways and road networks, the behavior of traffic flows is becoming more complex and diverse.

Traffic flows can be investigated both from the side of the vehicle and from fixed cameras installed either at the edge of the carriageway (side view) and from the overpass or UAV (top view) (Figure 3).

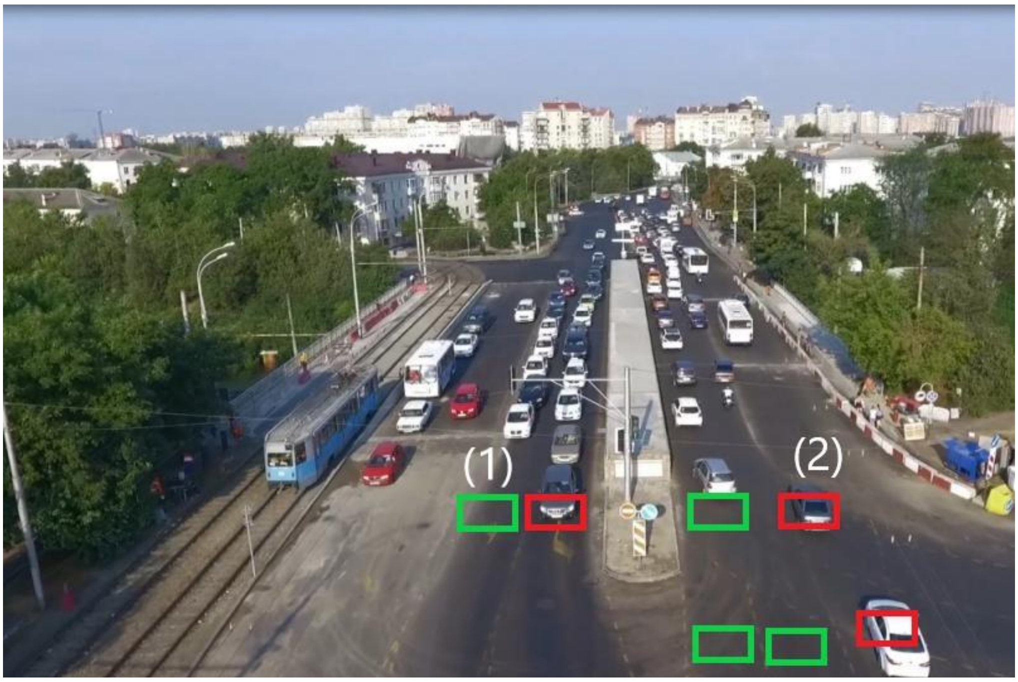

Figure 3. UAV shoot

When researching flows from a camera installed in a car, as a traffic participant, it is possible to recognize cars by video sequence, to obtain patterns for follow-the-leader models and the frequency of redevelopment. Such researches were carried out with the help of laboratories of MADI HM department (Figure 4).

With fixed cameras, we can monitor the intensity of traffic flows by counting the number of vehicles passing through all the lanes, or by compiling the intensity for each lane. With this method, we can calculate how the traffic intensity changes before and after the exit of the main road, obtaining data on the division of traffic flows.

