西北工業大學
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Geodetic Coordinate Calculation Based on Monocular Vision on UAV Platform

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Outline

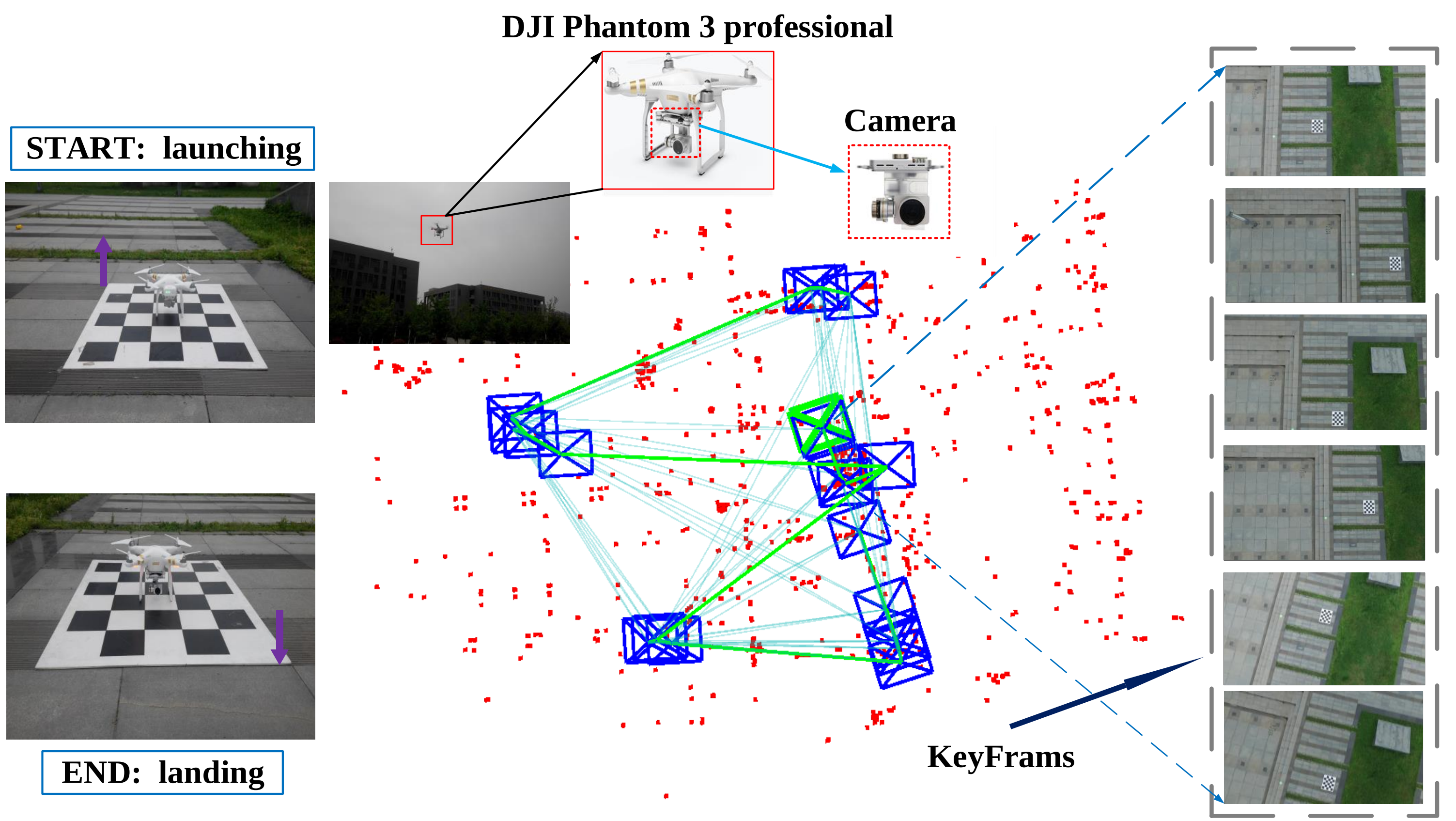
1. **Introduction**
2. Proposed Algorithm
3. Experiment Results
4. Conclusion

Introduction

- Vision Measurement Technology based on UAV Platform
  - **Goal**
    - Precise location of ground targets based on Monocular Vision.
  - **Challenges**
    - Uncertain motion of the UAVs & camera Pose information
    - Small (size) objects tracking
  - **Related Approaches**
    - Sensor-based: Satellite, laser, ultrasonic, etc.
    - Vision-based: Monocular vision, stereo vision and multi-view system.

