Hilti-Oxford Dataset: A Millimeter-Accurate Benchmark for SLAM

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Overview and Contribution

- Degenerate scenarios to challenge existing SLAM system
- High-precision data collection platform with modern sensors
- Novel sparse ground truth collection method
- Insights and discussion of the merits of each submitted system in the Hilti SLAM Challenge 2022

Step One: Prior Maps with Reference Target

Prior maps of the two facilities were built using the scanner shown in Fig. 1 Left. For the registration of the scans, we used reflective scanner targets as well as plane-to-plane registration followed by block adjustment. Reference target positions are extracted later to generate sparse ground truth positions.

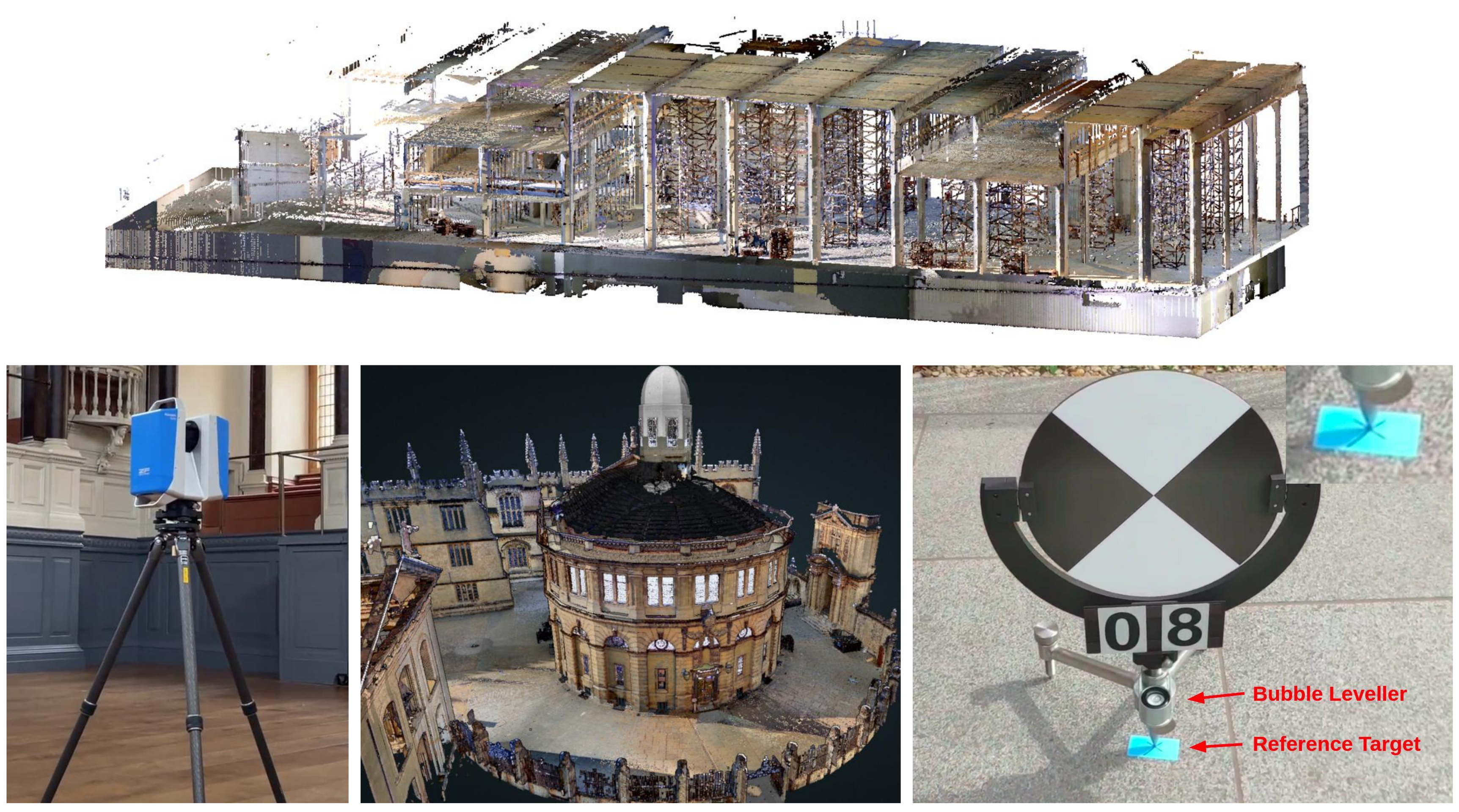
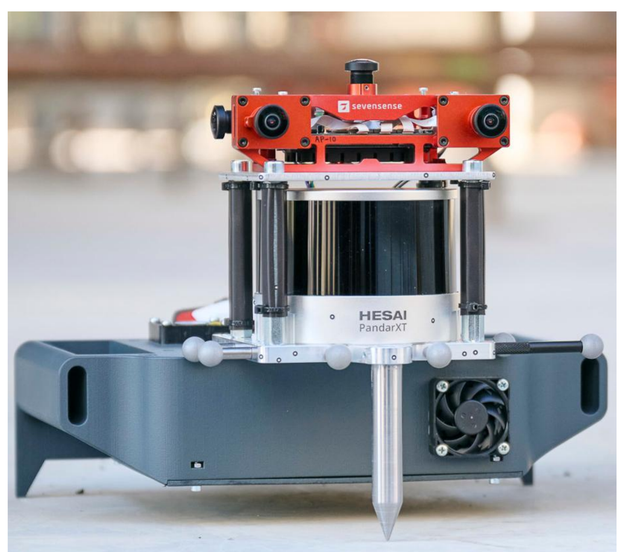


