Summaries of all articles

L.G. Afanasyeva, E.V. Bulinskaya

Mathematical models of transport systems based on queuing theory

The aim of the paper is to obtain ergodicity conditions for some traffic systems involving traffic lights. The cars arrival is described by Poisson processes. The traffic lights interswitching times can have an arbitrary distribution. The optimization of traffic lights performance is also considered. The existence of a steady state for the system with two consecutive traffic lights is established, with account taken of the cars size. The impact of traffic lights and different cars velocities on the cars flow density is studied as well. The queuing theory methods turn out to be useful for investigation.

Keywords: transport flows, traffic lights, unregulated crossroads, ergodicity, optimization, flow density, heavy traffic.

M.L. Blank

Exclusion processes with synchronous updates in transport flow models

We study several simple traffic flow models represented by exclusion processes (with both lattice and continuous spaces) and obtain explicit formulas for certain associated statistics. In particular, the so-called fundamental diagram showing the dependence of the average particle speed on the particle density is derived rigorously.

Keywords: exclusion process, traffic flows, systems of interacting particles, coupling.

P.P. Bobrik

Deriving a transport correspondences gravitation model from the law of diminishing marginal utility

In this paper, we study relationships between economic behavior patterns and the famous examples of transport correspondences distribution.

Keywords: transport, gravitation model, law of diminishing marginal utility, route utility.

A.S. Bugaev, A.P. Buslaev, A.G. Tatashev, M.V. Yashina

Optimization of partially-connected flows for a deterministic-stochastic model

We study a multilane partially-connected movement model. In this model the velocity of movement is a sum of determinate and stochastic components. We solve the problem of maximizing the average velocity and intensity of movement by the parameters which determine the model.

Keywords: Partially-connected flows, multilane movement, leakage, dynamic size, stochastic model.

A.V. Gasnikov, E.V. Gasnikova

On possible dynamics in the calculation model of a correspondence matrix (A. G.Wilson)

In this paper, we present the basic technique for investigating the dynamics of macrosystems at large time values. In the core of the dynamics lies the ergodic markovian chain with a huge number of states. At large time values the macrosystem distribution on macrostates is close to the stationary one. With growing dimensions of the macrosystem (quantity of states of the markovian chain), the stationary distribution is concentrated in a small neighbourhood of the most probable macrostate which is accepted for the equilibrium of the given macrosystem. As an example of application of the described formalism, we develop the static gravitational calculation model of a correspondence matrix (one of the most popular models in practice) using the "reasonable"(individually favorable) dynamics of exchanges of residences.

Keywords: Ergodic theorem, Lyapunov's function, entropy, gravitational calculation model, correspondence matrix , invariant (stationary) measure phenomena, canonical scaling, dynamic balance condition, principle of detailed balance.

E.V. Gasnikova, Y.V. Dorn

On stochastic markovian dynamics providing the Nash–Vardrop equilibrium in a stream distribution model

In this paper, the possible dynamics providing the Nash–Vardrop equilibrium in a stream distribution model (based on the Vardrop principles) is described. It is necessary to note that the conclusions drawn in the paper are mainly based on the results of numerical experiments which show, in a number of games, a very fast convergence of proposed stochastic (Gibbs' type) dynamics (of the best responses in the corresponding evolutionary game) to the Nash equilibrium.

Keywords: Evolutionary game dynamics, Nash equilibrium, Vardrop principles, Braess paradox, Pareto optimality, Grigoriadis–Khachiyan algorithm.

A.A. Zamyatin, V.A. Malyshev

Car traffic flows - introduction to a stochastic approach

Stochastic models of transportation flows exhibiting qualitative phenomena are rather numerous: starting from the midtwentieth-century queuing theory to recent mathematical statistical physics and locally interacting processes. In this paper, we discuss and rigorously formulate many models and consider some examples in detail.

Keywords: point processes, queuing networks, transportation flows, random grammars.

S.L. Klenov

Kerner's three-phase traffic theory as a theoretical basis for intelligent transportation systems

Foundations and results of Kerner's three-phase traffic theory are briefly discussed. Kerner's theory allows one to explain and predict empirical spatio-temporal features of traffic breakdown and the resulting traffic flow patterns. The measurement results of the empirical spatio-temporal traffic flow patterns occurring on highways in Germany, Great Britain, and the USA are considered. These empirical results are a basis both for empirical phase criteria and other conclusions of Kerner's three-phase traffic theory. In Kerner's theory, traffic breakdown is explained by a first-order phase transition from free flow phase to synchronized flow phase. The phase transition can occur in a wide range of traffic flow rates. This range corresponds to an infinite number of highways capacities. The features of wide moving jams formation in a synchronized flow as well as a classification of spatio-temporal traffic flow patterns in Kerner's theory are discussed. Novel intelligent transportation systems based on Kerner's three-phase traffic theory are exemplified.

Keywords: traffic flow, Kerner's three-phase traffic theory, intelligent transportation systems, traffic breakdown, infinite number of highway capacities.

A.V. Kolesnikov

Mass transportation and contractions

According to L. Caffarelli's celebrated result, every optimal mass transportation mapping, pushing forward the standard Gaussian measure onto a log-concave measure $e^{-W}dx$ with $D^2W \geqslant Id$, is 1-Lipschitz. We present a short survey of related results and various applications.

