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OPTIMIZATION OF MANAGEMENT OF URBAN LIGHTS WITH THE USE OF NEURAL NETWORKS

Abstract. One of the most pressing problems of large cities is the problem of traffic management of vehicles. The reason for this problem is an imperfect way to manage traffic flows. Traffic light regulation is of particular importance in traffic management. Most modern traffic light control systems operate at set time intervals and are not able to cope with the constantly changing situation on the road. A promising direction for solving this problem is to optimize the system using artificial neural networks. The advantage of neural networks is self-learning, which allows the system to adapt to the changing situation on the road.

Despite numerous attempts, it has not yet been possible to obtain a high-quality mathematical model of urban traffic management. This model should determine the functional dependence of transport flow parameters on control parameters. Nowadays, traffic flows are regulated everywhere by means of traffic lights. If we can get a fairly accurate mathematical model of traffic flows, we can determine the optimal duration of the traffic signal phases to achieve the maximum capacity of the road network node.

A fairly accurate mathematical model of traffic management that works in predictive mode will display an estimate of the optimal control parameters, as well as make correct decisions in emergency situations.

Well-known mathematical models of road traffic take into account only the average values of traffic flows, and not the exact number of cars on each road section at a particular time.

Key words: traffic management, artificial neural networks, self-learning, mathematical model, traffic flows.

The mathematical model of road traffic is based on the theory of controlled networks. This model takes into account the network and road structure, its changes according to traffic signals, and allows you to calculate the state of traffic flows at each time. The main difficulty is to determine the exact values of quantitative parameters of flow distribution. Overview of the use of neural networks for optimizing traffic management.

Artificial neural networks are widely used in traffic management in the road network. Let's look at some of the latest work in this area.

Cellular neural networks for the task of controlling traffic lights at individual intersections, i.e. without taking into account the mutual influence of traffic light modes on neighboring sections of the network. In this work, the total delay of vehicles at the intersection is minimized. For modeling purposes, the flow delay determined by the traffic light phase is considered as a quadratic function of the duration of the green light in this phase. Both linear and nonlinear equality-type constraints are applied to the duration of the green light.

A comparison of classical Ann and fuzzy controllers as the control systems for traffic lights. The authors of this article suggest using a neural network with a single hidden layer, the input of which is fed a vector with the number of idle cars in front of each traffic light, and the output is the duration of each phase. ANN is trained using a genetic algorithm. Application of "biology-inspired" neural networks (BiNN) for intersection management. In such methods, the emphasis is on the study of dynamics in contrast to the classical ANN, which mainly consider training procedures. BiNN is studied on a complex intersection model. The structure of BiNN is as follows: input neurons describe a queue of vehicles in each lane. Output neurons correspond to the phases on the bands. All output neurons are associated with inhibitory neurons that suppress the activity of other output neurons. The duration of the phases is limited by an equation describing the concept of "immanent plasticity" of the neuron.

Using a deep, ultra-precise artificial neural network for adaptive traffic management. For ANN training, reinforcement training is used. In the terminology of the reinforcement learning paradigm, an ANN is called an agent. The input signal in the ANN is formed from the state space proposed by the authors – discrete traffic state encoding (DTSE). The following neural network architecture is proposed. Two neural networks are used with an identical structure, but with a different set of input signals.

The first input is a binary vector describing the presence or absence of a car on a road section, and the second is a vector of real numbers describing the speed of cars on road sections. The outputs of neural networks deployed in the vector are glued together with each other and with the current state of the phases and fed to the input of a fully connected ANN. The output from the ANN is an indicator vector that shows the action that the agent should perform, namely, it contains the number of the phase that should be enabled.

In conclusion, we would like to note that in domestic practice, advanced knowledge and experience in the field of traffic light regulation are poorly used. This leads to a loss of time at traffic light intersections, reduced road safety, increased fuel consumption, and more intense environmental pollution from exhaust gases.

Currently, there are no mandatory rules governing the construction of a traffic light control cycle in our country. There are recommendations and tutorials that are not required for use and are not used. To fully understand the impact of regulation at intersections, regular data collection on road accidents is required, including location, time, conditions, age of participants, consequences of accidents, and other parameters. At a minimum, this will allow you to identify intersections with the most intense occurrence of accidents, as a maximum, to assess the conditions that provoke risky behavior of road users and avoid them in the future. Optimizing traffic light control using neural networks is a relatively cheap way to increase traffic safety at intersections. It is necessary to pay close attention to this method, since the effect may correspond to expensive measures.

