Algorithm and data support of traffic congestion forecasting in the controlled transport

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Abstract. The topicality of problem of the traffic congestion forecasting in the logistic systems of product movement highways is considered. The concepts: the controlled territory, the highway occupancy by vehicles, the parking and the controlled territory are introduced. Technical realizability of organizing the necessary flow of information on the state of the transport system for its regulation has been marked. Sequence of practical implementation of the solution is given. An algorithm for predicting traffic congestion in the controlled transport system is suggested.

Key words: Control, area, filling, transport, highway, parking, intensity, flow, congestion, forecast technical, facilities, algorithm.

1. Introduction

Logistical approach to the formation of a concentration-distribution systems of product movement allows us to justify economically suitable boundaries of geographical location of the zones of potential sales of products and services for manufacturers of products and enterprises of commodity-distribution network [5,6,7]. However, with the implementation of projects it is possible to observe a manifestation of the influence of factors not covered by the computational methods of logistic systems.

The continuous growth of the global vehicle fleet leads to the fact that traffic jams are becoming more and more likely, with a steady trend towards increasing of economic losses caused by their appearance. In this regard, the task of analyzing the conditions of emergence, development and evolution of the traffic congestion is urgent and that will help to predict and prevent their formation. To solve this problem it is necessary to identify the main factors and develop mathematical models of traffic processes, to investigate the mechanisms of formation, "life" and the elimination of traffic congestion, the impact of internal and external factors on these processes. Similar systemic tasks are worked out in relation to the organization of work of automated multiproduct manufacturing site of engineering enterprise, which can be adapted to the problems of traffic management [1,2,3,4,8]. All that will provide the reliable forecasts of the traffic conglomeration emergence of vehicles in order to prevent them. Despite the lack of system solutions of these tasks, and the results of the study of influencing factors, it is possible to offer basic approaches to solving of common problem at the level of its data support and algorithmization. In this paper we consider all necessary and possible sources of information about the elements of the road traffic and algorithms for information processing for decision-making on the prevention of traffic congestion.

2. Basic part
Analysis of publications on this topic [9, 10, 13] shows that in different countries, including the Russian Federation, serious attention is paid to monitoring and regulation of road transport processes, and the Moscow City Government conducts the systematic work aimed at technical and organizational support to reduce the danger of traffic congestion [11, 12]. Really in the world are used many varieties of traffic regulation means: traffic lights of varying complexity, video cameras as part of subsystems of video, information support of road users. A video camera mounted on a dangerous stretch of road translates the visual and numerical information in the information processing module, which analyzes the movement of vehicles and determines the specified integrated motion estimations. There are also used: multiposition road signs, light boards with interchangeable information about the traffic situation on the directions of movement, special radio and video channels. Radars and collision warning devices on the road; locking devices; satellite navigation and determining the location of the vehicle system; mounted in the roadway luminous beacons to determine the speed, identifying license plates of passing vehicles; video subsystem with an automatic fixing of a car number and driver's face with giving a ticket to owner of the car at excess speed; satellite tracking system for compliance with parking regulations; laser scanners for fast fixing of the place of traffic accident; automated system for collecting payments for the right to enter the city center during peak hours; self-learning traffic signal, automatically changing the mode of switching depending on the traffic on the streets at a crossroads – are developed.

Thus, there are technical opportunities for obtaining a variety of traffic information and the means to implement a centralized control within the controlled transport system. However, the likelihood of congestion formation on the roads is continuously increasing, which makes return to the tasks of their prevention. Consider a general statement of the problem. It is very easy. For a controlled area of the transport system is necessary to determine the conditions under which the likelihood of congestion becomes close to 100%.