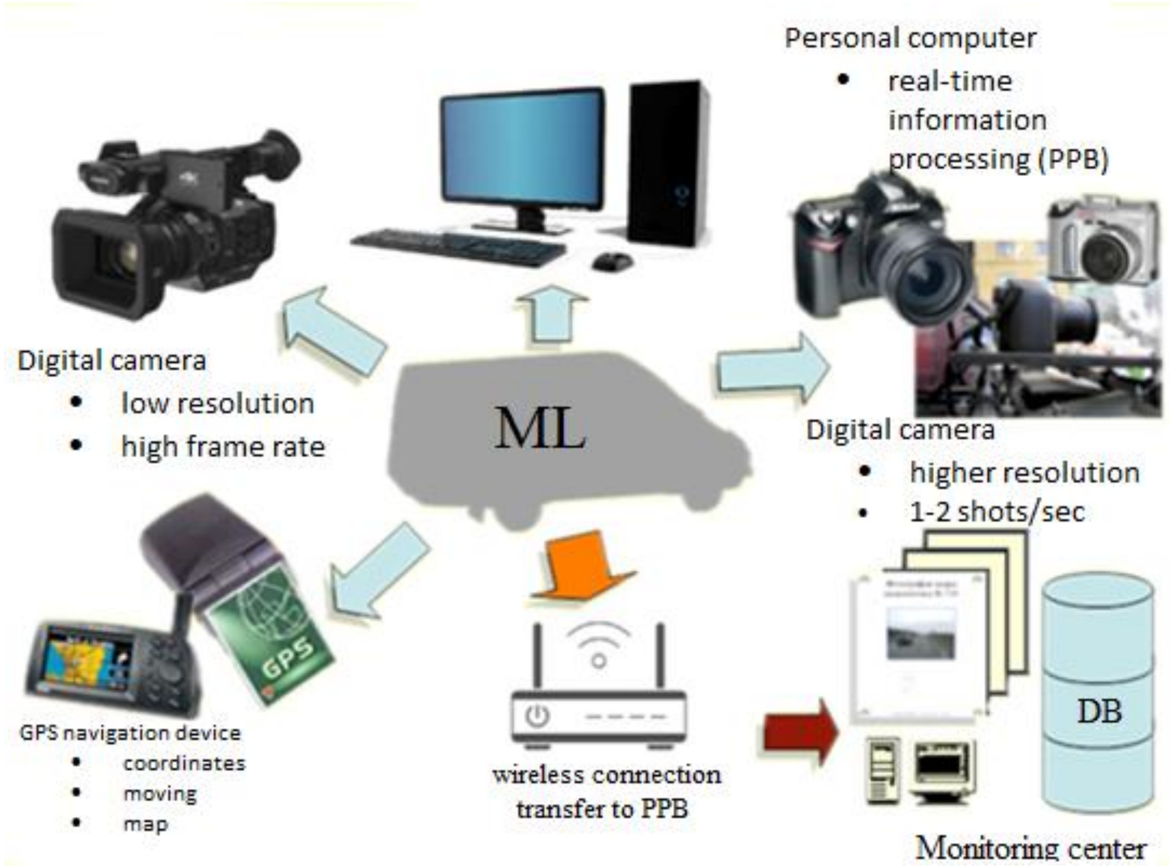

Figure 4. Road laboratory of the HM department

In this article, we introduce a new system for considering input and output flows at intersections. For this research, smartphone software has been written that allows the intensity of traffic flow to be read across the road. The intersections are divided into several types, depending on the number of adjacent roads: X- shaped, T- shaped and Y-shaped. Depending on the intersection type, we need to install cameras, for example, for the X intersection we need 4 operators with cameras if the road has no more than two lanes. In the case of multi-lane traffic, we need to double the number of operators with cameras by placing 2 operators at one of the directions of this intersection.

By reading the intensity data at any given time, a complete picture of the intersection is made. The developed algorithm, using the OpenCV library, reads the number of machines passing through the intersection. A client-server-type application has been created which implements this algorithm and stores data locally on a smartphone and sends it to the database for further analysis. The application has a "Operator inactive" clause to prevent false data from being stored. Based on this data, we can conclude that some lanes at the intersection are overloaded or too free.

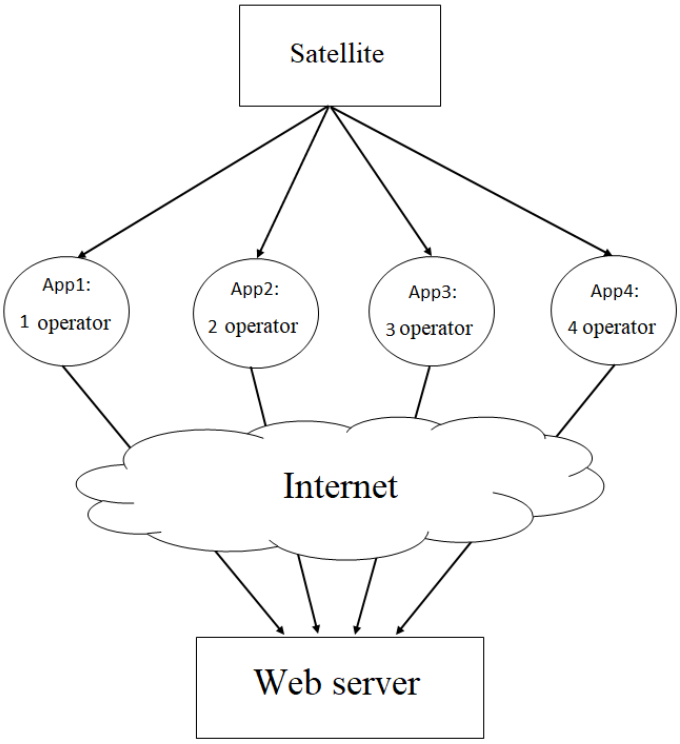

Figure 5. Architecture of the project

The characteristic of the flow is defined by the following relation $q = \frac{n_t}{T}$, where q - flow intensity, n_t – the number of vehicles that passed the road section, T – the observation time.

