基于 SLAM-Lidar 技术的自主导航系统研究报告

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Research Report of Autonomous Navigation System Based on SLAM Lidar Technology

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Abstract：Unmanned Aerial Vehicle (UAVs) have been widely used in areas such as military reconnaissance and disaster relief. In the absence of GPS signals and other complex environments, vision-based aircraft positioning navigation and map construction have gradually become research hotspots. An accurate and stable navigation and positioning is the basis for the cruise robot to perform the cruise task, which can make the flight robot operate more efficiently and reliably to complete the cruise task and reduce the labor intensity of the staff. The project team aims to solve problems that arise in traditional autonomous flight systems. A visual loop detection link was added to the graph-based laser SLAM system, combined with the FastSLAM algorithm-based UAV landing method, and the square root volume fuzzy adaptive Kalman filter SLAM algorithm was improved to complete an autonomous navigation system for complex environments. This article further optimized and applied the algorithm of SLAM lidar technology to solve the disadvantages of SLAM navigation system such as inconvenience.

Key words：UAVs；SLAM；lidar；autonomous navigation system.

1 Introduction

The research of the autonomous flight system based on the SLAM lidar technology of the ROS system is based on the use of vision to autonomously complete accurate navigation flight control and map construction tasks. It does not require other auxiliary positioning systems, and has high navigation flight control accuracy, which helps to solve problems such as the inability to detect loop points in complex environments, poor real-time navigation performance during landing, and improvement of motion noise and observation noise. Therefore, the system has great transformation prospects in military reconnaissance, medical assistance, disaster rescue and detection.

2 Existing Problems

2.1 Unable to detect loopback points

This paper compares the improved laser SLAM algorithm based on graph optimization with the traditional SLAM algorithm to build a map in the same environment. It is found that in the traditional algorithm, the UAV moves clockwise along the corridor from the monitoring point. After running for a circle, when passing the monitoring point again, the geometric information obtained is not rich enough, and the loopback point is not found in time. When the UAV continued to the next monitoring point, no loopback point was found. At this time, it can be clearly found that the cumulative error of the map is constantly increasing.

2.2 Poor real-time navigation when landing

At present, the navigation technologies used for landing of UAVs are mostly inertial navigation systems, GPS navigation systems, inertial/GPS integrated navigation systems, computer vision navigation systems, and so on. Studies have found that these landing methods have some disadvantages: navigation errors accumulate with time; susceptibility to signal interference affects navigation accuracy; and the processing data is too large to ensure the real-time nature of the landing process.

2.3 Severe motion noise and observation noise

In this paper, the traditional SLAM algorithm was studied under the influence of the Gaussian noise (analog system noise) of the same value. It is found that the positioning accuracy of traditional UAVs is seriously affected by noise. How to improve the compatibility and robustness of the algorithm by improving the motion noise and observation noise in the system is worthy of attention.

2.4 Connection of communication nodes and data interfaces

The communication interface node is the information transmission hub between the main control computer and the Pixhawk flight control board. This node is the key to the real-time acquisition of the flight status of the aircraft by the main control computer and autonomous control of the flight status. At present, the traditional communication node and data interface connection methods have problems such as poor real-time performance and short communication distance.

3 Research program

3.1 Construction of hardware UAV platform

The research object of this project was a quadrotor UAV. The hardware materials required for the flight control system included Pixhawk aircraft control motherboard (PX4), a number of visual optical sensors, on-board micro-central control computer, power supply system and motor drive network. The components worked together to achieve visual sensor information collection and real-time positioning, and sent the information back to the control board for interpretation in the MAVROS format, and then precisely controlled the flight trajectory and exercise route of the aircraft. To this end, a quad-rotor unmanned aerial vehicle that meets the above-mentioned load requirements has been assembled in this article, and on the basis of this, an additional micro-medium control computer was used to collect and process the sensor information. In order to ensure the reliability of the test and the reference value of the information, the flight endurance time was set above 20 minutes.

3.2 Deployment of communication nodes and data interfaces

As the transmission hub and conversion interface between the ground control computer and the airborne flight control board, communication data is the key to obtaining flight status and controlling flight trajectory. In order to deploy this communication node, this article mainly received the heartbeat packet, attitude angle packet and position data packet of the UAV through the Mavlink protocol, and published the data to different topics in a specific message format by category. It subscribed to topics such as Vision and Position, and then sent these topic data to the flight control board in the form of MAVLink protocol to obtain data from external sensors and achieve autonomous flight control. The design principle of the autonomous control node can be summarized as subscribing to the current position of the aircraft, providing position feedback, and then issuing position control commands to the communication node, so as to adjust the position control information through real-time monitoring of the status of the UAV.

3.3 Improvement of SLAM algorithm of square root volume fuzzy adaptive Kalman filter

This paper compared the positioning accuracy of the improved square root volume fuzzy adaptive Kalman filter SLAM algorithm with the traditional SLAM algorithm under the interference of the same value of Gaussian noise (analog system noise). The research found that the positioning accuracy of traditional UAVs is seriously affected by noise. Therefore, we introduced iterative ideas and time-varying fading factors into the square root volume Kalman filter, dynamically adjusted the

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means and covariance of the information, established a fuzzy adaptive model to adjust the noise weight, and improved the motion noise and observation noise in the system. Not only that, the algorithm has better compatibility and robustness than previous algorithms that can solve a single problem.

3.4 Improvement of laser SLAM based on graph optimization

This paper proposed a method of fusion of laser and monocular vision for simultaneous positioning and map construction aiming at large and complex environments with insufficient geometric features. Combined with the information-rich features of the vision sensor, the SLAM system with laser and monocular vision was designed. The laser SLAM system incorporating visual information was composed of 4 parts, which were laser data acquisition and scanning matching, visual data processing and loop detection, back-end map optimization, and map construction, so as to eliminate the errors caused by map construction in time.

3.5 Landing method of UAV based on FastSLAM

In order to solve the disadvantages of traditional UAV landing: navigation errors accumulate with time and are susceptible to signal interference to affect navigation accuracy. This paper proposed a UAV landing method based on FastSLAM algorithm. The UAV used the onboard camera to locate the UAV. The visual odometer was integrated into the SLAM framework to reduce the impact of the odometer's cumulative error. It relied on airborne inertial sensors and monocular cameras and used the SLAM algorithm for navigation, which overcame the effects of inertial device drift and dependence on GPS.

Conclusions

Through the research in this paper, the improved algorithms such as laser SLAM based on map optimization have obtained rich geometric information, and have been globally optimized multiple times to eliminate the accumulated errors in the map in time. Therefore, even if it is not used on UAVs, but used on traditional robots, it is a great upgrade of traditional robot functions. This makes the traditional robots more distinguish the environment, and the more accurate operations make the executable tasks to be miniaturized, which also has a good prospect for transformation.

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