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REVIEW AND ANALYSIS OF OBJECT DISTANCE ESTIMATION ALGORITHMS IN RESCUE DRONE CONTROL SYSTEMS

Rescue drones are typically used for searching and rescuing people in conditions where direct human intervention may be dangerous or impossible.[1] The main functions of the object recognition systems in rescue drones include: object distance estimation; person and object recognition algorithms; object tracking systems; integration with other systems and data.

To improve the accuracy of distance measurement to objects, advanced sensors such as LIDAR can be used, which allow for more precise distance measurements and the creation of detailed 3D maps of the terrain. The use of machine vision algorithms can also enhance distance determination in challenging conditions, such as poor visibility. Regarding the improvement of person and object recognition algorithms, deep neural networks can be implemented for more accurate recognition of people, animals, or other specific objects in various environments. The development of specialized algorithms for identifying people by clothing, condition, or other characteristics can assist in rescue operations.[2]

To improve the object tracking system, algorithms can be developed that allow an object to be kept in frame during movement, ensuring continuous monitoring. The use of automated response systems to changes in behavior or movement of objects will enable the drone to better adapt to dynamic conditions. Integration with other systems and data, such as satellite imagery or information from other drones, can significantly enhance the informativeness of the terrain picture. Creating more efficient communication channels between the drone and the base station will ensure rapid processing and analysis of the data received. [3]

In rescue drone navigation systems, distance determination to objects can be based on a variety of technologies, as the accuracy and efficiency of this determination can be of vital importance.

The following technologies are most often used to solve such problems. Global Navigation Satellite System (GNSS): GNSS, such as GPS or Galileo, can be used to determine the geographical coordinates of the drone and the objects around it. Distance can be calculated based on the difference in coordinates. Laser ranging (LIDAR): LIDAR measures the distance to objects using reflected light signals. Using LIDAR, you can get fairly accurate distance measurements in real time [4].

Ultrasonic distance measurement: This technology uses high-frequency sounds to measure distances to objects. It can be useful in low-light, smoke, or dust environments.

Cameras with depth sensors: Cameras that have depth sensors can determine the distance to objects based on parallax analysis or changes in the texture of objects.

Radar can also be used to measure the distance to objects using reflected radio signals. It can be useful in low visibility or weather conditions.

Infrared sensors can measure the thermal radiation of objects and use it to determine distances.

Let's take a closer look at the key technologies for object distance estimation used in the navigation systems of rescue drones, as presented in Table 1.

Table 1 – Key technologies for object distance estimation in the navigation systems of rescue drones.

Stereovision	LIDAR	SAR	Ultrasonic rangefinder	Machine vision algorithms
It uses two or more cameras to create a three-dimensional representation of the terrain. By comparing images obtained from different viewpoints, the algorithm can measure the distance to objects based on the parallax between corresponding points on each image.	It uses laser beams to measure the distance to objects. The drone emits laser pulses and measures the time needed for their return after reflecting off objects. This method is very accurate and can operate in various weather conditions.	It is used to create detailed images of the terrain using radio waves. It can operate effectively regardless of weather conditions and lighting, making it ideal for rescue missions at night or in poor weather conditions.	Ultrasonic sensors measure the distance to objects using sound waves that reflect off the objects and return. This method is primarily used for close distances and obstacle avoidance	They are used for processing images obtained from cameras. These algorithms may include deep learning methods that enable drones to recognize and classify objects, measure distances, and even predict potential obstacles.

In future research, it would be advisable to select the most effective among the considered algorithms in such a way that the tasks of the rescue drone are solved as efficiently as possible, combined with the tasks of recognizing persons and objects and tracking objects.

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