Introduction

- Vision Measurement Technology based on UAV Platform
  - **Our system**



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1. Introduction

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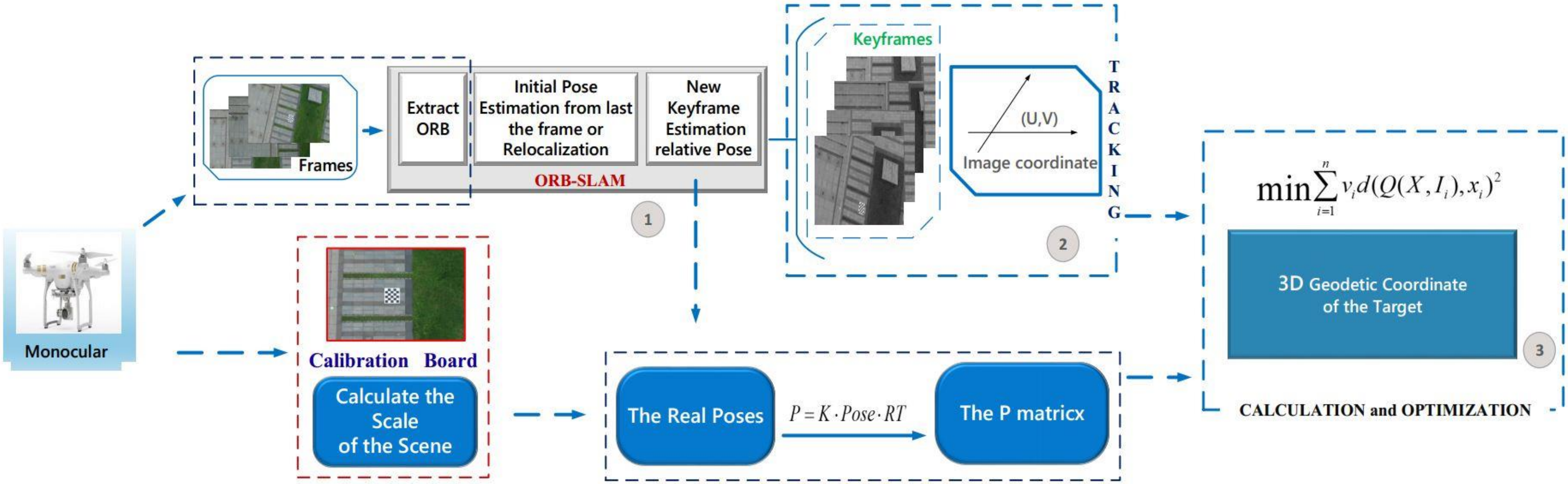
Proposed Algorithm

