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Imitation Model of Traffic Flows

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Introduction

Modern cities are unthinkable without the traffic control systems. Using traffic control systems you can solve a lot of traffic problems, such as traffic incidents, fuel consumption, delays, traffic jams, emission of pollutants, parking and others. Developing traffic control systems require less cost than other parts of the transport infrastructure improvements.

Traffic conditions are influence a lot of factors, such as roads conditions, number of traffic directions, vehicles speed, number objects of the transport attraction, number of traffic lights, urban transport and others factors. If you want to implement traffic control system to the streets of cities you must to estimate all traffic factors. In order to implement all traffic factors you need to create traffic flows imitation model. The developed imitational model of the traffic flows permits the modeling of various traffic flows at the intersections. With the help of this imitational model the simulations at three intersections were conducted [1].

Karaliaus Mindaugo Avenue was used for experimental and for imitation of traffic flows, because the Karaliaus Mindaugo Avenue was one of the busiest streets in the Kaunas city in 2004. This fact is also indicated by the analysis of the research of the traffic flows in the city of Kaunas. In 2007 a new shopping and amusement center was opened near the Karaliaus Mindaugo Avenue and the four-story car parking lot with capacity of 2500 cars was built besides it. After the shopping and amusement center was opened the car traffic in this street increased by 26%. A new sports and amusement arena with 15000 visitor seats should also begin its operation in 2011 near the mentioned shopping and amusement center. The car parking lot with capacity of 600 cars will be built near the arena. The car traffic in the Karaliaus Mindaugo Avenue will increase even more. When the car traffic flow is increased the probability to form the traffic jams becomes very high especially in the roads and intersections around the objects of the transport attraction. Large traffic jams may also be formed after the mass public events. In order to control the traffic flows near the objects of the transport attraction the transport control imitation model has to be created [2].

Experimental research of the model of the traffic flows

In order to create the imitation model of traffic flows the experiment in three intersections near the shopping and amusement center with the multistory car parking lot was carried out. The data was recorder during the experiment using automatic and manual methods [3, 4].

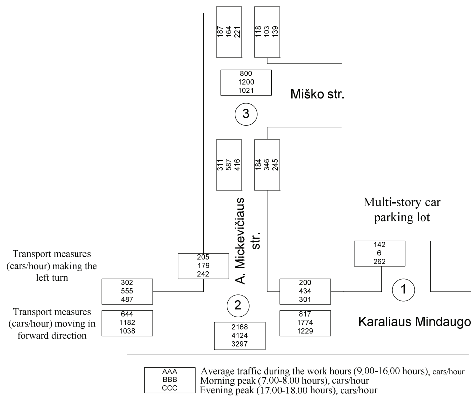

Fig. 1. The experiment scheme and the hourly data of the traffic flows

The meanings of the results of the experiment in this graph: PARK − the flow of traffic from the multistory parking lot, MICMI − the flow of the traffic at the intersection of the A. Mickevičiaus and Miško streets, KMST − the flow of the traffic in the direction of the Karaliaus Mindaugo from the railway station, KMSEN − the flow of the traffic in the direction of Karaliaus Mindaugo street from the old town. The data of the accomplished experiment was used when developing the traffic flow forecasting models and the imitational model of the traffic at the intersection.

Creation of the imitational model of the traffic flows

The developed imitational model of the traffic flows permits the modeling of various traffic flows at the intersections. The main task of this imitation model is traffic jam detection. The main parameters that were measured experimentally are time of traffic ligts, distances between intersections, vehicle speed, hourly traffic flows, average lengths of the cars.

The control of traffic lights is one of the cheapest and most effective ways to reduce vehicle jams, accidents, and environmental pollution.

Optimal traffic lights control is very important at morning and evening traffic jams. Mostly traffic lights are controlled by fixed-cycle management. Traffic signals working time can be divided into several modes: stroke, major stroke, stroke phase, phase, and cycle [5].

For traffic control red and green phases are used. These phases are determined by traffic volume and traffic composition. Developing simulation model, traffic light signals were measured. Traffic light cycles are shown in Fig. 2 [2, 5].

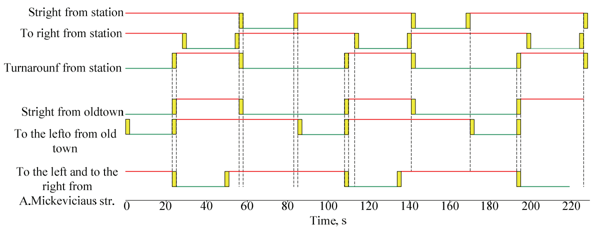

Fig. 2. Phases and cycles of traffic light

Traffic flow of the 1, 2 and 3 intersections are showed in figure Fig. 3. In first crossroad there are 4 traffic directions, in second crosroad there are 14 traffic directions and ind third crossroad there are 4 traffic directions.

