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MODEL FOR TEMPORAL CLUSTERING OF A WIRELESS SENSOR NETWORK BY A TELECOMMUNICATION AERIAL PLATFORM FOR MONITORING DATA COLLECTION

The method of direct data collection from military wireless sensor network (WSN) nodes of use by telecommunication aerial platform (TA), which in the basic version needs telecommunication aerial platform flying around each sensor node or flying around the whole territory of nodes placement on the battlefield, etc., is considered [1]. The main advantage of the direct data collection method is the absence of additional algorithms to control the process of data transmission in sensor nodes with the telecommunications aerial platform, which leads to a significant simplification of node control system and cheaper equipment of nodes in general; the main drawbacks - very long time of data collection and increasing the requirements for flight time TA.

To eliminate these disadvantages, it is proposed to combine nodes into temporary clusters with the help of TA, that is, it is proposed to put a role of the main node of the cluster on TA [2]. Ground control center (CC) of the network (or itself TA in conditions of autonomous flight), which has information about the coordinates of nodes position, calculates data collection points (determines the position of TA in space), for example, as the center of mass of the virtual cluster. In contrast to existing centroid clustering algorithms, it is proposed to use two clustering algorithms, k-means and FOREL (FORmal ELement), which are characterized by lower computational complexity.

After determining the data collection points, the control center (or TA) calculates the so-called basic trajectory of the TA flight (route and altitude) between them. A modified ConvexHullInsertionHeuristicmethod is proposed to solve the traveling salesman problem. Then TA flies along the route to the defined collection points and collects monitoring data from the nodes of each cluster.

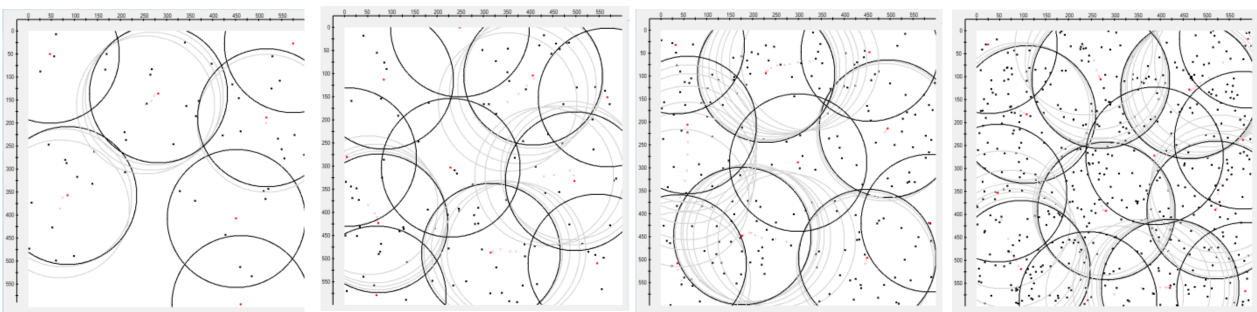
It is proposed to modify the FOREL and k-means algorithms taking into account the target control functions of the WSN during monitoring data collection.

It is proposed to modify the FOREL and k-means algorithms, considering the target control functions of the WSN during monitoring data collection.

The FOREL algorithm (FORmal ELement) is an algorithm for cluster analysis, which solves the clustering problem by minimizing the total quadratic deviation of cluster elements (network nodes) from the centers of mass of these clusters.

The cluster size is specified in the FOREL algorithm (in our case the size of TA coverage area). In two-dimensional geometric plane problem, R is the maximum distance from a cluster element to its center of mass (radius). Each element is also considered as a point on the plot and characterized by its coordinates (x_j, y_j).

Fig. 1 shows the results of the clustering of WSNs size n = 50, 100, 200 and 500 nodes using FOREL algorithm in C# environment. As a result of clustering, the WSN was divided into 7 clusters in a network of 50 nodes, 12 clusters in a network of 100 nodes, 10 clusters in a network of 200 nodes, 14 clusters in a network of 500 nodes.

