THE CONSTRUCTION OF AN OPTIMAL ROAD NETWORK

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It is undeniable that the road construction industry has become a very vital infrastructure in enabling the transfer of freight as well as people. It offers essential industry and community benefits. With rising globalization, making the better and sustainable development of roads is significantly important. Moreover, there is high government spending in building roads as well as maintenance, so there is also a need for the finding methods that will guarantee the reduction in public expenditures.

The research of possibility to optimize a road network and identification of criteria as the key to the cost-effective road construction are the object of this work. The tasks which are related to a construction of road network can be frequently found in the theory of graphs. Then, the problem of cost minimization can be presented as a linear programming problem. There are many common methods to solve it. However, different optimization goals need suitable methods. In this work the optimal solution was found with the help of genetic algorithm.

The algorithm proposed has been developed to minimize the total road network building cost and ton-kilometers expenditure by carriers by determination of the optimal network configuration, taking into account the road category and traffic. The solution of problem is based on using Floyd-Warshall and genetic algorithms.

Pervomaiskyi district in Kharkiv Oblast of Ukraine was chosen to present a numerical example of the algorithm in detail. Denote the network by a weighted undirected simple graph, where the vertices represent the villages or cities, the edges represent the directly-linked roads and the weight of the edge is the cost of building the road according to its length and category. Only two categories were used — double- and quadruple-lane roads. The objective function is the sum of total building and carriers expenses. The corresponding constraint conditions were constructed.

The result shows that the cost of construction the existing road network is 19% higher than the one that was calculated by the developed algorithm. Furthermore, the sum of total building and carriers expenditures is 10% lower.

Taking everything into consideration, the developed program based on Python determines the configuration of the optimal road network, the cost of its construction, its length and the carriers ton-kilometers expenditures, according to the following known data: a topographic map of Kharkiv region, traffic, the ton-kilometers cost of transportation, the cost of 1 km building of road due to its category.

References:

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2. Whitley, D. (1993). A Genetic Algorithm Tutorial.
3. Goldberg, D. (1989). Genetic Algorithms in Search, Optimization and Machine Learning.