- Calculation 3D Coordinate
  - **The framework of our algorithm**

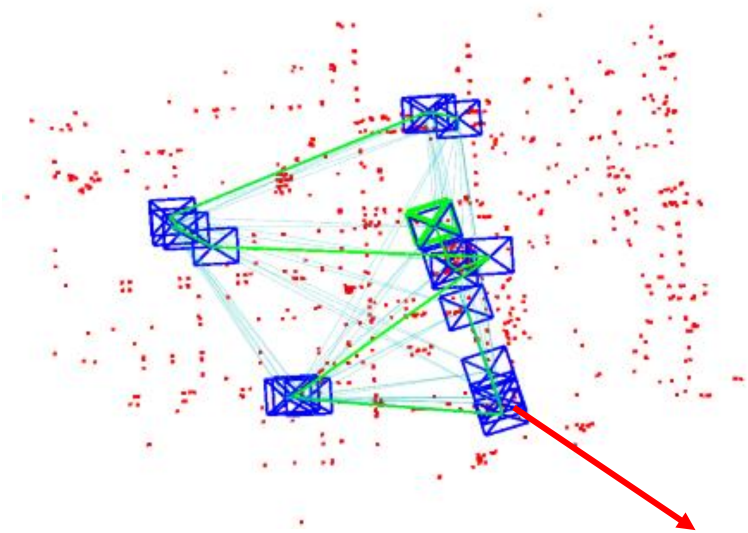


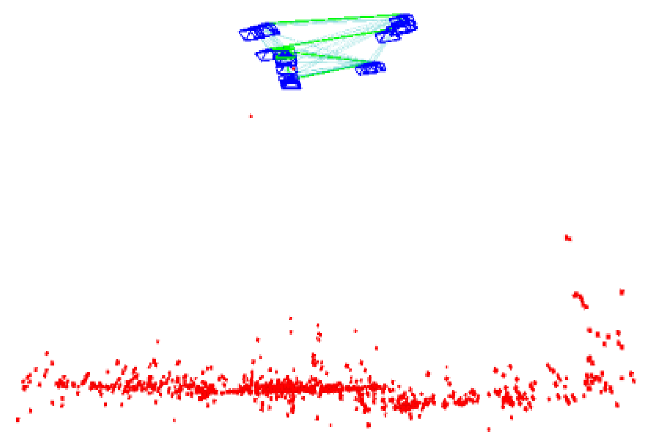
Proposed Algorithm

- Calculation 3D Coordinate

A. Estimate Camera Pose with ORB-SLAM

  - Estimate the relative poses of camera





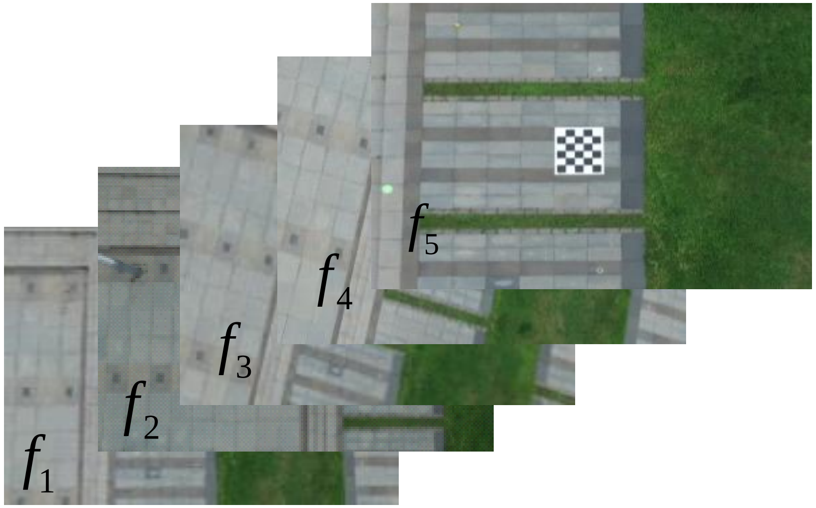
KeyFrames

Proposed Algorithm

- Calculation 3D Coordinate

A. Estimate Camera Pose with ORB-SLAM

- Monocular scale calculation based on calibration board



- Select 5 KeyFrames evenly

$$\{ f_1, f_2, f_3, f_4, f_5 \}$$

- Calibration external parameters

$$\{P_1, P_2, P_3, P_4, P_5\}$$

- Calculate real poses

$$Pose_{truei} = P_i P^{-1}$$

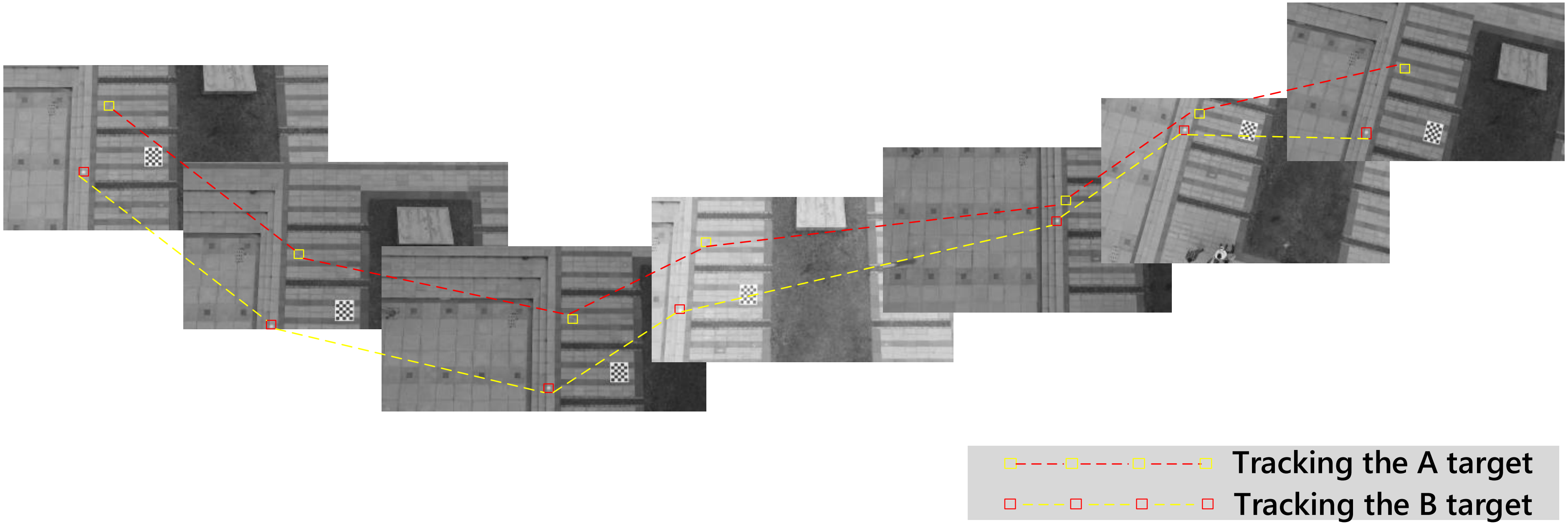
- Calculate scale compare the real and relative poses

