Parameter Reduction for OctoMap and ORB-SLAM Algorithms

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***Abstract*— This paper presents a parameter reduction method for OctoMap and ORB-SLAM algorithms using Neighbourhood Component Analysis (NCA). Results show that OctoMap parameters are of higher impacts on mapping performance than ORB parameters.**

I. INTRODUCTION

OctoMap [1] is an efficient mapping algorithm to generate occupancy maps. To build a map using OctoMap, point clouds and corresponding sensor poses are required. Point cloud generation parameters, OctoMap parameters and pose generation parameters will affect the quality of the final map. In [2], point clouds are produced by implementing StereoSGBM algorithm [3] on stereo images and the poses of the camera are derived by ORB-SLAM [4]. Point cloud parameters and OctoMap parameters have been studied in [2]. However, parameters in ORB-SLAM are not investigated. This paper aims to fill this gap.

The paper is organised as follows. In section II, parameters in ORB-SLAM are introduced and their default values are given. Then we introduce the method to analyse parameter weights in section III. Parameter space for analysis is presented in section IV. Results are also given in section IV.

II. BACKGROUND

In ORB-SLAM [4], the parameters are as follows.

- N_f is the number of features in each image.
- s_f is the scale factor between levels in the scale pyramid.
- N_l is the number of levels in the scale pyramid.
- t_i is the initial threshold implemented to extract FAST corners.
- t_{min} is the lower threshold to extract FAST corners. If no corners are detected with the initial threshold, threshold t_{min} will be imposed.

These parameters are all for ORB feature extraction. The corresponding default values are presented in table I.

TABLE I
DEFAULT ORB PARAMETERS

Parameter	Value
N_f	2000
s_f	1.2
N_l	8
t_i	12
t_{min}	7

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III. METHOD

In [2], ORB-SLAM parameters are of default values, and the weights of point cloud parameters and OctoMap parameters under different performance metrics are computed. Since OctoMap parameters have higher impacts on performance metrics, we will fix point cloud parameters in this paper to reduce computational time. We use the method in [2] to combine OctoMap parameters and ORB parameters and randomly divide all the combinations into different groups based on the number of data sets. For each combination of parameters, an occupancy map can be generated. The nodes in the map will be classified into four categories, i.e., true positives (TP), false positives (FP), true negatives (TN) and false negatives (FN), in a confusion matrix [5] using the method in [2]. The number of nodes in each class will be used for computing performance metrics, i.e., true positive rate (TPR) and false discovery rate (FDR), as introduced in [2]. Then we use Neighbourhood Component Analysis (NCA) [6] to calculate the weights of OctoMap parameters and ORB parameters under performance measures.

IV. EXPERIMENTS

A. Experimental Setup

In this work, the data sets introduced in [2] are used as test scenes and targets. The data sets are collected in two environments, i.e., in front of buildings and in a parking lot. The targets are two boxes either with plain brown surfaces or covered by Voronoi diagrams [7]. Different layouts of two boxes can be created with five free tetrominoes [8], [9], i.e., I, O, T, L and S, in Teris game. Taking environments, patterns on the boxes and layouts into account, the total number of data sets is 20.

Keyframes produced by ORB-SLAM are normally different when ORB-SLAM is run multiple times, even with the same data set and same parameters. To make results comparable, point clouds of keyframes of each data set in [2] are used for map generation. When ORB parameters are different, the poses corresponding to these keysframes can be derived by camera trajectories through matching keyframe time steps.

B. Parameter Space for Analysis

Point cloud parameters correspond to the 800th point cloud set in Voronoi box of I layout in front of buildings in [2]. The configuration of OctoMap parameters is the same as that in [2]. We vary all the ORB parameters in reasonable ranges to study their impacts. The configuration of ORB parameters is presented in table 2. The considerations for parameter settings are as follows. The number of features in each image should not be too small to make sure the features in two images can be matched. Considering the number of pyramid levels, 1.3 as maximum for s_f is relatively large and appropriate since the image size will be divided by $s_f^{N_l}$ at N_l-th level. N_l and t_i are varied based on the default values, and $t_{\min}$ is further decreased.

