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OPTIMIZATION TRAJECTORY OF FLIGHT PILOTLESS UNMANNED AERIAL VEHICLE IS WITH THE USE THEORY OF THE GRAPHS

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In the article, the algorithm optimization trajectory of motion unmanned aerial vehicle (UAVs) is described on the criterion of the least extent of way due to the use theory of the graphs and presentation of flight UAVs as a task of traveling salesman. The prospects of further research and use of algorithm are distinguished.

Key words: unmanned aerial vehicle, optimization, trajectory, algorithm of Little's, theory of the graphs.

Raising of problem. Lately all greater development is acquired by a pilotless aviation. The analysis of the last armed conflicts of the world shows that UAVs begin to be widely used in soldiery aims and all more often used for realization of secret service[1]. At the conduct of modern battle actions UAVs more effective and quicker execute the task of secret service as compared to reconnaissance facilities. The use of UAVs is generated by the row of substantial problems: effective management, minimization expenses of resources, minimization of losses UAVs and other. Researches are driven to the articles devoted to the decision of one of problems, namely: optimizations of trajectory of flight UAVs on the criterion of the least extent of way [2, p. 224; 3, p. 160].

Analysis of the last researches and publications. By the pressing question of development, use and planning of the pilotless aviation systems the devoted works [1]. By the general concept of the pilotless systems and

unmanned aerial vehicle the devoted labours [3, 5]. To illumination of questions of unmanned aerial vehicle and pilotless systems of military-oriented, their application in the last soldiery conflicts the devoted works [2]. Bases of theory of the graphs and use of theory of the graphs in the different types of scientific activity are described in works [6, 7]. The basic concepts of planning of route of motion of unmanned aerial vehicle are illuminated in-process [4]. The analysis of literature testifies that a question of development pilotless aviation is extraordinarily actual and investigated by the scientists of leading countries of the world. And a question of search, construction and research trajectory of flight UAVs is one priority in this scientific sphere.

Raising of task. In the article it is suggested to conduct optimization trajectory of flight UAVs, on the criterion of the least length of the passed way, using the theory of the graphs.

Exposition of basic material.

One of criteria of implementation of flights UAVs there is providing of safety of flight, his efficiency and economy. The criterion of economy can be arrived at by a few ways, such as: reduction of charges on resources, reductions to the block, reduction to the extent of flight hours et al. In the article the method of reduction of extent general to the way of motion UAVs offers due to a construction and calculation of route of motion by means theory of the graphs[4; 5, p. 50].

Will present a way that must pass UAVs during implementation of tasks as the oriented connected graph, where the objects of secret service will come forward as tops of count. In such case the set problem it can consider, as a task of traveling salesman and for her decision to apply the theory of the graphs, namely algorithm of Little's. Mathematically this task will be writtenin a formula:

$$L = Min\left(\sum_{i=1}^{n}\sum_{j=1}^{n} C_{ij}X_{ij}\right), \qquad i, j = 1 \div n, \qquad i \neq j. \tag{1}$$

where

L - is a general extent of way;

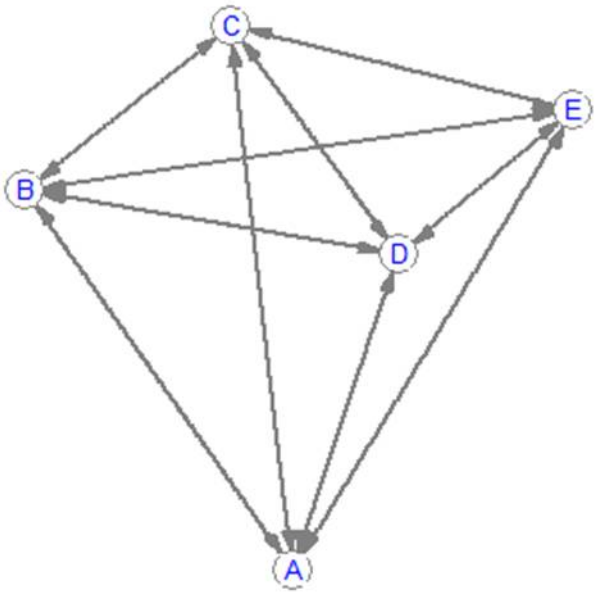
$C_{ij}X_{ij}$ - it is a great number of objects of secret service and distances between them.

For further researches will enter some suppositions:

1) limitation of absence of external influences (counteractions of opponent, difficult weather terms, and others like that);

2) will consider the terms of realization of secret service permanent.

Thus, simplest situation of aggregation trajectories of motion UAVs to four aims (objects of secret service) can be presented in a kind to the count (Pic. 1).