Obviously, this is possible when the controlled area is filled with vehicles so that it becomes difficult to move them along the roads of the territory, and then comes the stop of their movement. High intensity of input vehicles streams contributes to filling the area and high intensity of output streams - to releasing. The intensity of the traffic flow on the road is determined with all other equal conditions by the width of the roadway and vehicle speed. Speed of the vehicle within the controlled area, in turn, is determined by the established limitations of motion in the form of road signs and traffic lights devices and the degree of cluttering a roadway with parked cars, snow, repair work, the consequences of the accident. And here it should be noted that the majority of traffic signs and control devices help to reduce the average speed of the vehicle along a controlled area, and most of the sanctions to drivers of vehicles are imposed for exceeding the speed prescribed by traffic signs regulation. This apparent systemic contradiction can be resolved only by the systemic consideration of the issue. It is also clear that the preferred solution would be directed to the possible increase a throughput of a controlled territory, including at the expense of increasing of the average speed of vehicles, the introduction of unregulated intersection of highways in different levels, and creating of underground and overground pedestrian crossings. All this can stabilize the potential throughput of a controlled territory at the highest level. However, a high throughput of a controlled territory in relation to the traffic flows can not be the only of its function.

Another important purpose of any controlled area is the ability to accept and place (park) vehicles, as even on the country roads may occur planned and forced stops, and settlements, especially large cities are the areas to where, in general, vehicles move transporting people and cargo for various purposes, thus, vehicles stoppings and parkings are an integral part of traffic and should also be designed on the basis of a systematic approach with the design of areas and transport routes. Considering the problem of the vehicle parking in terms of providing throughput of the controlled area, it should be noted that the presence of organized parking contributes to unloading the roads from vehicles and thereby enhances the throughput capacity of the controlled area. But most of parked vehicles after parking time joined the transport stream again, reducing the throughput capacity. Availability of technical devices parking control allows you to organize monitoring of the degree of
filling of parking by vehicles and consider these data in predicting the likelihood of congestion of vehicles.

Taking into account stated above, and considering the use of any available technical means, we can consider an algorithm predicting traffic congestion in the controlled transport system.

1. Number all input \((i)\) and all output \((j)\) transport highways of the controlled territory, including the parking ins and outs of vehicles.

2. With the help of statistical observation or calculation methods to determine the value of:

\[ N_{krA} \] - critical value of the filling of the controlled territory by vehicles complying \(A\%\) of probability of formation of congestion;

\[ N_{max} \] - maximum permissible value of the filling of the controlled territory by vehicles in which the probability of congestion \(A = 100\%\).

3. Define by monitoring of highways and parkings the values:

\[ N_{m0}, N_{c0} \] - respectively, the initial number of vehicles on the carriageway of highways and parkings of the controlled territory.

4. Perform using technical control devices a monitoring of the time streams intensity of the vehicles for each of \(i\) input highways \(n_{ini}(\tau)\) and for each of \(j\) output highways \(n_{outj}(\tau)\) of the controlled territory.

5. To determine the number of vehicles entering \((N_{ini})\) the controlled territory and exiting \((N_{outj})\) out of it for forecast period \(\Delta \tau = \tau_k - \tau_n\), wherein \(\tau_k, \tau_n\) - respectively, initial and final moments of time of the forecast period:

\[ N_{ini} = \int_{\tau_n}^{\tau_k} n_{ini}(\tau) \, d\tau, \quad (1) \]

\[ N_{outj} = \int_{\tau_n}^{\tau_k} n_{outj}(\tau) \, d\tau. \quad (2) \]

6. Determine the current value of the filling of the controlled territory by vehicles, summarizing the obtained values:

\[ N = N_{m0} + N_{c0} + \sum_i N_{ini} - \sum_j N_{outj} \quad (3) \]

7. Compare the result at the end of the forecast period with the critical value of filling of the controlled territory by vehicles with the probability \(A\%\) of the congestion formation

\[ N \leq N_{krA} \quad (4) \]

8. When satisfying the condition \((4)\) continue to monitor the intensity in the time streams of vehicles of the controlled territory by the transition to 5 of the algorithm.

9. In case of violation \((4)\) make a notification of road users about load of highways, start a traffic control according to the unloading scheme of the considered highway of the controlled territory.