Figure 1: Top: construction site scanned map, Bottom Lleft: Z+F scanner; Mid: Sheldonian theatre scanned map; Right: reflective reference tagets

Step Two: Handheld scanning

During the handheld data gathering stage, we again place the tip of the handheld device at the crosshairs on the floor while walking around the environment.



Sensor	Type	Rate	Characteristic
Lidar	Hesai, PandarXT-32	10Hz	32 Channels, 120 m Range, 31° Vertical FoV
Cameras	Alphasense	40Hz	5 Global shutter (Infrared) 720×540 pixels
IMU	Bosch BMI085	400Hz	Sychronized with cameras

Table 1. Overview of the sensors on the Phasma device

Dataset Overview

Both of these locations challenge SLAM systems in different ways. We intentionally introduce challenging and degenerate scenarios into the dataset, which include aggressive motions, dynamic objects occasionally blocking the field of view, narrow staircases which are geometrically similar, and dark corners.

Users can find more information and the top-down trajectories on the dataset website.

Sequence	Challenges
Construction: Exp01 Ground Level Exp02 Multilevel Exp03 Stairs	Fast motion, blocking cameras or pointing at blank walls and stairs Going into dark corners while occluding the sensors
Hilti Offices: Exp07 Long Corridor	Few edge constraints along corridor
Sheldonian: Exp09 Cupola Exp11 Lower Gallery Exp15 Attic to Upper Gallery Exp21 Outside Building	Narrow stairs, fast lighting change Aggressive motion (outdoors)
Exp10 Cupola 2 Exp14 Basement 2 Exp16 Attic to Upper Gallery 2 Exp18 Corridor Lower Gallery 2 Exp23 The Sheldonian Slam	**New additional 5 sequences with both sparse and dense ground truth trajectories** Includes all sections and revisits the ground hall several times for loop closures