Picture 1. Totality of possible routes of flight UAVs is in a kind to the count

where,

top column A- is a location UAVs;

tops column B, C, D, E - are objects of secret service.

Will notice that even at the small amount of objects of research (in our case four) of possible variants route of motion UAVs is eight, that is why a task of search of optimal route of motion is actual.

For the construction route of motion UAVs will apply the algorithm of Little's[6, p. 322; 7, p. 114-118]. At the decision of task by means algorithm of Little's of columns present as an adjacency matrix:

$$\omega = \begin{pmatrix} \infty & \kappa_{12} & \kappa_{13} & \kappa_{14} & \kappa_{15} \\ \kappa_{21} & \infty & \kappa_{23} & \kappa_{24} & \kappa_{25} \\ \kappa_{31} & \kappa_{32} & \infty & \kappa_{34} & \kappa_{35} \\ \kappa_{41} & \kappa_{42} & \kappa_{43} & \infty & \kappa_{45} \\ \kappa_{51} & \kappa_{52} & \kappa_{53} & \kappa_{54} & \infty \end{pmatrix} \quad ((2)$$

where, κ_{ij} - are distances between the corresponding objects of secret service, here .

For a calculation will consider some cycle, a way is passed between all points of cycle will write down a formula:

$$\ell(i_1, i_2, ..., i_n) = \omega_{i_1 i_2} + \omega_{i_2 i_3} + ... + \omega_{i_{n-1} i_n} + \omega_{i_n i_1} \quad (3)$$

then

$$\min_j \omega_{ij} = \omega_{ij(i)} \quad (4)$$

From formulas (3) and (4) swims out :

$$\ell(i_1, i_2, ..., i_n) = \sum_{i=1}^{n} \omega_{ij(i)} + (\omega'_{i_1 i_2} + \omega'_{i_2 i_3} + ... + \omega'_{i_{n-1} i_n} + \omega'_{i_n i_1}) \quad (5)$$

then

$$\min_i \omega'_{ij} = \omega'_{i(j)j} \quad (6)$$

Coming from a formula (6) will write down :

$$\ell(i_1, i_2, ..., i_n) = \sum_{i=1}^{n} \omega_{ij(i)} + \sum_{j=1}^{n} \omega'_{i(j)i} + (\omega''_{i_1 i_2} + \omega''_{i_2 i_3} + ... + \omega''_{i_{n-1} i_n} + \omega''_{i_n i_1}) \quad (7)$$

Then expression takes place :

$$\ell(i_1, i_2, ..., i_n) \geq \sum_{i=1}^{n} \omega_{ij(i)} + \sum_{j=1}^{n} \omega'_{i(j)i} \quad (8)$$

And thus an estimation will be equal to expression :

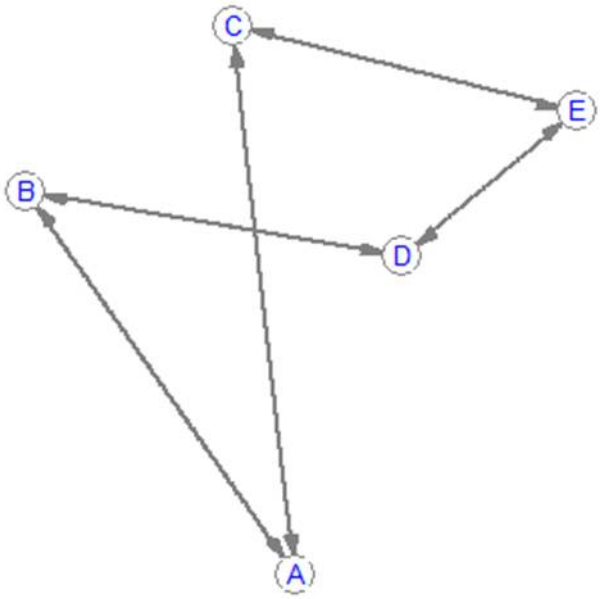
$$\psi = \sum_{i=1}^{n} \omega_{ij(i)} + \sum_{j=1}^{n} \omega'_{i(j)i} \quad (9)$$

Common expression for the search of optimal way will purchase a kind:

$$\ell(i_1, i_2, ..., i_n) = \psi + \ell''(i_1, i_2, ..., i_n) \quad (10)$$

After this algorithm, for our case have a route of motion UAVs to the objects of secret service in such order {A - C - E - D - B - A}.