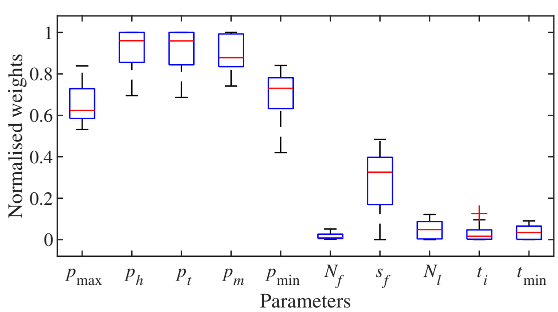
TABLE II

CONFIGURATION OF OCTOMAP PARAMETERS

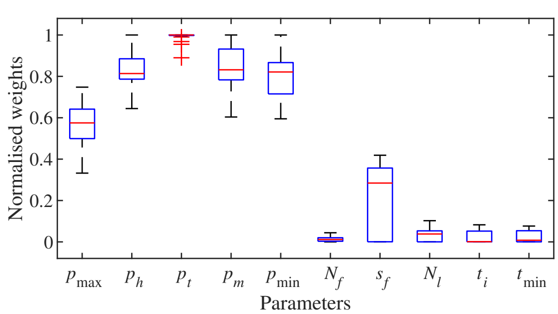
Parameter	Minimum	Maximum	Step
N_f	1500	2000	500
s_f	1.1	1.3	0.1
N_l	7	9	1
t_i	11	13	1
$t_{\min}$	5	7	1

C. Results

With the settings of OctoMap parameters in [2] and ORB parameters in table II, the number of combinations of parameters for each data set is 12 150. We analyse parameter weights using the metrics in TPR-FDR curve as introduced in [2]. Parameter weights in each data set are normalised as in [6]. The weight of each parameter is shown in figure 1. OctoMap parameters show higher weights than ORB parameters in both performance measures with mostly being above 0.5. While most ORB parameter weights are under 0.1, and s_f shows the highest weight among these parameters, but its weights are mostly under 0.4.



(a)



(b)

Fig. 1. Normalised parameter weights for performance metrics true positive rate (TPR) and false discovery rate (FDR). (a) TPR. (b) FDR.

V. CONCLUSIONS

OctoMap parameters have a higher impact on the mapping performance than ORB parameters.

REFERENCES

[1] A. Hornung, K. M. Wurm, M. Bennewitz, C. Stachniss, and W. Burgard, "Octomap: An efficient probabilistic 3d mapping framework based on octrees," *Auton. Robot.*, vol. 34, no. 3, pp. 189–206, 2013.

[2] Y. Miao, A. Hunter, and I. Georgilas, "Parameter reduction and optimisation for point cloud and occupancy mapping algorithms."

[3] S. Brahmbhatt, *Practical OpenCV*, 1st ed. New York, NY, USA: Apress, 2013.

[4] R. Mur-Artal, J. M. M. Montiel, and J. D. Tardos, "Orb-slam: A versatile and accurate monocular slam system," *IEEE Trans. Robot.*, vol. 31, no. 5, pp. 1147–1163, 2015.

[5] T. Fawcett, "An introduction to roc analysis," *Pattern Recognit. Lett.*, vol. 27, no. 8, pp. 861–874, 2006.

[6] W. Yang, K. Wang, and W. Zuo, "Neighborhood component feature selection for high-dimensional data," *J. Comput.*, vol. 7, no. 1, pp. 161–168, 2012.

[7] F. P. Preparata and M. I. Shamos, *Computational geometry: An introduction*, 1st ed. New York, NY, USA: Springer, 1985.

[8] B. C. Barnes, D. W. Siderius, and L. D. Gelb, "Structure, thermodynamics, and solubility in tetromino fluids," *Langmuir*, vol. 25, no. 12, pp. 6702–6716, 2009.

[9] S. W. Golomb, *Polyominoes: Puzzles, patterns, problems, and packings*, 2nd ed. Princeton, NJ, USA: Princeton Univ. Press, 1994.