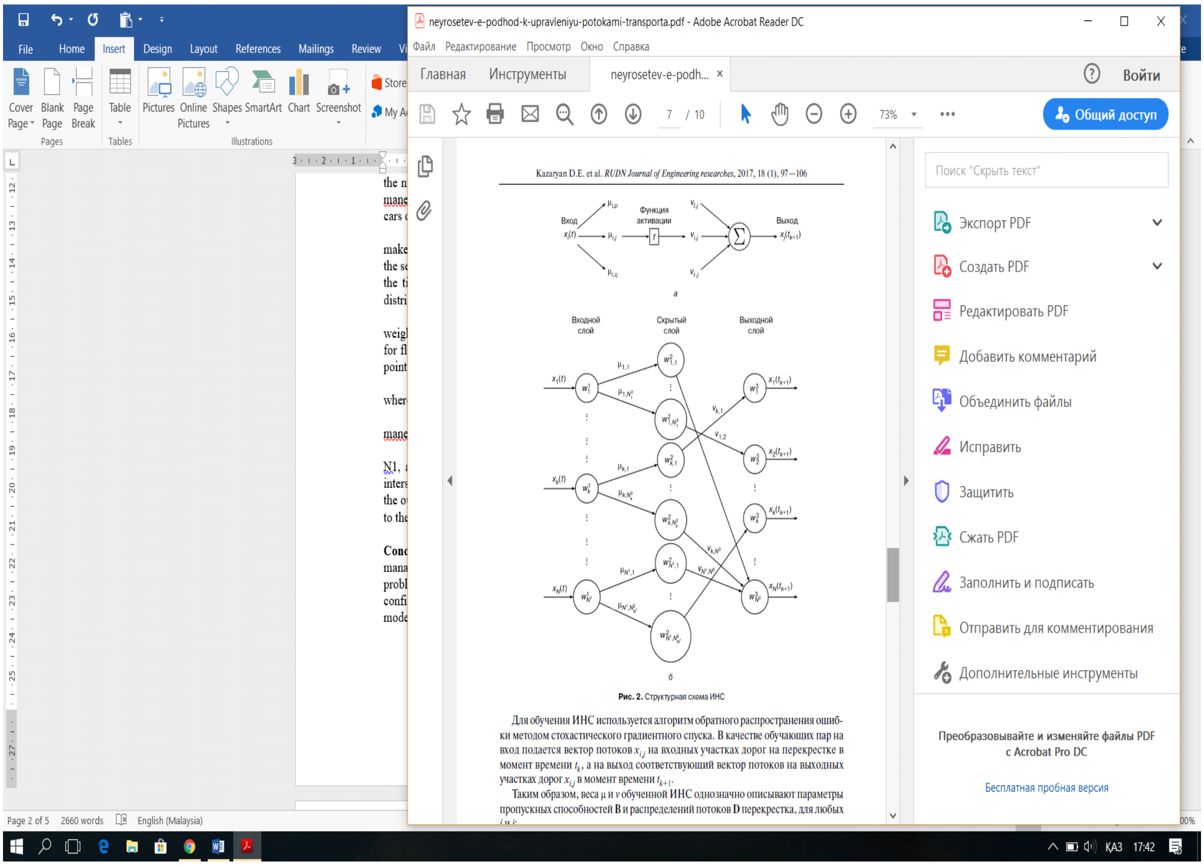

Figure 1 - Structural scheme of the Ann

The mathematical model of a traffic management system contains parameters that must be obtained experimentally for each intersection. These parameters include elements of the throughput matrix B and the distribution matrix D. The capacity of the maneuver bi, j from road section i to road section j determines the number of vehicles that can perform this maneuver in a single time interval. The capacity of the bi,j maneuver depends on the spatial characteristics of the intersection, the speed of the car, and the number of cars on sections i and j.

The elements di, j of the distribution matrix D determine the proportions of the flow of cars that make a maneuver from road section i to road section j. the Sum of these fractions is equal to the flow on the section i.the values of the parameters di,j depend on the routes of all cars and can change depending on the time of day, day of the week, and season. To determine the parameters of the throughput B and distributions D of the model, we use a two-layer incompletely connected ANN.

The architecture of the Ann chosen accordingly to the relationship of the roads at intersections, the weight values of the Ann coincide with the parameters of the capacity and distribution flows. Input values for flows on road sections at some point in time, and output values for flows on road sections at the next point in time.

The ANN structure is determined by the intersection structure: the input layer consists of N0 inputs, where N0 = n, n is the number of input road sections at the intersection.

Each input is associated with the mi of neurons in the hidden layer, where mi is the number of maneuvers that can be performed from the I section.