In a kind the route of flight UAVs will purchase a kind a count (Pic. 2)

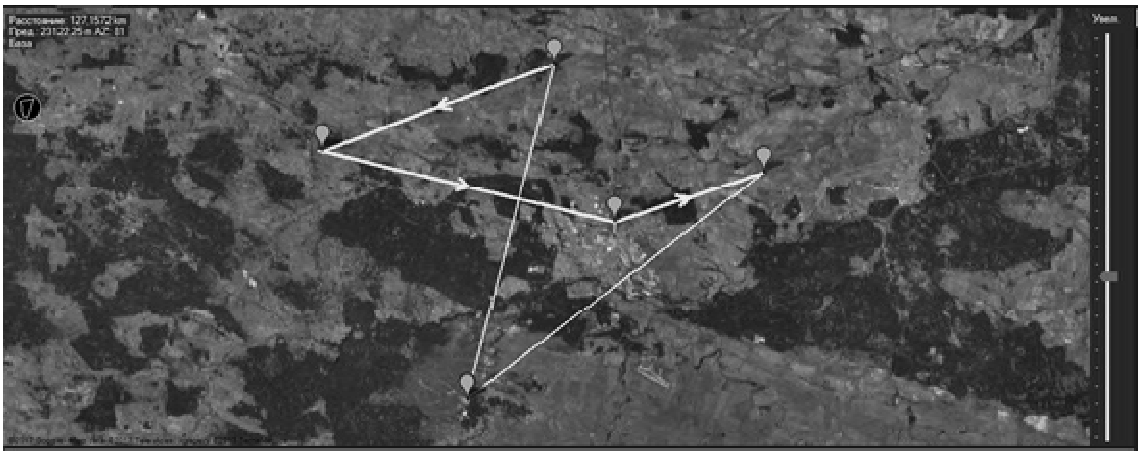


Picture 2. A route of motion UAVs is in a kind to the count Little's built with the use of algorithm

For evidentness will represent this task with attachment to the map with the reflection of route and directions of motion between the objects of secret service.

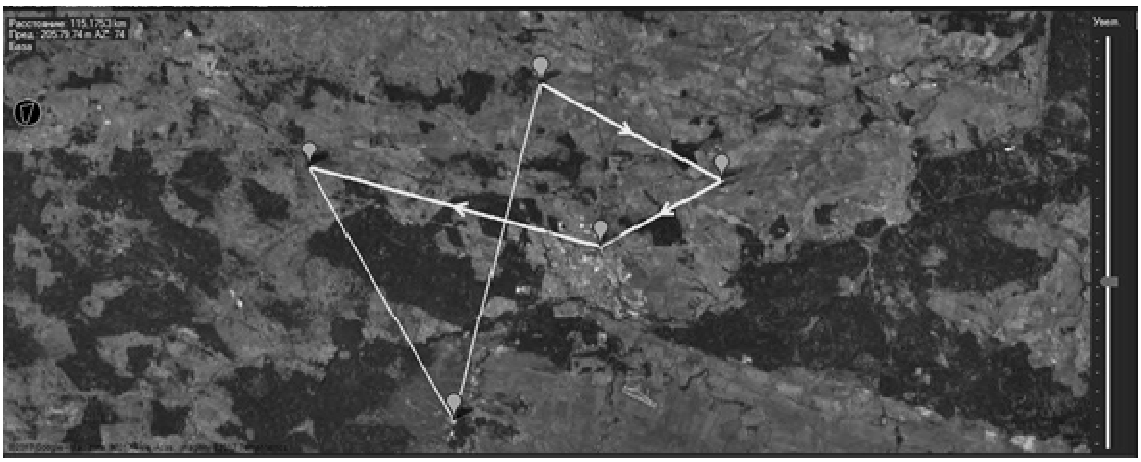
On picture number 3 the route of motion UAVs is shown that flies around objects in a simple appropriate sequence from the first to the last.

From the expounded route evidently, that the general extent of the passed way makes about 127 kilometres.



Picture 3. Route of motion UAVs with attachment to locality in the ordinary order of the following

