Vision Feature Extraction Algorithm for Occupancy Grid Maps Merging

LIANG Jian
Academy of Armored Land Forces
Beijing, China
liangj001@126.com

Zhang Chen
Academy of Armored Land Forces
Beijing, China
buaa0318@163.com

lV Qiang
Academy of Armored Land Forces
Beijing, China
rokyou@live.cn

WEI Heng
Academy of Armored LandForces
Beijing, China
wh_killer@foxmail.com

Ma Manzhen
Academy of Armored Land Forces
Beijing,China
853856037@qq.com

ABSTRACT
With the improvement of single robot SLAM technology, multi-robot SLAM became a research hotspot.Map merge is one of the difficult issue.In this paper, aORBfeature extraction algorithmfor occupancygrid maps mergingwasimproved. ORB features have good rotation and scaleinvariance, while maintaining a compromise calculation speed, in the real-time SLAMaccess to a large number ofapplications.Based on Robot Operating System,two omnidirectional robots equipped with a 2D laser sensor RPLIDARbuildgrid maps via Hector SLAM. Map mergeisintegrated as an image registration problem, by extracting the ORB features of the grid mapsand usingBruteForce search method to match, among thebest matches,calculatingaffine transformationand merging.The experimental results show that the improved algorithm has abetter performance on real-time and effectiveness.

CCS Concepts
•Computing methodologies→Computer graphics → Image manipulation→Image processing

Keywords
ORB; Grid map;Map merge; Robot Operating System

1. INTRODUCTION
In acomplex and dangerous environment,multirobot collaboration shows a great advantage that can handle problems well,such as emergency treatment,exploration resources,spaceexploration[1], makinglots of contributions to human society.

Collaborative multi-robot system has four obvious advantages: (1)high efficiency-the use of spatial distribution of the sensor, compared to a single system, can be faster to reduce the uncertainty of the map;(2)reliability and robustness;(3)specialization - with more sensory perspectives and sports skills, multi robots have more scalable features, overcoming the limitations of a single robot and increasing the overall utility of the collaborative system; (4)highfault tolerance - a robot making mistakescan not affect the overall situation.

TheMultiRobot Systems (MRS) SLAM algorithm[2-4]began to be widely studied by more and more researchers. Map merge is an effective means to solve multi-robot SLAM, including direct merge[5] and indirect merge[6].

In this paper,weimproveaalgorithmthat uses ORB feature extraction to merge two maps. Section2 presents the experimental materials andmethods.The algorithms analysisis presented in Section3. Section4 shows the experiment procedure.

2. MATERIALS AND METHODS

2.1 ROS
The whole experimental environment is based on the robot operating system (ROS), a distributed andopen source operating system for robots.In some ways, ROS is equivalent to a robot frameworks.ROS has a three-tier concept, a file system layer, acomputationalgraphical layer, and a community layer. The package in the file layer is the primary unit of the ROS organization software. The computational graphics layer is the network that handles data point-to-point. Community layer is a platform where Robot researchers learn from each other.

2.2 RPLIDAR
Among two-dimensional laser radars, combined with cost-effective and ease of installation, the experiment selected RPLIDAR as a 2D laser sensor. RPLIDAR is a low-cost 2D laser radar developed by the RoboPeak team, and the 2D data generated by scanning can be used for SLAM.There is an open source interface driver on ROS. The appearance view is as shown in figure 1:

ICCIS 2017, November 7-9, 2017, Wuhan, China

ACM ISBN 978-1-4503-5348-9/17/11…$15.00
DOI: https://doi.org/10.1145/3158233.3159372

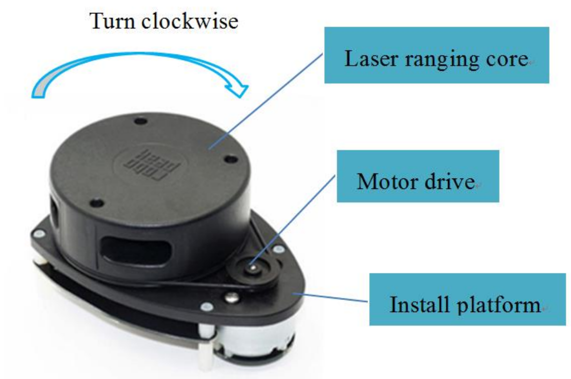

Figure 1. RPLIDAR appearance view

2.2.1Principle of distance measurement

RPLIDAR uses laser triangulation technology, ranging action can be up to 2000 times per second. After being calculated by an internal DSP processor of RPLIDAR realtime, thedistance value and the current angle informationof target object will export from the communication interface.The schematic is as shown in figure 2:

