A Visual Odometry with Planar Markers and Feature Point Cues

Zhiyuan Zhang[1], Tong Ning[1], Yimei Liu[1], Hao Fan[1], and Junyu Dong[1],

***Abstract*—This paper proposes a novel visual odometry system by fusing marker-based and feature point-based cues for the camera tracking. This system is robust in the challenging textureless region. For better tracking, we extract plane constraints of the marker with the geometric line cues and corner points cues except the natural feature points. In detail, when the natural feature points and marker corner points tracking fails, we utilize the line segments in the markers and the environment to calculate planes. Consequently, our method mitigates drift errors and significantly enhances the performance of the visual odometry system.**

***Index Terms*—Marker cues, Plane constraints, SLAM**

I. INTRODUCTION

Currently, many SLAM methods using natural landmarks like feature points often face tracking issues in weak-textured areas [1]. Some SLAM methods use artificial landmarks like square markers to aid tracking and relocalization [2]. However, in underwater environments, marker placement may lead to obscured intersection points due to rocks or sand, resulting in localization inaccuracies.

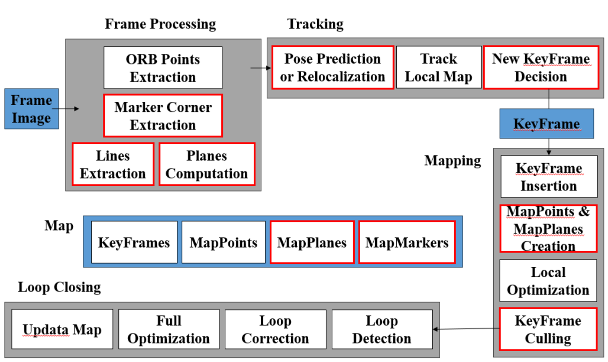

Fig. 1. The pipeline of our proposed SLAM system.

The pipeline of the proposed SLAM system is illustrated in Fig. 1. The components highlighted in red boxes depict the parts that differ from or have been improved over the ORB-SLAM3 system [1]. It can be divided into four parts: Frame Processing, Pose Tracking, Mapping, and Loop Closing.

In the frame processing stage, we extract feature points and marker corners from the images and match these features. Line segments are extracted to calculate plane features.

In the Pose Tracking stage,we estimate the camera pose based on matched valid marker corners and feature points. With the introduction of markers, adjustments have been made to the keyframe insertion and removal strategies.

In the mapping stage, feature points, marker corners, and plane features are constructed and saved in the map, contributing to the local map optimization.

We extract line segments from the images using Line Segment Detector [3] and match them using LBD descriptors [4]. Their 3D positions are calculated based on the disparity Δu. Subsequently, plane features are calculated from the intersecting lines.

1 The Department of Information Science and Engineering, Ocean University of China, QingDao, China.

II. EXPERIMENTS & CONCLUSIONS

In this section, we evaluate our proposed SLAM system on both public datasets and datasets recorded by ourselves. Due to the lack of stereo image datasets with markers, we recorded some datasets in a laboratory environment to test our system, using markerSFM to obtain ground truth.

TABLE I
BUILT MAP OF OUR SYSTEM IN OUR DATASET.

Sequence	ORB-SLAM3	UcoSLAM	Our System
LAB_01	0.035877	**0.032874**	0.036299
LAB_02	0.060442	0.057705	**0.037158**
LAB_03	lost	0.051192	**0.048045**
LAB_04	0.163129	0.181626	**0.139306**
LAB_05	lost	lost	**0.127433**

Our system has achieved better estimation results on most publicly available datasets and our self-recorded datasets. In regions with weak textures, ORBSLAM3 tends to experience tracking failures. Our method mitigates drift errors, enhances robustness, and significantly improves the performance of the visual odometry system.

REFERENCES

[1] Carlos Campos, Richard Elvira, Juan J. Gomez Rodriguez, Jose M. M. Montiel, and Juan D. Tardos. Orb-slam3: An accurate open-source library for visual, visual–inertial, and multimap slam. *IEEE Transactions on Robotics: A publication of the IEEE Robotics and Automation Society*, (6):37, 2021.

[2] Rafael Muoz-Salinas and R. Medina-Carnicer. Ucoslam: Simultaneous localization and mapping by fusion of keypoints and squared planar markers. *Pattern Recognition*, 101, 2020.

[3] J. M. Morel R. G. Von Gioi, J. Jakubowicz and G. Randall. Lsd: A fast line segment detector with a false detection control. *IEEE Transactions on Pattern Analysis Machine Intelligence*, 32(4):722–732, 2010.

[4] L. Zhang and R. Koch. An efficient and robust line segment matching approach based on lbd descriptor and pairwise geometric consistency. *Journal of Visual Communication and Image Representation*, 24(7):794–805, 2013.