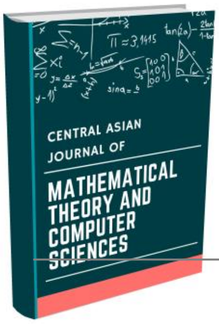

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A METHOD FOR PREDICTING THE STATE OF A TRAFFIC FLOW WHEN MANAGING ON A NETWORK

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Abstract

Effective management of traffic flows on the network is carried out through a traffic flow management system, which is a complex of integrated tools for solving all types of transport problems based on high technologies, methods for modeling transport processes, software, and organizing information flows in real time. Efficiency is ensured by the adequate response of the system, system intelligence, to changes in traffic characteristics

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Introduction

It is clear that the construction of such an intelligent traffic management system[1-5] is a complex, complex task based on the development and use of traffic models, which are used to assess and forecast the state of traffic flow.

Managing traffic flow[6-9] in real time is the implementation of an optimal strategy for managing the current state of traffic flow based on progressive methods for optimizing the operating mode of control technical means of traffic management.

Today, there is specialized software for modeling traffic[10-14], optimizing the operating mode of technical means of organizing traffic, etc., which can be used when building a traffic flow management system in real time. The problem is to ensure the development, in real time, of an adequate strategy for managing the current state of traffic flow. Technical systems for monitoring traffic flows provide the ability to obtain estimates of the characteristics of traffic flows to record a specific flow state. But, since the set of traffic flow states is uncountable, it is necessary to develop a system of criteria for classifying transport states, followed by determining a flow control strategy for a specific class based on existing models for optimizing the movement of traffic flows on the network.

When developing a system of criteria for classifying traffic flow states, it is necessary to take into account the problem of contradictions, on the one hand, caused by the need to comprehensively take into account the characteristics of traffic flows, which entails a recognition error, and on the other hand, the need to reduce the dimension of the space of these characteristics, which deprives the process in question of a sufficient degree of objectivity in the assessment. The difficulty of identifying a transport state in this case lies in the fact that the structure of the characteristics of transport flows is probabilistic and the areas of criteria for belonging to different classes intersect. In this regard, there is a high probability of error in assigning a transport situation to the desired class, a probability that can only be minimized.

Materials and Methods

It is proposed to develop a neuro-fuzzy system for classifying transport states (SCTS), on the basis of which a system for generating optimal strategies for managing traffic flows on a network (SGOS), which is a base of fuzzy rules for managing the transport situation, is already being built. Neuro-fuzzy systems have many advantages, but the limiting factor is the duration of filling them with knowledge (building a rule base) in the process of iterative learning, which is carried out using programs for modeling and optimizing traffic flows.

The SCTS system is developed for nodes (transport network) of various configurations, and then the SGOS system implements coordinated management of the transport network.

It is proposed to carry out the development on the basis of a universal method for constructing a base of fuzzy rules based on numerical data [3]. The advantages of this method are its high efficiency. In addition, it allows you to combine numerical information, presented in the form of training data, with linguistic information, in the form of a rule base, by supplementing the existing base with rules created on the basis of numerical data. The specificity of development in relation to the transport network in this case is manifested both in the method of generating initial data and in the construction of special functions used in the rule procedure.

A generalized scheme for managing transport flows in a node (with no more than four inputs) of a transport network is represented by a sequence of stages:

1. Detection of characteristics of traffic flows in direction k ($k = \overline{1,4}$) along the i-th lane ($i = \overline{1,p}$): traffic intensity $x_i(k)$, traffic speed $v_i(k)$.
2. Determination of $v(k)$ - the average speed of movement in direction k.
3. Checking the condition $v(1) \vee v(2) \vee v(3) \vee v(4) < 10$, when fulfilled, the state of traffic flow saturation is determined and a traffic flow management strategy for the expert system is generated [2]; otherwise, the transport state belongs to a certain class, for which the control strategy is generated from the developed base of fuzzy control rules.