Each neuron of the hidden layer is associated with only one element of the output layer, with N2 ≥ N1, and each neuron of the output layer defines the output section of the road that departs from the intersection. Several neurons of the hidden layer can be connected to one neuron in the output layer. Since the output layer defines the output road sections, the link to the hidden layer is defined from road section i to the output road section j.

Conclusion. The article describes a neural network approach for solving the problem of traffic flow management in the urban road network. Traffic flows are managed as a result of solving the optimal control problem using a mathematical model based on the theory of managed networks. The ANN provides configuration of model parameters when there is a discrepancy between the output data obtained on the model and the output data on a real object or road network section.

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НЕЙРОНДЫҚ ЖЕЛІЛЕРДІ ҚОЛДАНУ НЕГІЗІНДЕ ҚАЛАЛЫҚ БАҒДАРШАМДАРДЫ БАСҚАРУДЫ ОҢТАЙЛАНДЫРУ

Аннотация. Ірі қалалардағы өзекті мәселенің бірі – көлік құралдарының жол қозғалысын ұйымдастыру. Аталған мәселенің пайда болу себебі – көлік ағынын басқарудың жетілмеген тәсілі. Көлік ағынын басқаруда бағдаршамды реттеудің ерекше маңызы бар. Бағдаршамды басқарудың қазіргі заманғы жүйелерінің көпшілігі берілген уақыт аралығы бойынша жұмыс істейді және жолдағы үздіксіз өзгермелі жағдайды жеңе алмайды. Бұл мәселені шешудің перспективалық бағыты – жасанды нейрондық желілер арқылы жүйені оңтайландыру. Нейрондық желілердің артықшылығы – өзін-өзі оқыту мүмкіндігінің аталған жүйеге жолдағы өзгермелі жағдайға бейімделуге мүмкіндік береді. Көптеген талпыныстар жасалса да, қалалық қозғалысты басқарудың жоғары сапалы математикалық моделі негізделмеді. Мұндай модель көлік ағыны параметрлерінің басқару параметрлеріне функционалдық тәуелділігін анықтауы тиіс. Қазіргі уақытта көлік ағыны барлық жерде бағдаршамдар арқылы реттеледі.

Егер көлік ағынының нақты математикалық моделін жасасақ, жол желісі торабының барынша өткізу қабілетіне қол жеткізу үшін бағдаршам сигналдары фазаларының оңтайлы ұзақ уақытын анықтай аламыз.

Болжау режимінде жұмыс істейтін жол қозғалысын басқарудың нақты математикалық моделі басқарудың оңтайлы параметрлерін бағалауды білдіреді, сондай-ақ төтенше жағдайларда дұрыс шешім қабылдайды. Жол қозғалысының белгілі математикалық модельдері нақты сәтте жолдың әрбір учаскесіндегі машиналардың нақты санын емес, ағынның орташа мәнін ғана ескереді.

Түйін сөздер: трафикті басқару, жасанды нейрон желілері, өзін-өзі оқыту, математикалық модель, көлік ағыны.

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ОПТИМИЗАЦИЯ УПРАВЛЕНИЯ ГОРОДСКИМИ СВЕТОФОРАМИ С ПРИМЕНЕНИЕМ НЕЙРОННЫХ СЕТЕЙ

Аннотация. Одной из наиболее актуальных проблем крупных городов является проблема организации дорожного движения транспортных средств. Причина возникновения данной проблемы – несовершенный способ управления транспортными потоками. В управлении транспортными потоками особое значение имеет светофорное регулирование. Большинство современных систем управления светофорами работает по заданным интервалам времени и не способно справиться с непрерывно меняющейся ситуацией на дороге. Перспективным направлением для решения этой задачи является оптимизация системы с помощью искусственных нейронных сетей. Преимущество нейронных сетей заключается в возможности самообучения, что позволяет системе подстраиваться под изменяющуюся ситуацию на дороге.

Несмотря на многочисленные попытки, до сих пор не удалось получить качественную математическую модель управления городским движением. Такая модель должна определять функциональную зависимость параметров транспортных пото-ков от параметров управления. В наши дни транспортные потоки повсеместно регулируются посредством светофоров.

Если удастся получить достаточно точную математическую модель потоков транспорта, мы сможем определять оптимальную длительность фаз сигналов светофоров для достижения максимальной пропускной способности узла дорожной сети.

Достаточно точная математическая модель управления дорожным движением, работающая в режиме предсказания, будет отображать оценку оптимальных параметров управления, а также принимать корректные решения в экстренных ситуациях. Известные математические модели дорожного движения учитывают только средние значения потоков, а не точное количество машин на каждом участке дорог в конкретный момент.

Ключевые слова: управление трафиком, искусственные нейронные сети, самообучение, математическая модель, транспортные потоки.

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