Keywords: optimal tranposrtation, Monge–Ampére equation, log-concave measures, Gaussian measures, isoperimetric inequalities, Sobolev inequalities.

A.B. Kurzhanski, A.A. Kurzhanski, P. Varaiya

Role of macromodeling in network active traffic management

Active Traffic Management (ATM) is the ability to dynamically manage recurrent and nonrecurrent congestion based on prevailing traffic conditions in order to maximize the effectiveness and efficiency of road networks. It is a continuous process of (1) obtaining and analyzing traffic measurement data; (2) operations planning — simulating various scenarios and control strategies; (3) implementing the most promising control strategies in the field; and (4) maintaining a real time decision support system that filters current traffic measurements to predict the traffic state in the near future, and to suggest the best available control strategy for the predicted situation. ATM relies on a fast and trusted traffic simulator for the rapid quantitative assessment of a large number of control strategies for the road network under various scenarios, in a matter of minutes. The open source macrosimulation tool Aurora Road Network Modeler is a good candidate for this purpose. The paper describes the underlying dynamical traffic model and what it takes to prepare the model for simulation; covers the traffic performance measures and evaluation of scenarios as part of operations planning; introduces the framework within which the control strategies are modeled and evaluated; and presents the algorithm for real time traffic state estimation and short term prediction.

Keywords: Active Traffic Management, road network, traffic congestion, dynamical traffic model, decision support system, scenarios simulation, fundamental diagram, control strategy, fast and trusted traffic simulator, performance measures, operations planning, real time traffic state estimation, prediction.

E.A. Nurminski, N.B. Shamray

Forecast modeling of car traffic in Vladivostok

Considerable funding is now allocated for improvement of transportation networks in Vladivostok and surrounding areas in federal programs for development of the Russian Far East. In the current work, the forecast models of car traffic load and redistribution of automobile flows are developed to estimate the effects of implementation of these projects. The results of numerical experiments of traffic assignments for existing and future networks based on the economic equilibrium and stationary dynamics model are described.

Keywords: competitive equilibrium, traffic assignment problem, variational inequalities, trip matrix, projective methods.

A.M. Raigorodskii

Models of random graphs and their applications

In this paper, we give a survey of the main contemporary directions of research in the theory of random graphs. It should be stressed that the models of random graphs are connected with some public transportation problems.

Keywords: random graph, Internet, transport networks.

N.N. Smirnov, A.B. Kiselev, V.F. Nikitin, A.V. Kokoreva

Mathematical modeling of traffic flows by a continua approach. Two lanes roads: modeling T-shape crossing and the effect of lane change on handling capacity

In this paper, the further development of continua models for traffic flows simulations is presented. The model for two-lanes traffic flows is developed. It takes into account changing lanes by some cars and is based on the approach of multiphase flow mechanics. Numerical simulations of traffic flows in T-shape crossing is performed as an example of taking into account the three- phase traffic lights regulation.

Keywords: mathematical modeling for traffic flows, traffic lights, T-shape crossing, lane change, handling capacity, continua mechanics, multiphase flows.

Y.A. Kholodov, A.S. Kholodov, A.V. Gasnikov, I.I. Morozov, V.N. Tarasov

Traffic flow modeling — modern problems and solution methods

This paper deals with mathematical modeling of vehicular traffic flows, the discussion of arising problems and solution methods. We develop the original macroscopic models for vehicular traffic description in the complex transport network graph. The macroscopic model is based on a hydrodynamic approach by analogy with a motivated compressible multicomponent fluid. We consider, as a component, a set of vehicles with some identical features. Also, we develop the original algorithm for deriving equation systems at the graph nodes that are crossroads. The numerical simulation results demonstrate the workability of the proposed model as compared to the experimental data.

Keywords: vehicular traffic flow, hydrodynamic approach, transport network graph, multiphase traffic flows.

B.N. Chetverushkin, M.A. Trapeznikova, I.R. Furmanov, N.G. Churbanova

Macro- and microscopic models for vehicular traffic description on multilane motorways

The paper deals with mathematical modeling of vehicular traffic flows in urban streets and on motorways. Original 2D macro- and microscopic models of multilane traffic are developed to predict flows on multilane roads, with account taken of their real geometry. The macroscopic model of synchronized flows is based on the kinetic approach by analogy with the quasi-gas-dynamic (QGD) system of equations. The microscopic model uses the cellular automata theory. Both models are generalized to the case of "multiphase" traffic to describe heterogeneous traffic flows. The phase implies a set of vehicles with some identical features. Test predictions demonstrate the adequacy of the models in different road situations.

Keywords: vehicular traffic flow, macroscopic and microscopic models, multilane traffic, multiphase traffic flow.

V.I. Shvetsov

Problems of the development of complex models of transportation systems

The paper gives a brief review of the recent approach in the development of mathematical models of traffic flows in the transportation network. This approach is characterized by transition from the trip-based to tour-based and daily activity-based models, and the use of the Monte-Carlo simulations. We also discuss the problem of evaluating the estimate of the interzone transportation distance, which is averaged over the trip modes. We propose the general correct- averaging method. Also, we discuss the different algorithms of evaluating the user equilibrium assignment in the network. The equilibrium principle defines the unique values of link flows, though the distribution of flows along different routes remains nonunique. The entropy maximization model can be used to eliminate this nonuniqueness.

Keywords: traffic flows, trip matrix, activity-based models, modal split, traffic equilibrium.