We create a base of rules for classifying transport states for a system with two inputs and one output, as follows:

We define $x(k) = \sum_{i=1}^{p} x_i(k)$ ($k = \overline{1,4}$), for $x1 = max\{x(1), x(3)\}, x2 = max\{x(2), x(4)\}$ we find the domains of definition X_1, X_2, which we divide into $2N + 1$ areas (segments), and the value of N is selected individually, and the segments can have the same or different lengths.

We construct membership functions for a certain class of transport states; it is proposed to use the normal distribution density function according to the principle: the vertex of the graph is located in the center of the partitioning area, the branches of the graph lie in the centers of neighboring areas. The degree to which data x_1, x_2 belong to certain classes will be expressed by the value of the membership functions. Then, for each pair x_1, x_2 , a rule for matching the transport state class is determined (by the researcher). Since there are a large number of pairs x_1, x_2, there is a high probability that some of the rules will be inconsistent. This refers to rules with the same premise (condition) but different consequences (conclusions). One method for solving this problem is to assign a so-called degree of truth to each rule, then select from among the conflicting rules the one with the greatest degree of truth, after which the rule base is filled with qualitative information. To determine the quantitative value of the parameters of the optimal control strategy for data x_1, x_2, it is necessary to perform a defuzzification operation. This method is easy to generalize to the case of a fuzzy system with any number of inputs and outputs.

Experimental Results

The considered principles of constructing the SCTS system were implemented for the transport network of the central part of the city. To implement optimal traffic flow management, key intersections of four types were identified depending on the configuration of permitted traffic directions:

1st type of intersection – direction of movement "north-south", "south-north" in three lanes straight and to the right, direction "west-east", "east-west" in two lanes straight and to the right;

2nd type of intersection - the direction of movement is only "north-south", or "south-north" in one lane straight ahead, right and left, the direction "west-east", "east-west" in two lanes straight ahead and to the right in the direction of cross traffic flow;

3rd type of intersection - direction of movement "north-south" in three lanes straight, "south-north" in three lanes straight and to the right, direction "west-east" in one lane straight ahead and to the right, "east-west" in one lane to the right and to the left;

4th type of intersection - direction of movement "north-south" in three lanes straight, "south-north" in three lanes straight and to the right, direction "west-east" in one lane straight ahead and to the right, "east-west" in one lane to the right and to the left.

Membership functions $\mu_j(x), j = \overline{1,3}$ traffic intensity, vehicles/hour have been developed:

$\mu_1(x) = e^{-\frac{(x-a_i)^2}{800}}, a_i = 100i, i = \overline{1,6}$ along one strip of the partition area $X_1 = [0; 600]$;

$\mu_2(x) = e^{-\frac{(x-a_i)^2}{1800}}, a_i = 100i, i = \overline{2,14}$ along one strip of the partition area $X_1 = [0; 1500]$;

$\mu_3(x) = e^{-\frac{(x-a_i)^2}{5000}}, a_i = 100i, i = \overline{3,19}$ along one strip of the partition area $X_1 = [0; 2000]$;

Traffic delay is used as a criterion for classifying the transport state. Based on the results of modeling the movement of traffic flow at intersections of the indicated types, regression models of the criterion for assessing the state of traffic flow and traffic delays were developed:

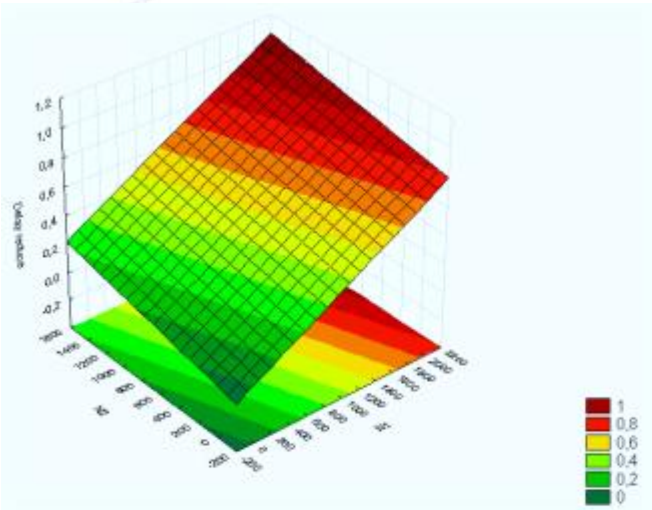

Figure 1. Changing the traffic delay at type 1 intersection

- $z_1 = -0.43 + 0.0005N_1 + 0.0002N_2$ at the intersection of type 1 (Fig. 1);

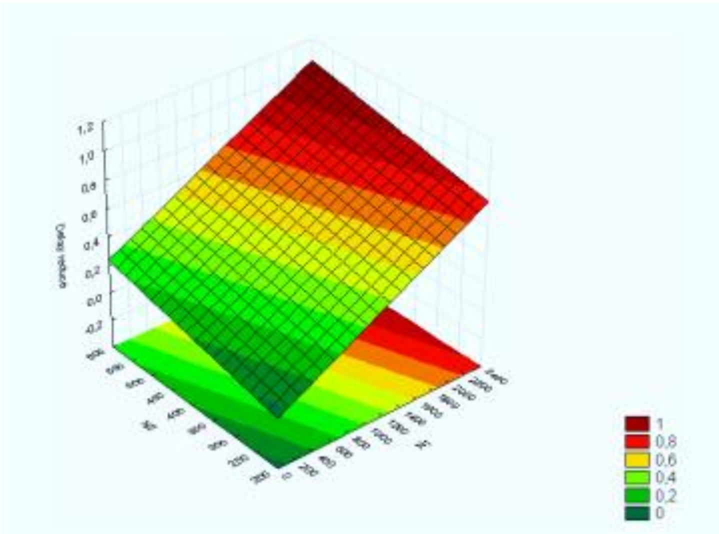

Figure 2. Changing the traffic delay at type 2 intersection

- $z_2 = -0.30 + 0.0004N_1 + 0.006N_2$ at the intersection of type 2 (Fig. 2);

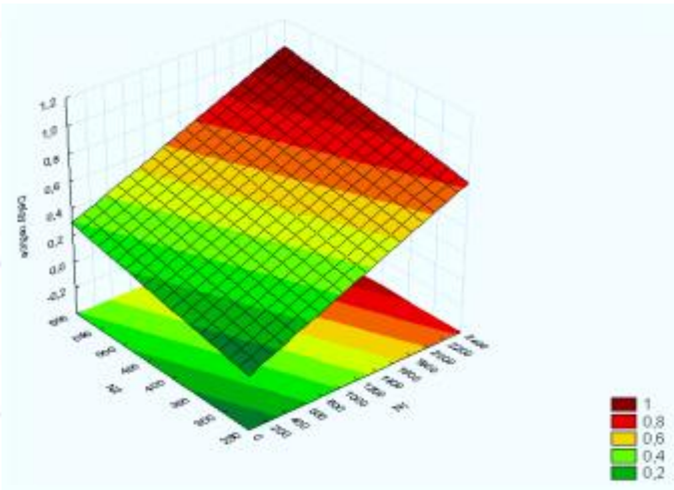

Figure 3. Changing the traffic delay at type 3,4 intersection

- $z_3 = -0.49 + 0.0005N_1 + 0.001N_2$ at the intersection of type 3,4 (Fig. 3), where $N_1(x) = x_1(k), N_2(x) = x_2(k)$- maximum intensity of cross traffic directions.

Conclusion

Based on the developed models for assessing delays after the adjustment procedure using correction factors, the state of the traffic flow is determined. The base of rules for identifying transport states constructed in this way is the basis for designing a SGOS system for managing transport flows on the network.

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