New System

The task of the application (Figure 5) is to synchronize the collection of data on the intensity of traffic flow at the intersection with several smartphones, located at given points as in Figure 6. Knowing the turn of the intersection (in the case of unregulated, the order of travel is governed by traffic rules; in the case of regulated observe the work of traffic lights), we can know the intensity of incoming flows and the ratio of their separation in different directions.

The intensity of the traffic flow is the number of vehicles passing through a cross-section per unit of time Veh./h. Thus, by calculating the number of vehicles passing through each lane in the given period we can obtain data on the intensity of traffic flow.

Necessary equipment: Android-based smartphones, tripods.

Preparation for the experiment:

1. Enter the name of the operator;
2. Enter the number of the point under study;

3. Select the flow direction (flow to/from us);
4. Enter the number of strips;
5. Select the time averaging (min.);
6. Select the auto-off time.

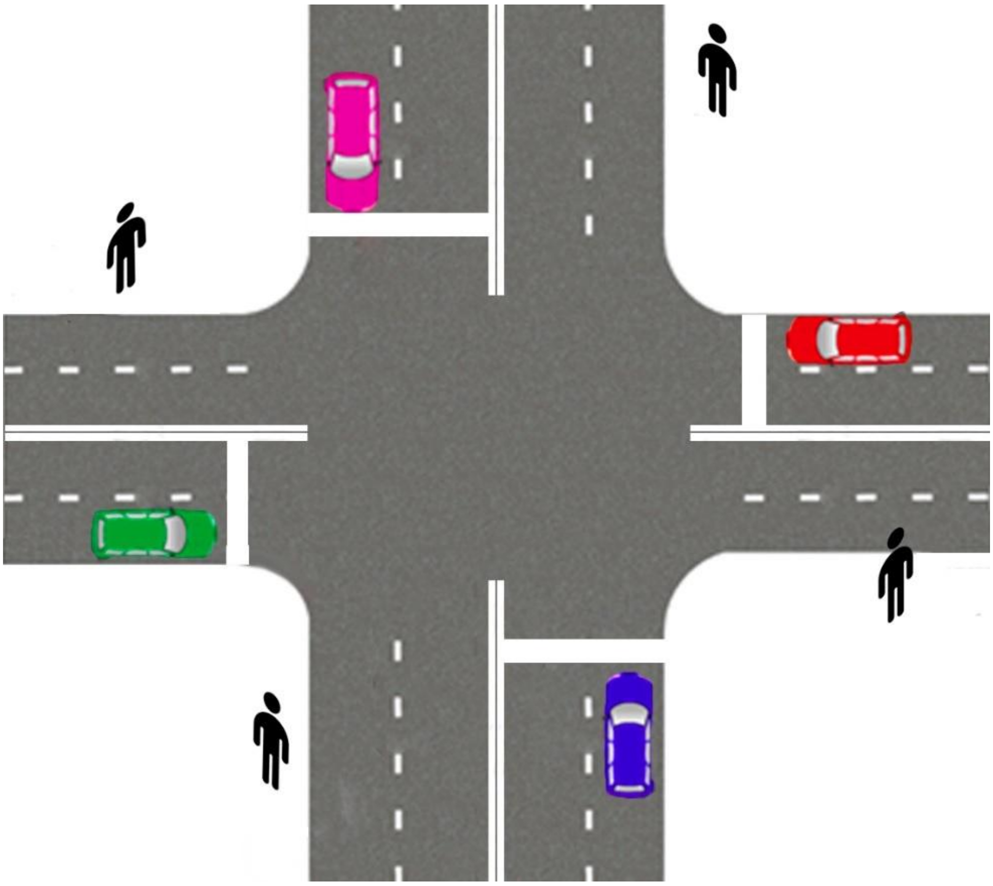

Figure 6. A junction diagram with the arrangement of operators

It has been experimentally proved that the duration of the interval at which measurements of the given value of the relative error of measurements caused by the factor of chance will be made was quite small.