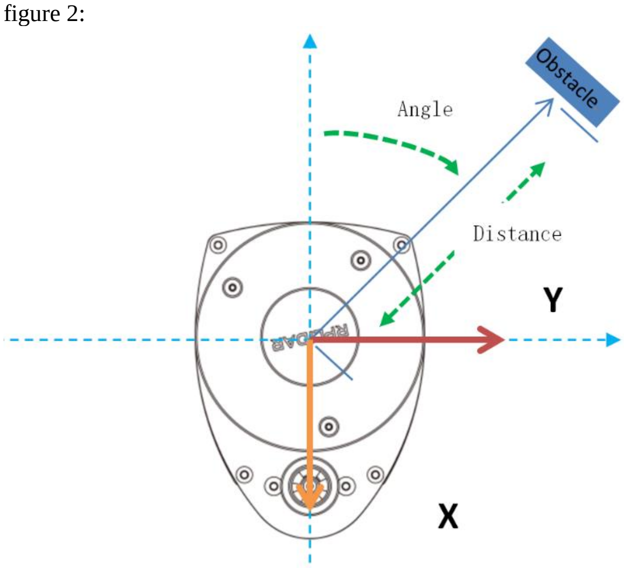

Figure 2.Principle of distance measurement

2.2.2 Specific parameters

The specific parameters of the RPLIDAR is demonstrated as shown intable1:

Table 1. RPLIDAR specific parameters

Content	Typical value
Distance range	0.2~6m
Angle range	0~360°
Distance resolution	<0.5mm
Angle resolution	≤1°
Sampling period	500ns
Sampling frequency	≥ 2000Hz
Scanning frequency	5.5(1~10)Hz

2.3 Omnidirectional robotplatform

We buildomnidirectional robot platformindependentlyas shown in figure 3:

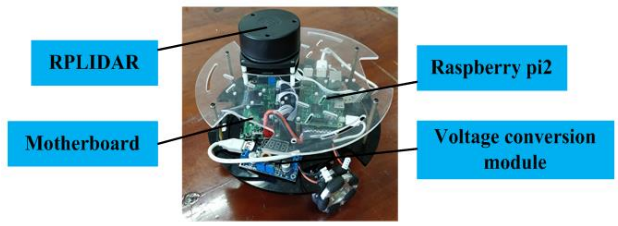

Figure 3. Robot platform

RPLIDAR:As a laser sensor,scan the 2D point cloud information of the surrounding environment, as the input of the Hector SLAM algorithm.

Raspberry pi2:As a CPU,mainly run SLAM algorithm for map building.

Motherboard:Three motor drive modules are configured, which enlarges PWM signal exported by raspberry pi2 to drive the motor，achievingpositive and negative speed control.

Voltage conversion module: Model aircraft lithium battery output 12V, the DC power supply provides a stable 5V voltage through the voltage conversion module to power the raspberry pi2.

2.3.1 Hardware connection

Hardware connection is as shown in figure 4.

2.4 HectorSLAM

HectorSLAM[7] is an open source 2D SLAM method，through the least squares method to match the scanning point，and relys on high-precision laser radar data, buildsthe two-dimensional grid mapofthe environment.

3. ALGORITHMS ANALYSIS

3.1 ORB Feature

The ORB features include the oriented FAST keypoints andthe rotated BRIEF descriptor,With good rotation and scale invariance.

3.1.1 Oriented FAST

Take a piece of the image B , define the moment of the block:

$$m_{pq} = \sum_{x,y \in B} x^p y^p I(x,y) \qquad (1.1)$$

Through the moment to obtain the center of mass C :

$$C = \left(\frac{m_{10}}{m_{00}}, \frac{m_{01}}{m_{00}}\right) \qquad (1.2)$$

Find the direction of the keypoints:

$$\theta = \arctan(m_{01} / m_{10}) = \arctan\left(\frac{\sum_{x,y} yI(x,y)}{\sum_{x,y} xI(x,y)}\right) \qquad (1.3)$$

Where $x, y \in [-r, r]$, r is the radius.

3.1.2 Rotated BRIEF

BRIEF is a binary descriptor, through the random selection point, speed is fast.