Proposed Algorithm

- Calculation 3D Coordinate

B. Tracking the Target

  - We make the image coordinate calculation of the target as a tracking problem
  - We adopt one of the most successful tracking algorithm STC

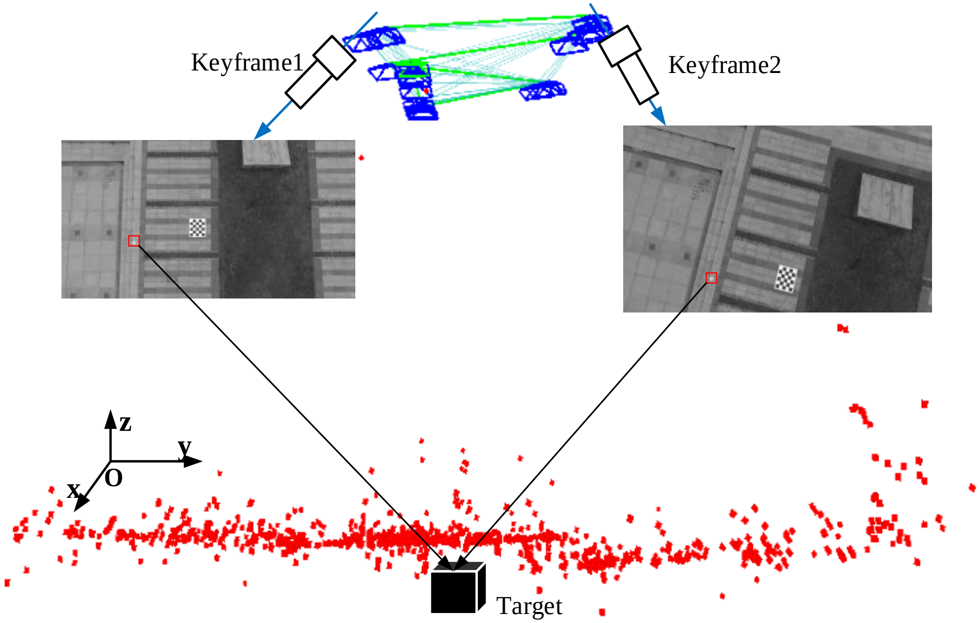


Proposed Algorithm

- Calculation 3D Coordinate

C. Calculation and Optimization

  - We calculate the initial value X using double KeyFrame positioning method

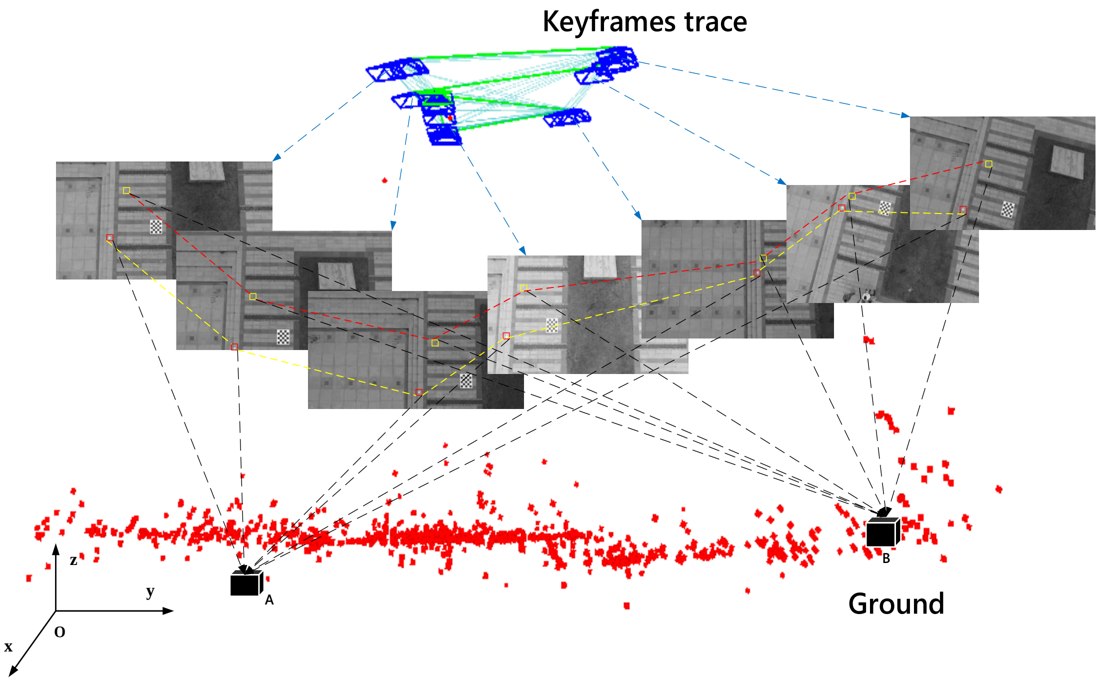


Proposed Algorithm

- Calculation 3D Coordinate

C. Calculation and Optimization

  - We optimize the value of X using the method of multiple view projective reconstruction
  - BA (Bundle Adjustment)



Proposed Algorithm

- Calculation 3D Coordinate

C. Calculation and Optimization

  - BA (Bundle Adjustment)

$$\min \sum_{i=1}^{n} \boxed{v_i} \boxed{d(Q(X, I_i), x_i)^2}$$

The re-projection errors of I_i

Where I_i is the i KeyFrame

$$\begin{cases} v_i = 1, & x_i \in I_i \\ v_i = 0, & x_i \notin I_i \end{cases}$$