The method of experimenting:

1. Mount your smartphone on a tripod, pointing it at a road section so that the camera captures the image of the flow from the desired angle.
2. Place several sensors (dots) on the image by pressing any point on the screen.
3. Press the "RECORD" button. The application will start counting the traffic intensity and speed (Figure 7). Press "STOP" to finish the flow analysis and send the data to the server.

Figure 7. The flow analysis process

The results of the experiment are shown in Table 1 and Figure 8.

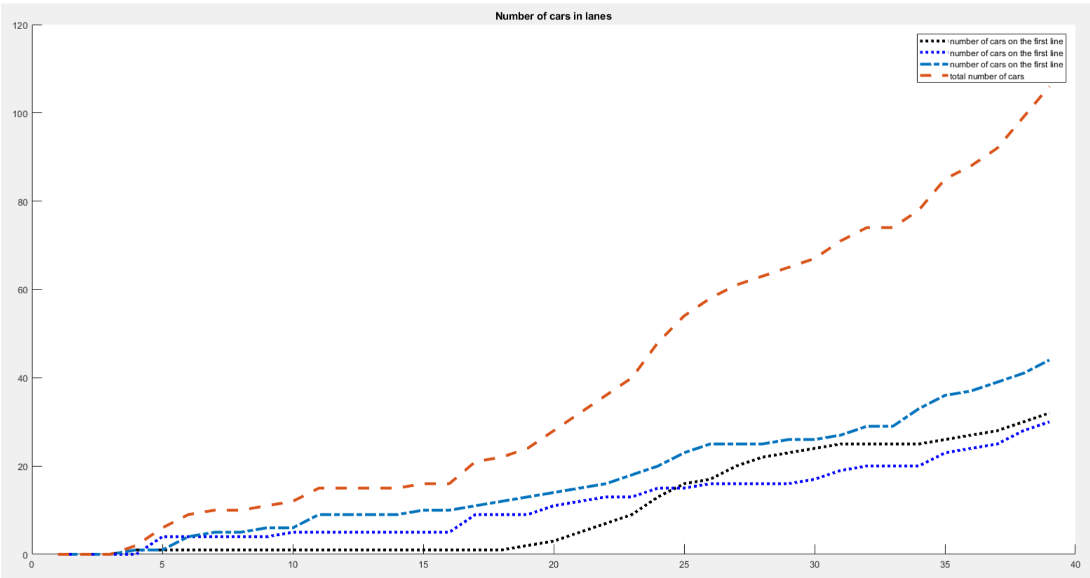

Figure 8. The number of cars per lanes

Table 1. Results of the experiment

Data	**Result**
Operator: Maria Point number: 1 x: 55.8462965 y: 37.6383706 z: 0.0 Date: 4 Feb. 2020 15:48:02 Direction: from us Number of traffic lanes: 3 Averaging (min): 1 Auto power off (min): 1	=0= 0 0 0 =1= 0 0 0 =2= 0 0 0 =3= 1 0 1 =4= 0 4 0 =5= 0 0 3 =6= 0 0 1 =7= 0 0 0 =8= 0 0 1 =9= 0 1 0 =10= 0 0 3 =11= 0 0 0 =12= 0 0 0 =13= 0 0 0 =14= 0 0 1 =15= 0 0 0 =16= 0 4 1 =17= 0 0 2 =18= 1 0 1 =19= 1 2 1 =20= 2 1 1 =21= 2 1 1 =22= 2 0 2 =23= 4 2 2 =24= 3 0 3 =25= 1 1 2 =26= 3 0 0 =27= 2 0 0 =28= 1 0 1 =29= 1 1 0 =30= 1 2 1 =31= 0 1 2 =32= 0 0 0 =33= 0 0 4 =34= 1 3 3 =35= 1 1 1 =36= 1 1 2 =37= 2 3 2 =38= 2 2 3

Conclusion

In this paper we used a client-server application to investigate the intensity of traffic flows at an intersection. Based on the results of the experiment, we can say that the given direction after the intersection is normally loaded, that is, when passing it there is neither a situation with an "empty" road nor traffic congestion.

Acknowledgments

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