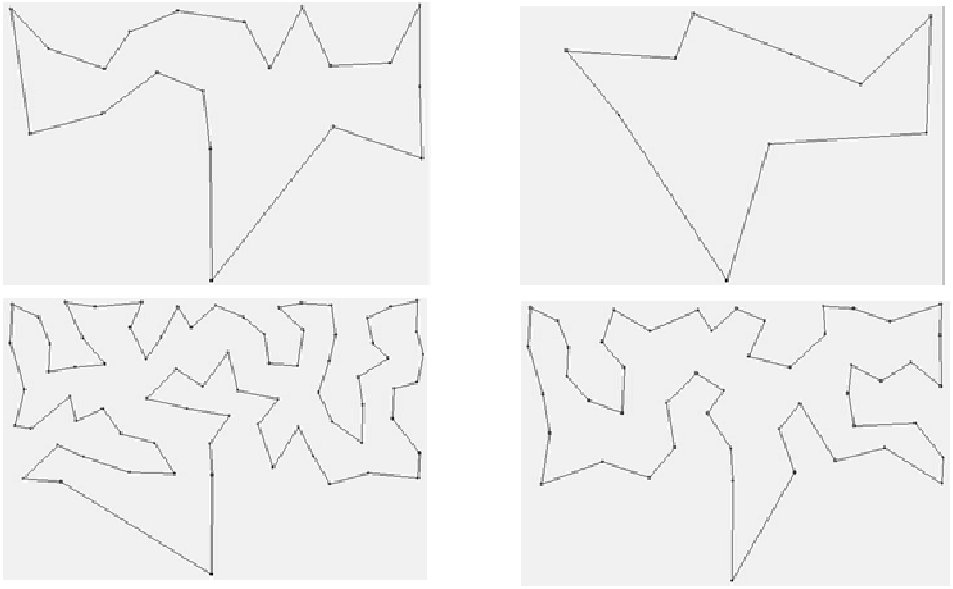
Using calculation data receipt by means of application algorithm of Little's will get the trajectory of flight UAVs, that is represented on picture 4.



Picture 4. The route of motion of UAVs with attachment to locality is built with the use of theory of the graphs

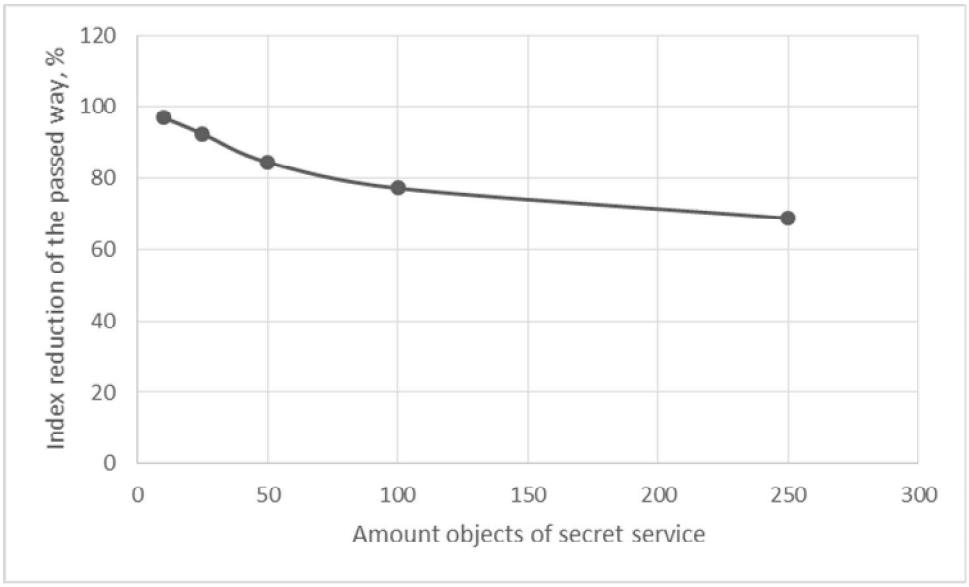
During realization of corresponding calculations general extent of way that passed UAVs between all objects makes about 115 kilometres, that in comparing to ordinary to the routes of motion less than on 12 kilometres.

Using calculations and worked out algorithm of findpath of close to the optimal route of motion UAVs during implementation of functional tasks with the use of algorithm Little's will get the routes of motion a programmatic way at the amount of objects of secret service 10, 25, 50 and 75 [7, p. 114-118].



Picture 5. Variants of construction route of motion pilotless aircraft are with the use theory of the graphs for 10, 25, 50 and 75 objects of supervision accordingly

Analysing the prospected routes of motion UAVs, comparing the extent of routes depending on the amount of the prospected objects, will systematize data and will represent them as a chart of dependence:



Picture 6. A chart of dependence of extent of the passed way is from the amount of objects of secret service with the use algorithm of Little's

Conclusions.

Using the theory of the graphs and directly algorithm of Little's it was conducted and analysed optimization trajectory of flight UAVs on the criterion of minimum pathlength, that in the prospect of further researches gives an opportunity of the use these calculations at the construction of frame case flight UAVs and constructions model of group flight UAVs, that will increase efficiency and quality of implementation of the put tasks of secret service and other important tasks.

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