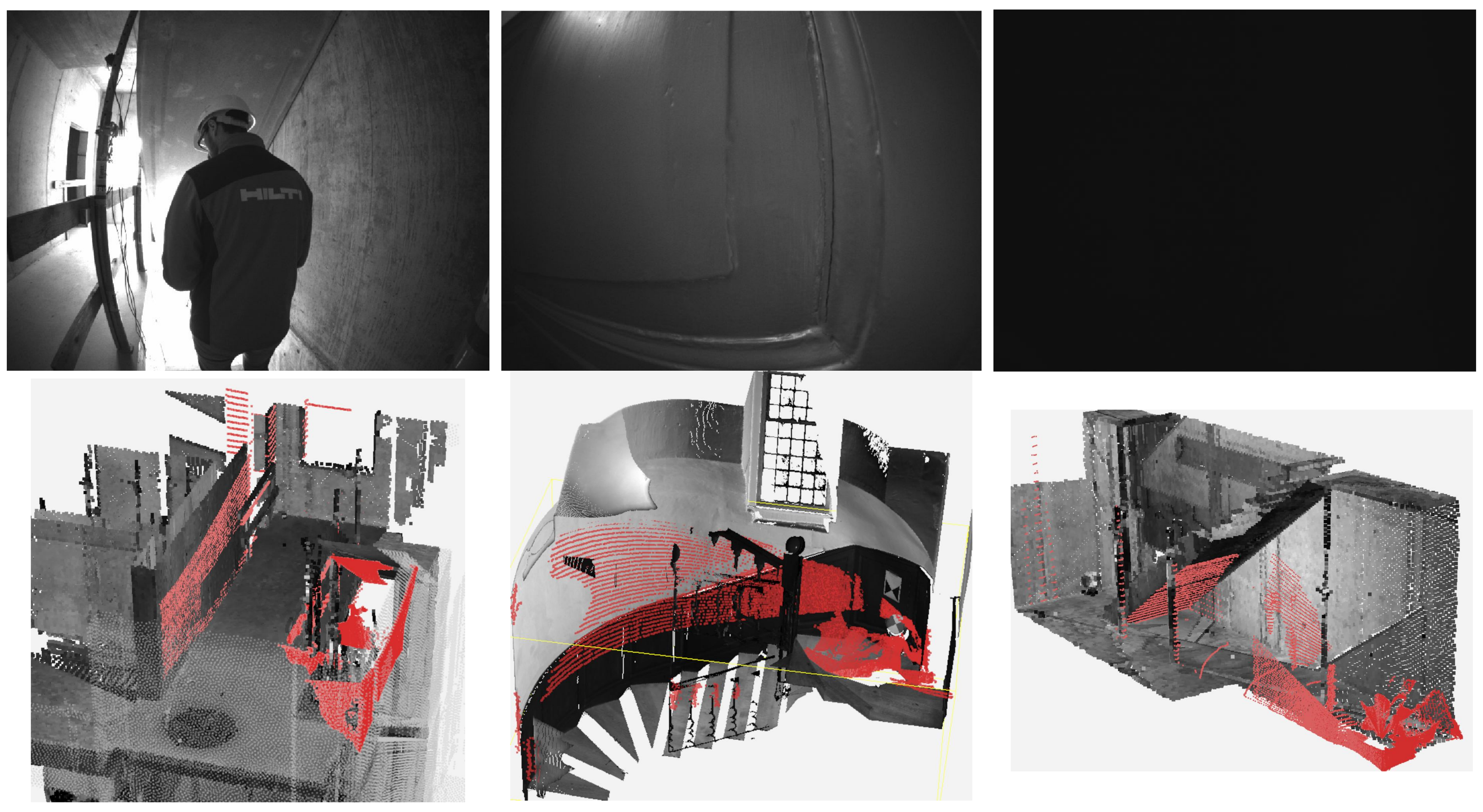
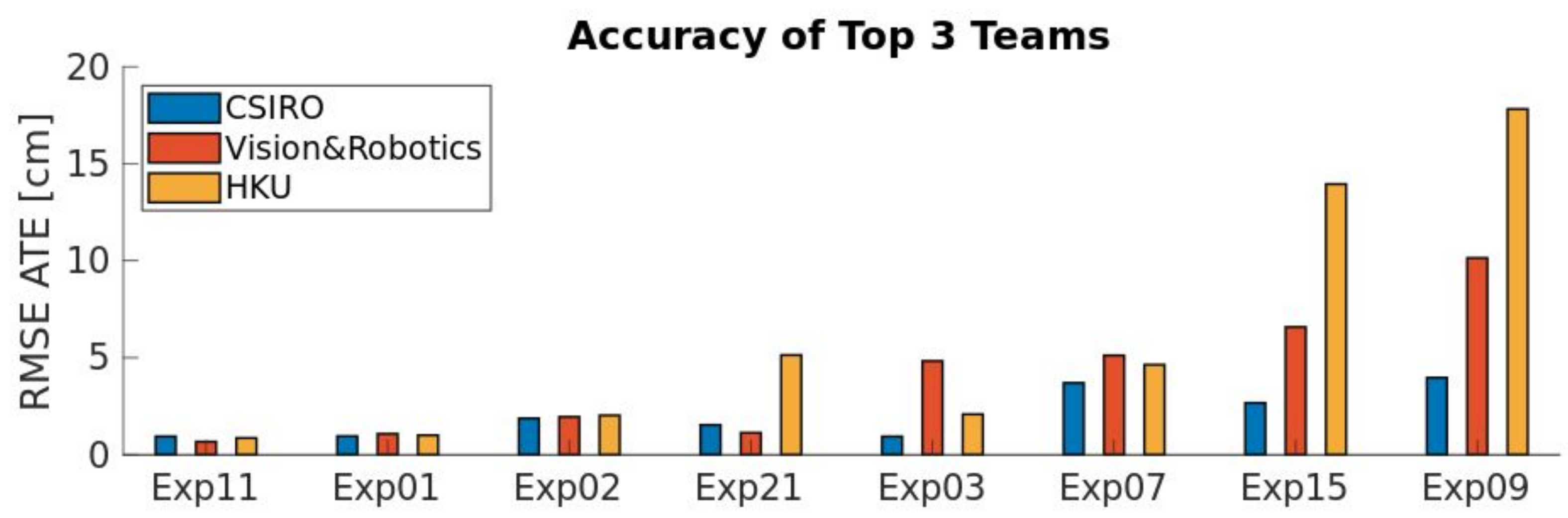


Figure 2: Top row shows camera images in challenging scenarios with their corresponding lidar scans in red at the bottom (aligned to our ground truth model in grey)

Challenge Results

Sequences with open spaces and overlapping areas had the lowest error (Exp01, 02, 11, 21), while those with challenging geometries for LIDAR-based algorithms, like long narrow corridors (Exp07) and small staircases (Exp03, 09, 15), had the highest error.



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