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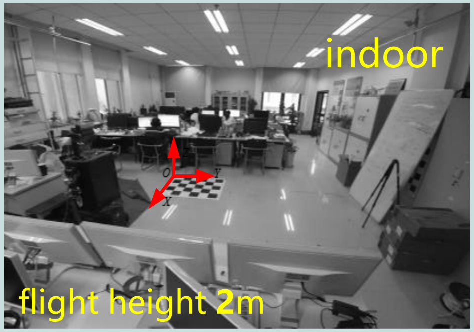
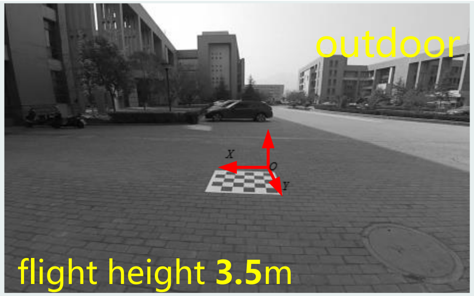
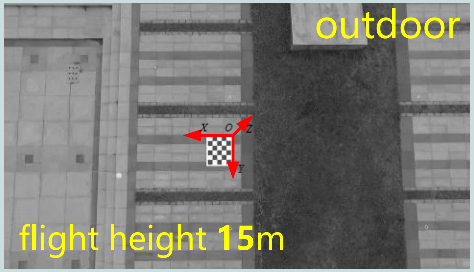
Experiment Results

- Scale, Relative and Real Poses of Keyframes

Scene	Scale /m	Relative Poses				Real Poses			
		kf1	kf2	kf3	kf4	kf1	kf2	kf3	kf4
1	$\boxed{3.75}$	-0.38107 -0.06016 0.087729	-0.55692 -0.11677 0.151738	-1.04067 -0.237356 0.551887	-1.06467 -0.28363 0.611086	-1.51670 -0.22949 0.267462	-2.98702 -0.40928 0.777607	-3.90339 -0.89217 1.996418	-3.97602 -1.10984 2.22229
2	$\boxed{3.95}$	-0.53457 -0.03906 0.25177	-0.41344 -0.01658 0.21582	0.23116 -0.00601 0.10269	0.25755 -0.00489 0.086608	-2.14142 -0.14621 0.99082	-1.64356 -0.12191 0.78864	0.91398 -0.04197 0.35710	1.04209 -0.03159 0.32269
3	$\boxed{8.90}$	0.04316 0.27279 -0.04291	-0.16993 0.014856 -0.03585	0.06805 -0.29751 -0.00054	0.07750 -0.21015 -0.08687	-1.81466 1.71391 -0.30023	-3.50321 -1.33897 0.00374	-1.31856 -4.71583 0.42791	0.69146 0.95745 -0.67724

