GROUND PLANE-AIDED EXTRINSIC CALIBRATION OF INERTIAL AND RGB-D SENSORS FOR UNCREWED AERIAL VEHICLES

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INTRODUCTION

Robotic systems require accurate pose estimation, which can be achieved using sensors. To reliably estimate the state, sensor fusion becomes essential. Among many sensors, IMU/RGB-D camera fusion is widely used. Such fusion is only possible if the extrinsic relative orientation and translation between the sensors are known. The widely utilized Kalibr [1] addresses this requirement but relies on targets that are not available during a robot's mission. Target-less methods [2] depend on detecting visual features, which cannot be detected in poor illumination conditions. In this research, we propose a robust floor-segmentation-based IMU/camera extrinsic estimation technique. The proposed method assumes that gravity and the floor-plane normal are parallel vectors which is typically true in most human-made indoor and outdoor structures. Floor plane segmentation plays a key role in robotics by imposing height constraints during aerial robot trajectory estimation [3]. However, classical image processing cannot reliably detect this plane due to shadows, highlights, and reflections. To overcome this, our method employs a deep neural network trained to estimate the floor plane.

METHODS

The proposed method relies on three modules. The first module, floor-plane normal detection, uses a deep learning network to extract the floor segment, followed by a back-projection and plane extraction. The second module processes the IMU data to reliably extract the gravity vector. Finally, in the third module, the gravity vector and floor-plane normal are matched using a robust estimator RANSAC [4], to estimate the extrinsic calibration parameters.

RESULTS AND DISCUSSION

To evaluate the proposed method, we utilized low-cost IMU and RGB-D sensors. The test platform, shown in Fig. 1, includes three IMUs. The precision and recall for floor segmentation are reported in Table 1. Floor segmentation achieves higher precision and recall when using local images. Furthermore, the accuracy of the proposed calibration method is compared with MATLAB's Toolbox in Table 2, demonstrating the superior performance of the proposed method.

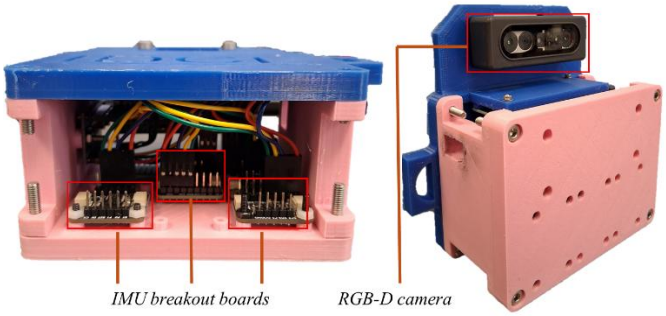

Fig 1 The test platform includes three IMUs and a RGB-D camera,

CONCLUSIONS

Estimating the relative pose amongst sensors is essential for multi-sensor robotics. In this research, we propose a novel IMU/camera calibration method based on floor segmentation. The proposed deep neural network achieves a precision and recall of 0.96 in similar indoor environments. The robust extrinsic calibration method outperforms MATLAB's Toolbox.

REFERENCES

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Table 1: Precision and recall of the proposed method

	Number of images	Precision	Recall
Local images	31	0.96 ± 0.05	0.96± 0.07
Online images	33	0.96 ± 0.23	0.71± 0.31

Table 2: Accuracy of the proposed extrinsic calibration compared to MATLAB

	ISM330DHCX	MPU6050	LSM6DSOX
Proposed	3.65 (°)	5.20 (°)	3.85 (°)
MATLAB	7.97 (°)	9.77 (°)	6.70 (°)