OPTIMIZATION OF ROUTES OF EMERGENCY SERVICES' VEHICLES TO THE PLACES OF CALLS

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ABSTRACT

An algorithm is described for optimizing the routes of emergency service vehicles between their initial locations and the places of calls. The algorithm uses graph theory to minimize the time or distance traveled.

To reduce material and human losses at extraordinary situations, the task of minimizing the time between a fire, explosion, accident etc., reception of a message in the means and forces' management centre, and arrival of response vehicles at the place of call is critical. One of the ways of accomplishing this is to choose optimum routes for the vehicles.

To solve this problem we propose to present the map of a district as a suspended graph G, the tops of which are crossroads (V), and arches of which are the streets joining adjacent crossroads. The value of graph's arches can be the distance between crossroads, time of traveling between them, etc. Moreover, the following features of the graph should be taken into account:

- for taking into account one–way roads, tops of the graph can be connected by oriented ribs;
- the speed of traveling along a two-way road can differ depending on the direction;
- if traveling time is chosen as a value of the graph's arches and ribs, it can vary depending on season and time of the day;
- in general, graph G is not flat (such crossroads as overpasses, bridges, tunnels, etc., are possible).

To solve the task of optimization it is necessary to give a mathematical description of the graph. It can be described by incident and contiguity matrices, as well as in list form. We propose use of the latter way as the most saving of operating memory of the computer.

Raising the task of optimization is as follows: let a graph of the map of a district $G = (V, A)$ be given, where V is the set of tops and A is the set of ribs. Let each rib a_i have weigh g_i. It is necessary to find the route from top V_l, corresponding to the location of emergency services, to any top V_k, such that $S(l,k) = SUM(g_i)$ is minimized.

The task can be solved by sorting out all possible routes; however, there are too many of them on the map of a real city. That's why the task should be solved by the method of dynamic programming (or step–by–step optimization).

An algorithm to solve the task is made on the basis of the Diikstra approach, in view of the features of graph G. This approach permits us to find the route of minimum length between any two tops of the graph, however, it is not practically applicable for a real city in a real scale of time in spite of minimizing calculations by using dynamic programming.

In this regard, an algorithm enabling us to solve the task in two stages is proffered. In the first stage, calculation of the shortest route's trees from the locations of emergency services' vehicles to all the tops of the graph is made after filling of the data base containing the description of the map of the city and locations of emergency services' vehicles. Solving of this problem requires the heaviest temporary costs and is performed beforehand. Results are recorded in a matrix of shortest routes' trees of graph G. The estimated accounts show that, using the "assembler" programming language on the computer "Besta" to solve this problem for Moscow, which has about 100,000 crossroads, it requires about two months.

The second stage consists of restoration of the optimum route from the vehicles' locations to any top of the graph. It is done when a request for dispatch is received and requires very little time, because it just consists of consecutive "reading" of the route along the tops of the trees already built in the first stage.

Thus, use of the proffered algorithm permits us automatically to define the nearest location (by time or by distance) of emergency services' vehicles and find the optimum route in the admissible time.

If it is necessary to take into account the changes of weights of the graph by the time of the day, by seasons, or by periodic changes of city traffic (raised bridges, etc.), it is possible to calculate several variants of matrices of the shortest routes' trees of graph g and use the variant that satisfies the present situation at each particular moment.

The proffered algorithm was realized as a program in the computer language, BASIC. The program allows us to calculate a graph of 100 tops, each of which has four ribs on average. The number of locations of emergency services' vehicles is not limited. The time of calculation of this graph is 24 minutes. After that, the route to any top is built without delay and is determined by the speed of display units working.