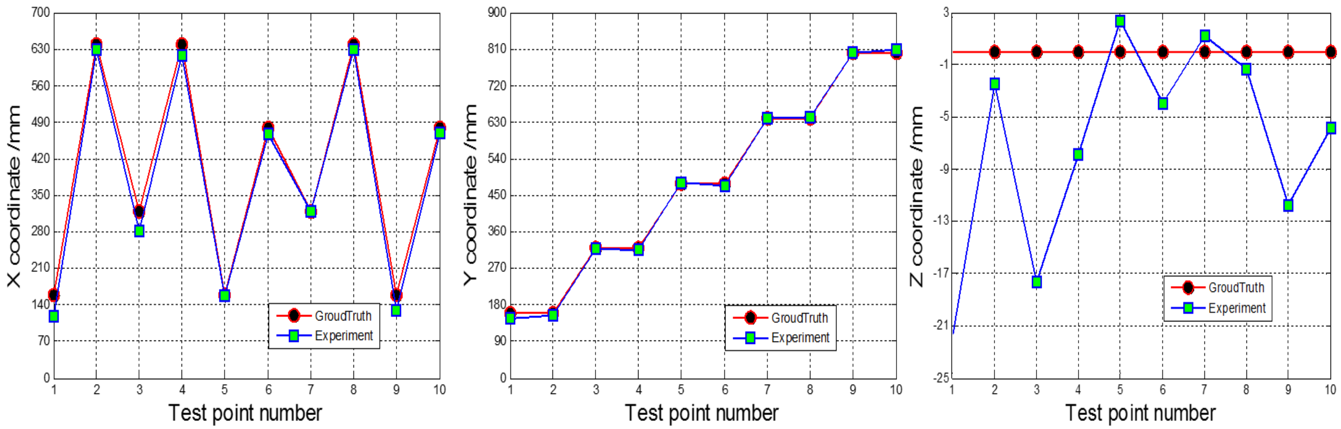
Experiment Results

- The 3D geodetic coordinate result in our experiments

Scene	Experiment result /m	Ground true /m
	[0.2824, 0.3169, -0.018] [0.6299, 0.1539, -0.002] [0.6197, 0.3146, -0.007] [0.4661, 0.4746, -0.004] [1.7613, 2.3836, -0.001]	[0.3200, 0.3200, 0.0000] [0.6400, 0.1600, 0.0000] [0.6400, 0.3200, 0.0000] [0.4800, 0.4800, 0.0000] [1.8000, 2.4000, 0.0000]
	[0.1897, 0.1496, 0.0215] [0.6625, 0.1479, 0.0195] [0.3395, 0.3024, 0.0160] [0.6500, 0.6237, 0.0141]	[0.1600, 0.1600, 0.0000] [0.6400, 0.1600, 0.0000] [0.3200, 0.3200, 0.0000] [0.6400, 0.6400, 0.0000]
	[0.3168, 0.0962, 1.1042] [0.1794, 0.3485, 0.9823] [0.0582, 0.4781, 1.0234] [0.3055, 0.4622, 0.9827]	[0.6400, 0.1600, 0.0000] [0.1600, 0.3200, 0.0000] [0.1600, 0.4800, 0.0000] [0.3200, 0.4800, 0.0000]

Experiment Results

- Accuracy evaluation



  - Indoor
    - Total 10 sets of data, 5 scenes
    - <1cm level accuracy
  - outdoor
    - Total 8 sets of data, 3 scenes
    - <1m level accuracy in the range of 30m

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Conclusion

- Contribution:
  - Extend the **monocular to multi-view camera system** with ORB-SALM.
  - Proposed a **multiple KeyFrames location** method.
- Limitation:
  - **Lower measurement accuracy** in **large scale scenes**.
- Future work:
  - Solve the **accuracy of target tracking** in large scene .
  - Improve the accuracy of pose estimation.

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Thank you！