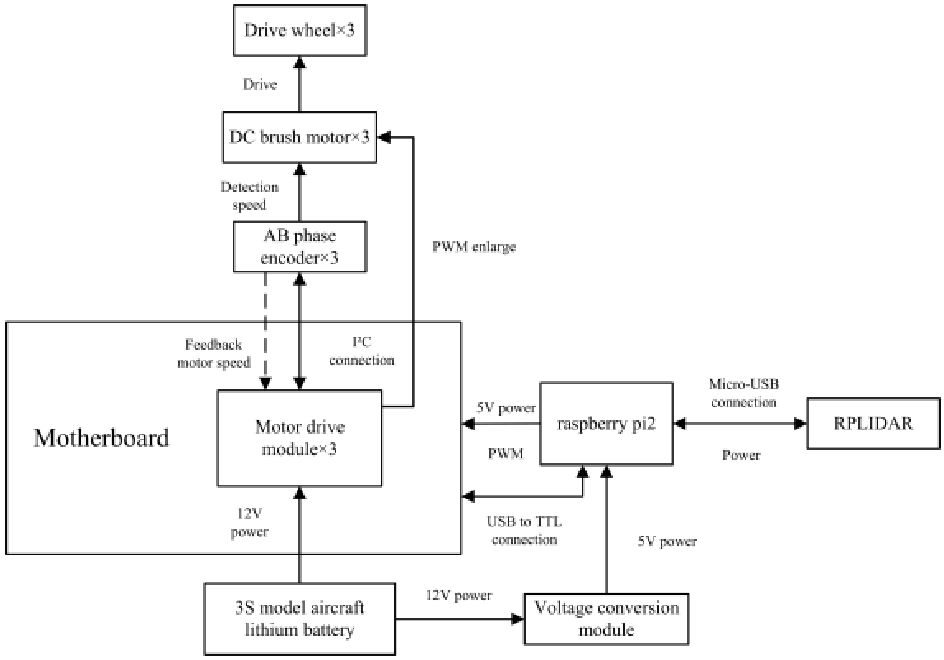

Figure 4.Hardware connection

3.2 Algorithm Flow

Opencv provides two methods for image feature point matching, Brute Force and FLANN (fast library for approximate nearest neighbors). In combination with the requirements of this paper, the extraction of image features should be as accurate as possible in order to ensure the accuracy of subsequent merge, the accuracy more important than the efficiency, so choose BruteForceMatcher function class as a means of matching.

The algorithm flow is as shown in figure 5:

At last, we get the optimal affine transformationmatrix T, including rotation R and translation t.

4. EXPERIMENT PROCEDURE

4.1 Map Building and Merging

Selecting corridor as a test environment. Two omnidirectional robots run the HectorSLAM algorithm individuallyto get the local grid mapsand mergeinto a global map. First, extract the ORB features and match，the map matching effect is shown in figure 6:

Second, calculate the optimal affine transformation matrixis as follows:

$$T=[R,t]=\begin{bmatrix} 0.9754 & 0.2399 & -56.1720 \\ -0.2399 & 0.9754 & -310.3975 \end{bmatrix} \quad (1.4)$$

$$R=\begin{bmatrix} 0.9754 & 0.2399 \\ -0.2399 & 0.9754 \end{bmatrix} \quad (1.5)$$

$$t=\begin{bmatrix} -56.1720 \\ -310.3975 \end{bmatrix} \quad (1.6)$$

Third, merge two maps, the red circle represents the repeat area,map merge effect is as shown in figure 7:

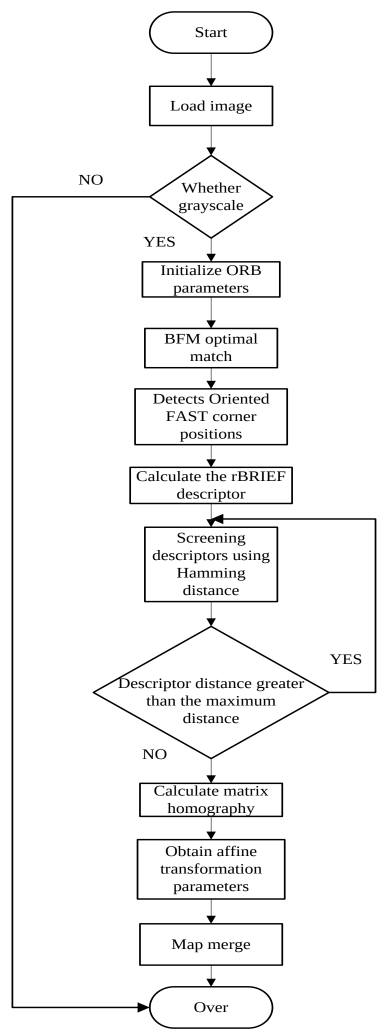

Figure 5. Algorithm flow

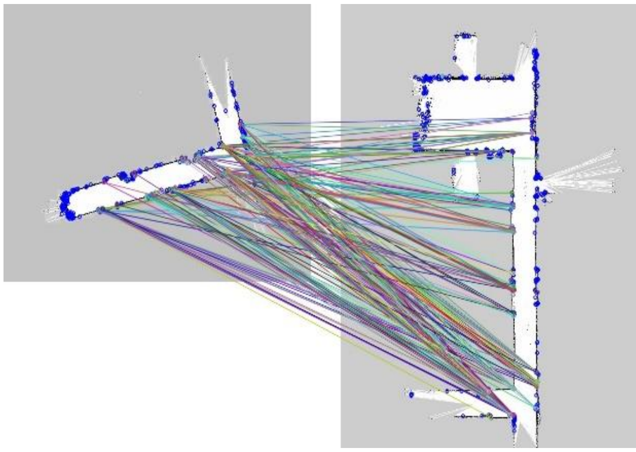

Figure 6. Feature extraction and match

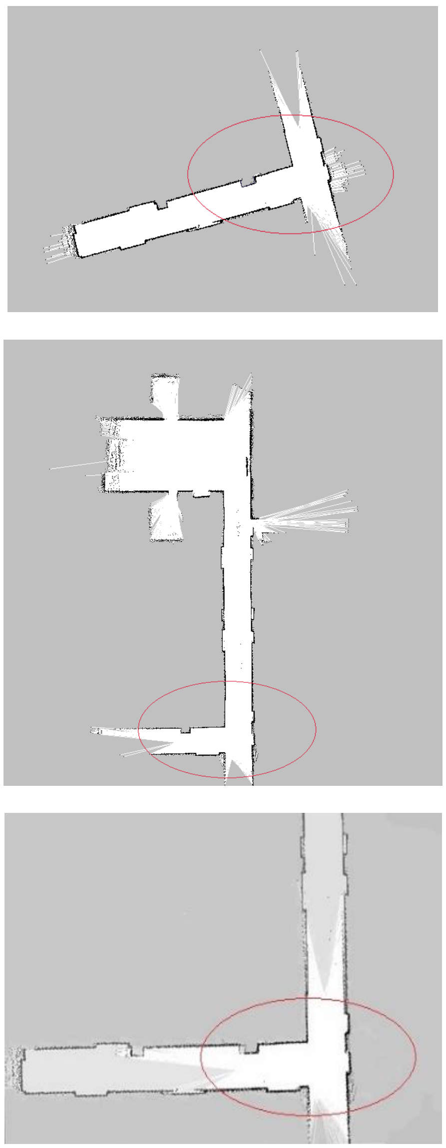

Figure 7. Map merging

5.CONCLUSIONS

In this paper, the multi-robot grid map fusion algorithm based on ORB features is studied. The innovation is that in order to improve the effectiveness of the fusion algorithm, the traditional method and the ORB algorithm are combined and applied to the multi-robot raster map fusion.

Combining with the selected grid map building algorithm and fusion algorithm, the innovation lies in using Raspberry Pi 2 as a development board, and building a low-cost omnidirectional robot platform for building a clear two-dimensional grid map.

Based on Raspberry Pi 2 multi-omnidirectional robotic platform, HectorSLAM is used to construct a roaming grid map in real environment. Combining the fusion results based on the ORB feature method, the experimental data show that the improved fusion algorithm has the efficiency in map fusion Fast and high precision.

6. REFERENCES

[1] Simmons R, Smith T, Dias M B, Goldberg D, Hershberger D, Stentz A, Zlot R. Multi-robot systems: from swarmsto intelligent automata. In: Proceedings of the 2002 NRL Workshop on Multi-Robot Systems. Netherlands: Springer,2002. 103−112.

[2] Gil A. Multi-robot visual SLAM using a Rao-Blackwellized particle filter[J]. Robotics & Autonomous Systems, 2010, 58(1):68-80.

[3] Atanasov N, Ny J L, Daniilidis K, et al. Decentralized active information acquisition: Theory and application to multi-robot SLAM[C]// IEEE International Conference on Robotics and Automation. IEEE, 2014:4775-4782.

[4] Deutsch I, Liu M, Siegwart R. A framework for multi-robot pose graph SLAM[C]// IEEE International Conference on Real-Time Computing and Robotics. IEEE, 2016:567-572.

[5] Lee H S, Lee K M. Multi-robot SLAM using ceiling vision[C]// Ieee/rsj International Conference on Intelligent Robots and Systems. IEEE, 2009:912-917.

[6] Carpin S. Fast and accurate map merging for multi-robot systems[J]. Autonomous Robots, 2008, 25(3):305-316.

[7] S. Kohlbrecher, J. Meyer, O. Von Stryk, U. Klingauf. A Flexible and Scalable SLAM System with Full 3D Motion Estimation, In the Int. Symp. on Safety, Security and Rescue Robotics (SSRR), Nov. 2011.