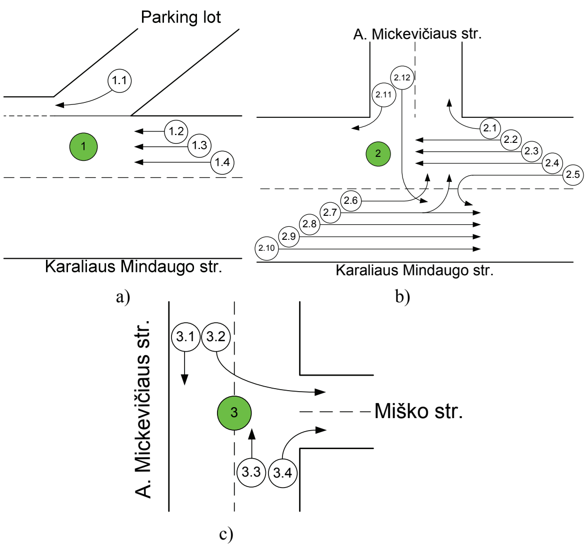

Fig. 3. Traffic directions at first, second and the third crossroads

In order to develop the imitational model of the traffic flows the algorithms describing the vehicle movement to the intersection and through it were designed. In Fig. 4 is showed algorithm of the third intersection.

When the vehicle coming to the direction 3.4 and if there is a row, joining to the end of the row. If in the direction there is not row, goes to traffic light and turn right or re- form from the first to the second lane and go straight. If in the second line there is row, vehicle waiting at the first line.

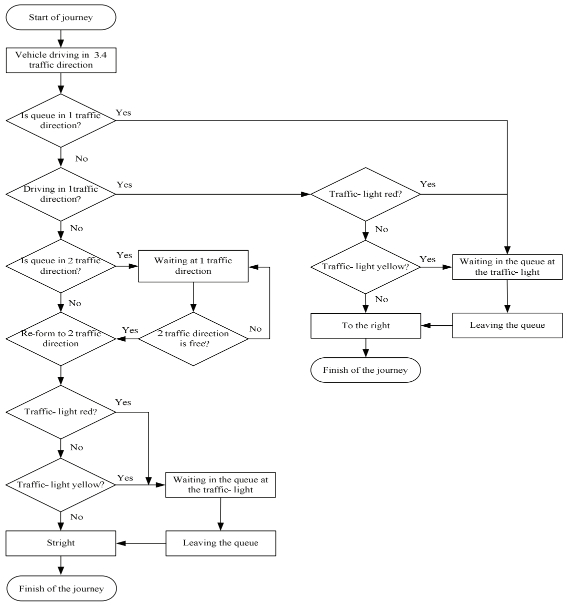

Fig. 4. Algorithm of the third intersection

All algorithms describing the vehicle movement to the intersection and through are implemented in program “Arena”. This program is made by the company of „Rockwell Software“. Arena simulation software helps demonstrate, predict, and measure system performance.

The model developed with the imitational modeling software package Arena is shown in Fig. 5.

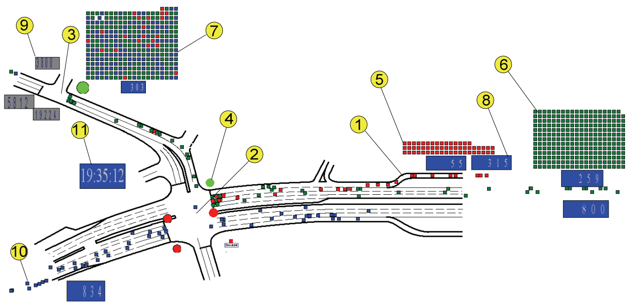

Fig. 5. Imitation Model of Traffic Flow

In the intersections traffic simulation model, the number of fragment values are: 1- exit from the multistore car parking lot, 2- Intersection of Karaliaus Mindaugo avenue and Mickevičiaus street, 3- Intersection of Mickevičius and Misko streets, 4- Traffic lights, 5- Transport flow from multistore car parking lot (PARK flow), 6- Transport flow from station (KMST flow), 7- Transport storage, 8- Transport storage counter, 9- Ariving transport counter, 10- Traffic flow from Karaliaus Mindaugo avenue from old town (KMSEN flow), 11- Daily clock. Traffic flows of the transport storages are used from real experimental data. Vehicles form the storages released under the exponential law (Expo(t)). Vehicles arrived to the intersection stands up to the end of the row. Vehicle movement speed is also selected according to the exponential law. In places of intersections where cars can turn right or left and right, the probability was calculated according to the experimental data. The probability of vehicles lane changes from one zone to another was calculated also.

