Journal of Information and Computing Science
J. Info. Comput. Sci., Vol. 19, No. 2, pp. 171-190

DOI: 10.4208/JICS-2024-010
December 2024

MFIPC: Point Cloud Registration Algorithm via Multi-feature Fusion and Interval Pairing Consistency

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Abstract. Inspired by the Fast point Feature Histogram (FPFH) feature extraction algorithm, this paper proposes a new 3D point cloud registration method, MFIPC (Multi-feature Fusion and Interval Pairing Consistency). The method uses feature fusion and interval pairwise consistency to improve the registration accuracy. In the MFIPC framework, the point cloud is first downsampled to optimize computational efficiency and expand the analysis domain. Then, clustering algorithm using local directional centrality (CDC) classification algorithm is used to calculate the DCM (directional centrality measure) value of each point. The Gaussian curvature values of the points are calculated at the same time, and these eigenvalues are fused. To further refine the registration process, the range between the minimum and maximum eigenvalues is divided into several equal intervals and sorted in ascending order. A sorting algorithm is used to assign each eigenvalue to a corresponding interval. For the global point cloud computing step, after the operation is completed, the number of points in each interval and its proportion are calculated. The program processes both point clouds in order to analyze their interval percentage. This algorithm significantly improves the robustness of MFIPC in establishing point correspondence. To verify the effectiveness of MFIPC for 3D point cloud registration, we conducted extensive testing on various datasets, including 3DMatch, RESSO, ModelNet40, Stanford Rabbit, and Dragon. The experimental results show that the algorithm has high efficiency, good consistency of point cloud, significantly reduced registration errors, low error and high registration accuracy.

AMS subject classifications: 68W40, 68W05

Key words: Point cloud registration method, Multi-feature fusion, Interval pairing consistency

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1 Introduction

Traditional 2D image sensors can only obtain two dimensional image information, for the detection of complex scenes, such as the number of people passing through the intersection statistics, semantic segmentation [1], the need for complex algorithmic processing of two-dimensional image data, which will take up most of the CPU's computing resources, and the real-time accuracy is low, so the threedimensional depth camera has become a hot spot in the current research of machine vision, which is more than the two dimensional image, which has more depth information [2] [3]. The extraction of three-dimensional information can complete the object recognition, classification [4], motion tracking and other aspects of complex applications. Two kinds of binocular stereo vision matching algorithms are available: Partial and total [5]. The method of partial has the advantages of simple implementation and high performance for image regions with rich texture, but it suffers from low accuracy for photo regions with poor or repetitive configuration [6–10]. Compared to the method of partial, the total one performs better on matching low and repetitive substance, but it has higher computational complexity, more dependency on the object in the scene, and weak compatibility with on-line addressing. Both techniques have difficulties in solving the occlusion region problem, and they are not robust enough to deal with different measurement scenes [11].

Provided a pair of point clouds, the registration tries to find the best tele-transform alignment with the smallest possible error for multiple point clouds to obtain a complete 3D scene [12] [13].As spending on 3D scanning equipment decreases, point cloud processing technology continues to evolve. Point cloud registration is often applied in AR/VR, autonomous driving [14], robotics and other fields. The registration quality affects the purpose and effect of image registration, such as unmanned driving, pattern recognition, and 3D reconstruction [15]. The achievement of high registration quality depends heavily on the choice of registration methods, the adjustment of registration parameters, and the evaluation criteria used. Given the diverse range of application scenarios and needs, different registration qualities may be required.

Point cloud registration algorithms have been researched in the 1970s, we often use the ICP algorithm [16] (which is an iterative nearest-point based point cloud fine registration method, and it aims to go and locate a rigid transformation including rotational and translational transformations) to maximize the registration between two point clouds. The algorithm is simple and light to come true, applicable to various types of point cloud data; The disadvantage is that it is easy to trap in a local optimum, the prerequisite for implementation is the need for a good initial transform, which is sensitive to noise and occlusion.

RANSAC algorithm is a robust registration method based on the consistency of random samples, which aims at the same as the ICP algorithm, so as to minimise the error between