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An Improvement in ant Algorithm Method for Optimizing a Transport Route with Regard to Traffic Flow

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Abstract

The modification of ant algorithm method for optimizing the transportation route with regard to traffic flow in the street network has been developed in this paper. It was also made possible to confirm the results of optimization of partly covered distance for calculating a further route when changing the length of links while ant agents traveling on the links of a two-way graph. Besides, the procedure of ant agents' traffic in the graph was improved so that ant agents can travel both synchronously and asynchronously. The proposed modification of ant algorithm for optimizing the goods delivery route when changing the speed of traffic flow in specific sections of the street network has been approbated, using the example of Kyiv's specific street network within traveling salesman problem. We conducted the quantitative and comparative analysis of solving the problem of optimization of the goods delivery route in the street network, applying ant algorithm method and the respective findings of other existing classical methods. The obtained results of the study show the prospects of applying the proposed modification of ant algorithm for solving routing problems, particularly for transport networks which are characterized by high dimensionality and dynamism of functional parameters.

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Keywords: transport, methods for transport route optimization, ant algorithm, performance analysis

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1. Introduction

Nomenclature

$J_{i,k}$	a list of cities which ant agent k has to visit and the city i is where ant agent k is located
η_{ij}	visibility is inversely proportional to the distance between the cities
τ_{ij}	the amount of pheromone on the link (ij) at the instant in time t
α, β	parameters which weigh with pheromone trail
T_k	a way travelled by the ant k to the point of the time t
L_k	the length of this way
Q	parameter which means the order of optimal way length
t_{ij}	the value of travel time
l_{ij}	length section ij
υ_{ij}	average speed of a vehicle in section ij of street network

A great number of research papers are devoted to the problem of improving optimization processes when creating routes. Existing traditional methods for solving the problem of discrete optimization of the processes in logistics systems, which are considered in network representation, as a rule, are not perfect and do not provide unequivocal solutions (eg. [1]). What is more, proposed methods in [1] do not allow us to solve the problems of high dimensionality, and consider the actual state of transport network while creating a route.

Knight [2] suggests a new algorithm, which, unlike [1], allows us to perform the procedure of discrete optimization when simultaneously considering all the ways of traffic between graph junctions, taking into account the capacity of each link. This method is based on presenting the graph in the form of an electric network, whose sections have a specific resistance, which characterizes the respective capacity. The proposed method, according to the author [2], also makes it possible to first of all focus on problem areas and structures of a high level instead of wasting a lot of time on finding insignificant solutions, which means it enabled us to effectively use the time of respective calculations. However, a deeper analysis of method [2] indicates that the solution to the problem of discrete optimization is to solve the problem of linear algorithm connected with solving respective system of linear equations of a specific dimensionality. Therefore, finding the ways of solving system equation of the maximum possible dimensionality still remains topical. It should be noted that method [2] in fact is analogous to the method of discrete optimization which is based on ant algorithm [3]. The classical method of ant colony self-organization provides the possibility for finding the optimal way for a static graph. Ant agents, which are located in the junctions of the graph in the initial period, also travel on the links of the graph simultaneously. It eventually enables us to substantially reduce the time of calculations, taking this method's features into consideration.

In addition, various characteristics, which are attributed to ant agents, allow us to solve a wide range of discrete optimization problems, taking account of a large number of investigated system characteristics. Further numerous researches done through ant algorithm method showed the perspective of its application for solving the problems of discrete optimization of high dimensionality (see eg [4, 5]). Still, as a rule, existing methods, models of optimizing transportation route and corresponding software and hardware complexes of their realization mostly solve the optimization problems for stationary states of transport traffic. Meanwhile, the development and improvement of methods and models of controlling transport optimization processes, considering actual dynamics of traffic flows in the street network, are extremely topical in the modern conditions of transport functioning. First of all, it concerns large cities and functioning of street networks characterized by traffic capacity dynamism, substantial changes in traffic speed, congestions and etc.

The problem of ant algorithm application for solving dynamic transport problems has drawn researchers' attention recently. In particular, to employ ant colony algorithm while optimizing complex planning process was suggested in paper [6], with the possibility of taking dynamic emergency situations into account. But there are very few papers on such a topic in the literature nowadays.

The purpose of this paper is to improve the existing ant algorithm method for optimizing transport route with regard to traffic flow dynamics in the street network. Within the developed modification of this algorithm, we made