With the help of imitational model the simulations of the intersections 1, 2 and 3 were conducted. During the modeling in addition to the different flows KMST, KMSEN and PARK the traffic flows at the intersection 3 were measured, so that it would be possible to determine the emerging car jams in the each traffic lane.

Results of modeling with traffic flows

The rows of the vehicles at the 3rd intersection are illustrated in Fig. 6. As we can see the traffic intensity in the second lane is almost two times higher that in the first lane.

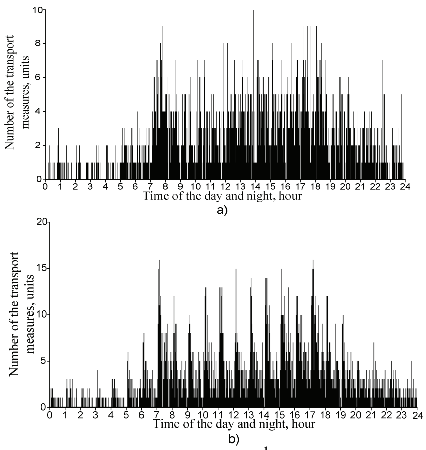

Fig. 6. The traffic flow rows at the 3rd intersection, a) the first lane; b) the second lane

Since even during the morning and evening peak hours the larger than 20 car rows in a lane are not formed we can draw a conclusion that the throughput of the intersection and the operation mode of the traffic lights is properly matched, and that very large jams do not emerge under sufficiently high load of the intersections.

When performing the further modeling the regression flow forecasting model was used [6]. During the modeling 700, 1000, 1500 and 2000 cars were let out from the parking lot in different times of day and night. The results of the regression forecasting model and Arena modeling are given in Fig. 7.

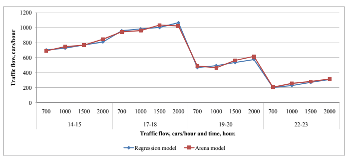

Fig. 7. The comparison of the regression forecast and Arena modeling

During the first stage of the modeling the flow from the parking lot was varied. It was selected that 700 automobiles leave the parking lot over one hour. The modeling results of the 3rd intersection are presented in Fig. 8.

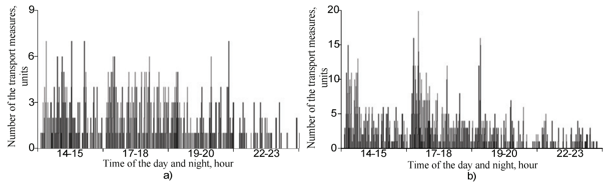

Fig. 8. The rows of the traffic flows at the 3 intersection**,** a) first and b) second traffic lane, under the flow of 700 cars leaving the parking lot over one hour

During the second modeling stage it was selected that 1000 cars leave the parking lot over one hour. The modeling results at the 3rd intersection are given in Fig. 9.

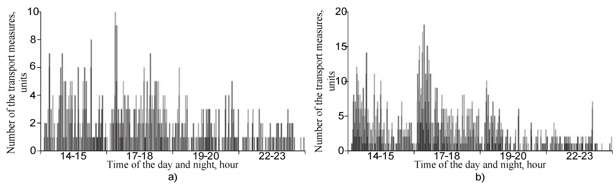

Fig. 9. The rows of the traffic flows at the 3 intersection, a) first and b) second traffic lane, under the flow of 1000 cars leaving the parking lot over one hour

During the third modeling stage it was selected that 1500 cars leave the parking lot over one hour. The modeling results at the 3rd intersection are shown in Fig. 10.

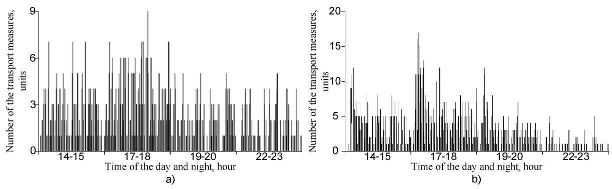

Fig. 10. The rows of the traffic flows at the 3 intersection, a) first and b) second traffic lane, under the flow of 1500 cars leaving the parking lot over one hour

As we can see from Fig. 8- Fig. 10, even when 700 to 1500 cars leave the parking lot, a very large car jams between the intersections 2 and 3 which would block the traffic entirely, would not be formed, since the main car traffic from the parking lot moves forward along the Karaliaus Mindaugo Avenue.

