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ОПТИМАЛЬНЕ РОЗМІЩЕННЯ БАЗИ ДРОНІВ ДЛЯ КОНТРОЛЮ ЗАДАНОГО РАЙОНУ

DRONE BASE OPTIMAL PLACEMENT TO CONTROL A GIVEN AREA

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In the theory of continuous problems of optimal partitioning of sets, there is a developed toolkit for solving problems in known formulations. The report discusses the basic formulation of the problem.

Let Ω be a bounded Lebesgue-dimensional set in the n-dimensional Euclidean space En. Let us denote $P_N(\Omega)$ by the class all possible sets Ω to be divided into subsets N :

$$\hat{P}_N(\Omega) = \{\bar{\omega} = (\Omega_1, \dots, \Omega_N):\ \Omega_i \subseteq \Omega, i = \overline{1,N};\quad \bigcup_{i=1}^{N} \Omega_i = \Omega;\ \Omega_i \cap \Omega_j = \emptyset,$$
$$i \neq j;\ i,j = \overline{1,N}\}. \tag{1}$$

It is necessary to determine the partition $\bar{\omega} * \in \hat{P}_N(\Omega)$ and the set of "centers" of subsets $\tau^* = (\tau_1, \tau_2, ..., \tau_N) \in \Omega^N$ that deliver the minimum value of the functional

$$F(\overline{\omega}, \tau) = \sum_{i=1}^{N} \int_{\Omega_i} (c(x, \tau_i) + a_i) \rho(x) dx. \tag{2}$$

Here $c(x, \tau_i)$ are real, bounded, defined on Ω×Ω, measurable in x for any fixed $\tau_i \in \Omega$ (∀ i=1,..,N) function; $\rho(x)$ is a bounded, non-negative function measurable by Ω; a_i (∀ i=1,..,N) are given non-negative values.

The variety of initial data, including information about the properties of the set, restrictions on certain problem parameters and quality criteria, determines a wide range of applied partitioning problems. Modern transport processes are characterized by high speeds, new vehicles are involved in them. Accordingly, there is a need to analyze the trajectories of movement and the properties of this trajectory.

The paper investigates the problem of optimal placement, which is a special case of the continuous problem of optimal partitioning of sets with placement of centers of subsets. The cost function is interpreted as the flight path of the drone under the conditions of bypassing existing obstacles. The possibility of taking into account the influence of curvature and torsion on the cost of movement is taken into account. In fact, a new metric is introduced for this class of problems.

The general summary of the research carried out in this work can be formulated as taking into account during movement not only the length of the trajectory, but also the cost of maneuvering along this trajectory within the framework of the problem of optimal partitioning of sets with the placement of centers. Taking geometric characteristics into account translates the described problems of optimal partitioning of sets into the application area related to drone control. In this case, it is the geometry of trajectories; the next step is the physics of the process, interaction with the road or airspace.

Let's consider the formulation of the problem of optimal placement of the base.

A Kwitka task. Let Ω, T_i ($i=1,\dots,N$) , X_j ($j=1,\dots,M$) , Z_k ($k=1,\dots,L$) be a bounded Lebesgue-measurable sets in the n-dimensional Euclidean space En. We denote by $T_N(\Omega)$ the class of all possible sets T_i on Ω:

$$\hat{T}_N(\Omega) = \left\{\bar{\omega} = (T_1, \dots, T_N) : \ T_i \subseteq \Omega, i = \overline{1,N}; \quad \cup_{i=1}^{N} T_i \leq \Omega; \ \Omega_i \cap \Omega_j \neq \emptyset, i \neq j; \ i,j = \overline{1,N}\right\}. \tag{3}$$

It is necessary to determine the partition $\bar{\omega}* \in \hat{T}_N(\Omega)$ and the set of "centers" of subsets $\tau^* = (\tau_1, \tau_2, \dots, \tau_N) \in \Omega^N$, that deliver the minimum value of the functional

$$F(\overline{\omega}, \tau) = \sum_{i=1}^{N} Ti(Xj, Zk), \tag{4}$$

де X_j ($j=1,\dots,M$) : $X_j \cap T_i \neq \emptyset$, $Z_k \cap T_i = \emptyset$ ($\forall\ k,i$).

Schematically, the idea of the task for placing one center can be presented as follows in Fig. 1.

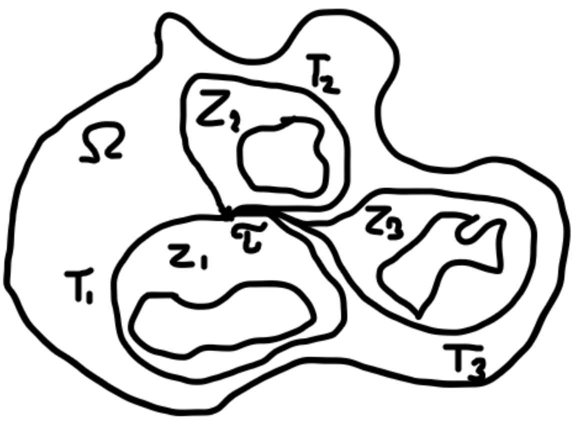

Figure 1. Sets and location center

The given statement of the problem is specified by limitations related to the characteristics of the drones themselves; this is both the radius of action, and limitations on maneuver and speed.