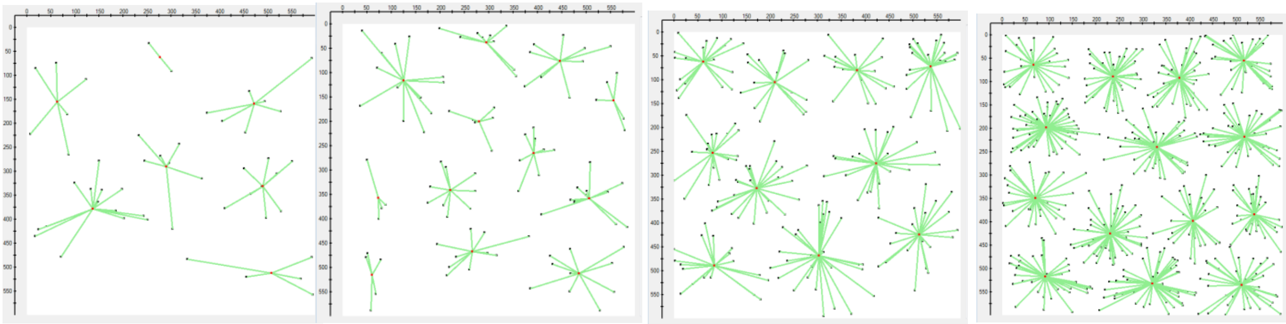


n = 50 n = 100 n = 200 n = 500

Fig. 1. Results of network clustering (FOREL method)

From the classical approaches to the implementation of FOREL when solving the data collection problem, we propose its modification (adaptation of the coverage area and taking into account the number of nodes in the cluster; the initial cluster is created in the place of the largest concentration of nodes) in order to implement the target control functions (minimum collection time or maximum WSN functioning time) and consider resource restrictions.

The k-means algorithm is a classical variant of the algorithm which solves the cluster analysis problem by minimizing the total quadratic deviation of cluster elements from the centers of these clusters. The function of the minimization can be written as: як: $M = \sum_{i=1}^{k} \sum_{x_j \in S_i} (x_j - \mu_i)^2$, where k – number of clusters, S_i– multiplicity of the elements for i-th cluster; μ_i- coordinates to the mass center for i-th cluster; x_j– coordinates to the mass center for j-th element of the cluster. The value ($x_j - \mu_i$) represent the euclidean distance between the cluster element and the center of the cluster mass. Fig. 2. shows the results of the clustering of the WSN size $n = 50$, 100, 200 and 500 nodes using the k-means method in the C# environment. As a result of clustering, the WSN was divided into 7 clusters in the network of 50 nodes, 12 clusters in the network of 100 nodes, 10 clusters in the network of 200 nodes, and 14 clusters in the network of 500 nodes.



$n = 50$ $n = 100$ $n = 200$
$n = 500$

Fig. 2. Results of network clustering (k-means method)

The considered methods obtain close to optimal solutions, so in practical applications it is useful to use both methods and choose the most acceptable result. Thus, unlike using the FOREL algorithm, using the k-means algorithm requires multiple solutions of the clustering problem. However, it allows to obtain a more uniform distribution of collection points over service areas.

The heuristic rules for adjusting (adding) exchange points and the basic route of TA flight in clusters to achieve certain target network management functions are proposed.

Conclusions.

1. The main stages of synthesizing the method of direct data collection from WSN nodes with their TA clustering are proposed: methods of network clustering and data collection points construction are defined.

2. For temporal clustering of the network as the main cluster node it is proposed to use TA, which implements (in contrast to existing centroid algorithms) modified iterative algorithms of cluster analysis FOREL (k-means) and finds the minimum (given) number of data collection points.

3. It is proposed a generalized data collection algorithm that builds a finite minimum (given) number of clusters based on the known TA coverage radius and sensor node position coordinates.

4. To check in practice the results of the algorithm functioning, the software implementation in the C# environment was performed. The model allows to reduce the length of the route around nodes on the telecommunication aerial platform by 10-15% in comparison with the centroid algorithms.

References

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