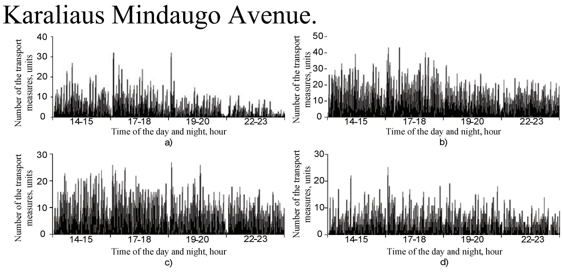

Fig. 11. The rows of the traffic flows at the 2 intersection**,** a) first traffic lane; b) second traffic lane, c) third traffic lane; d) fourth traffic lane, under the flow of 2000 cars leaving the parking lot over one hour

In Fig. 11 the results are presented when the car traffic from the parking lot reaches 2000 over one hour. A very large traffic jams are formed at the 3rd intersection under such traffic flow. Also a very large traffic jams are formed at the 2 nd intersection.

The performed modeling has shown that the modes of operation of the traffic lights are selected properly enough to manage significantly large traffic flows, even when the flows of the traffic leaving the parking lot increase rapidly. Based on the results a conclusion can be drawn that the probability for the traffic jams to be formed at the 2nd and the 3 rd intersection is highest during the time from 14 to 18 hour. Therefore a conclusion can be mane that the large public events should be avoided during this time of the day because they would attract a large number of the cars.

Conclusions

1. Intersection operation algorithms when the traffic flows move to the intersection ant through it were developed which were also implemented in the imitational model of the intersection. The simulations of the traffic flows in one of the busiest city streets were accomplished and they demonstrated that the operation of the traffic lights under the average load of the intersections is configured sufficiently properly.
2. When the traffic flow was increased up to 1500 cars per hour the traffic jams at the intersections are still manageable, and when the traffic of the cars leaving the parking lot is increased up to 2000 cars per hour, the traffic lights are not sufficient to ensure the throughput of the traffic flows.
3. The developed imitational model of the intersection can be applied to any intersection of the city. Also the developed imitational model of the traffic flows at the intersection has a possibility to perform the modeling with the additional traffic flows which will be formed after the „Žalgiris“ sports arena will be built in Kaunas.

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Using traffic control systems you can solve a lot of traffic problems, such as traffic incidents, fuel consumption, delays, traffic jams, emission of pollutants, parking and others. Developing traffic control systems require less cost than other parts of the transport infrastructure improvements. If you want to implement traffic control system to the streets of cities you must to estimate all traffic factors. In order to implement all traffic factors you need to create traffic flows imitation model. The developed imitational model of the traffic flows permits the modeling of various traffic flows at the intersections. The main task of this imitation model is traffic jam detection. Imitation model was tested with real and forecasted data. The developed imitational model of the intersection can be applied to any intersection of the city. Ill. 11, bibl. 6 (in English; abstracts in English and Lithuanian).

K. Balsys, A. Valinevičius, D. Eidukas. Transporto srautų imitacinis modelis // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2011. – Nr. 6(112). – P. 65–68.

Naudojant transporto valdymo sistemą, galima išspręsti daugelį problemų, susijusių su eismu, tokių kaip avaringumas, kuro sąnaudos, vėlavimas, oro tarša, parkavimas ir kt. Transporto valdymo sistemų plėtra reikalauja daug mažiau investicijų, nei kitų transporto infrastruktūrų plėtra. Norint įdiegti eismo valdymo sistemą mieste, reikia įvertinti daugelį eismo veiksnių. Visiems svarbiausiems su eismu susijusiems veiksniams įvertinti reikalingas imitacinis modelis. Sukurtas transporto srautų imitacinis modelis leidžia modeliuoti sankryžose skirtingus transporto srautus. Pagrindinis sukurto imitacinio transporto srautų modelio tikslas – aptikti automobilių spūstis. Sukurtas imitacinis modelis buvo išbandytas su realiais ir prognozuotais duomenimis. Šis modelis gali būti panaudotas kiekvienoje miesto sankryžoje. Il. 11, bibl. 6 (anglų kalba; santraukos anglų ir lietuvių k.).