10. Compare value \(N\), obtained on a parity \((3)\), n.7 of an algorithm with a maximum value of filling of the controlled territory

\[ N \leq N_{max} \quad (5) \]

11. When condition \((5)\) continue to monitor the intensity in the time of vehicle streams of the controlled territory, passing to 5 of the algorithm.

12. In case of violation \((5)\) overlap with the input highways of the controlled transport system taking measures to alert road users on the near and distant approaches of all input highways.

13. These monitoring results with reference to real time and weather conditions direct to the precedent bank for further use in statistical studies and as a real precedent in the analysis of road situations in a controlled transport system.

The considered algorithm can be applied as a control procedure in any transportation system and can be adjusted according to the settings as they gain experience of its application. If necessary, the major transportation systems can be divided into separate fragments, working on the same algorithm with centralized coordination of their functioning.

3. Conclusion

1. A general statement of the problem of traffic congestion forecasting in the controlled transport system is formulated.

2. Systemic contradiction in the current system of regulating traffic flows is revealed.
3. An algorithm for predicting traffic congestion in the controlled transport system is designed.

References
[1] Adgamov RI, SV Dmitriev, Karimov TN, AK Khayrullin Mathematical model to evaluate the performance of automated multiproduct manufacturing in mechanical engineering // Nauchno-tekhnicheskii vestnik Povolzh’ya. - 2012, №6, P.68-71.
[2] Adgamov RI, SV Dmitriev, Karimov TN, AK Khayrullin Performance of automated manufacturing site of engineering enterprise with a centralized management system // Nauchno-tekhnicheskii vestnik Povolzh’ya. - 2012, №6, P.72-75.
[3] Adgamov RI, SV Dmitriev, Karimov TN, AK Khayrullin Evaluation of automated manufacturing site performance of engineering enterprise with a hot standby control system // Nauchno-tekhnicheskii vestnik Povolzh’ya. - 2012, №6, P.76-79.
[4] Adgamov RI, SV Dmitriev, Karimov TN, AK Khayrullin A mathematical model of an automated performance of multiproduct manufacturing in mechanical engineering, taking into account the interaction of internal factors // Nauchno-tekhnicheskii vestnik Povolzh’ya. - 2013, №1, P.75-78.
[5] Anikin BA, Tyapukhin AP Commercial Logistics: Textbook. - M. : Prospect, 2009. - 432 p.
[6] R. Valiev, Karimov TN, Sibgatullin RK, AH Khayrullin Multicriteria scheduling tasks of delivering fuel by energy and transport company to networks of gas stations // Nauchno-tekhnicheskii vestnik Povolzh’ya. - 2013, №1, P.143-145.
[7] Hadjinsky AM Logistics: Textbook. - 16 th ed. Revised. and add. - M. : Publishing and Trading Corporation "Dashkov & Co", 2008. - 484 p.
[8] Zubkov EV, Dmitriev SV, Khayrullin AH Algorithmization of processes of automated testing of diesel engines. Kazan: Kazan University Press, 2011.
[9] Kasymnin A. When the whole world will stand. Phenomenology of traffic jams. - M. : "Zavtra" №49 (994). - 2012.
[10] Kasymnin A. Again "jam"! Is it possible to solve the transportation problem in the Russian capital. - M. : "Zavtra" № 52 (997). - 2012.
[11] Liverovskii E. Managing of the traffic lights of the capital is now concentrated in the hands of Moscow Government [electronic resource] URL: http://maps.mail.ru/articles/?id=51 (date accessed 01/12/2014).
[12] On the transfer to public institutions of Moscow city - Centre of traffic organization of Moscow Government – city-wide automated traffic control system SYSTEM - "START" [electronic resource] URL: http://www.dtis.ru/Doc/PProjects/project_2010-11- 29.pdf (date accessed 12/01/2014).
[13] Orlov M. Kukushkin L. Tverskaya congestion. - M. : "Zavtra" № 49 (994). - 2012.