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OPTIMIZATION OF SLAM ALGORITHMS FOR MOBILE ROBOTS IN DYNAMIC ENVIRONMENTS

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SLAM (Simultaneous Localization and Mapping) algorithms are the basis for autonomous navigation of mobile robots, allowing them to simultaneously build a map of the environment and determine their location. However, in dynamic environments with moving objects (people, vehicles), traditional SLAM methods face problems as dynamic objects introduce errors into the map, reducing the localization accuracy [1].

The goal of the work is to propose SLAM optimization methods for such conditions, paying special attention to filtering dynamic objects and integrating data from various sensors.

Traditional SLAM algorithms, such as ORB (Oriented Fast and Rotated Brief)-SLAM and LSD (Large-Scale Direct)-SLAM, assume a static environment. In reality, robots often operate in dynamic conditions, which leads to mapping inaccuracies, localization errors, and increased computational load. To solve these problems, an approach based on semantic segmentation and sensor fusion is proposed. Semantic segmentation, implemented using neural networks, allows classifying objects into static (walls, furniture) and dynamic (people, cars) [2].

Dynamic object data is excluded from the map construction process. To improve SLAM accuracy, sensor fusion is used, combining data from the lidar, camera, and IMU (Inertial Measurement Unit). The lidar provides accurate distance data, the camera provides semantic information, and the IMU provides acceleration and orientation data. An Extended Kalman filter (EKF) is used to integrate the data. To reduce the computational load, sparse methods are used, which process only key points in the image, as well as optimization using the GPU. The experiments were conducted in the Gazebo simulator and in real conditions. Dynamic objects (people, cars) were used in the simulation, and in real conditions, testing was carried out on a mobile robot in a room with moving people.

To evaluate the effectiveness of the proposed approach, the metrics of localization accuracy (RMSE), map quality (number of artifacts), and processing time were used. The results showed that the proposed approach reduces the localization error by 30% compared to traditional SLAM methods, reduces the number of artifacts on the map by 50%, and increases the processing time by 15%, which is still within the acceptable limits for real-time operation [3].

One of the key advantages of the proposed method is its ability to adapt to changing environmental conditions. For example, in low-light conditions or in the presence of a large number of dynamic objects, the algorithm demonstrates stable operation. This is achieved by combining data from different sensors, which allows compensating for the shortcomings of each of them. For example, lidar provides accurate data even in the dark, and the camera provides semantic information that helps identify objects. The results confirmed the effectiveness of the proposed methods. The integration of semantic segmentation and sensor fusion allowed to significantly improve the accuracy of SLAM in dynamic environments.

However, the increase in computational complexity requires further optimization, especially for robots with limited resources. In the future, it is planned to explore the possibility of using reinforcement learning to adapt algorithms to various environmental conditions. The possibility of using quantum computing to further accelerate data processing is also being considered.

References

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