Hierarchical Visual SLAM based on Fiducial Markers

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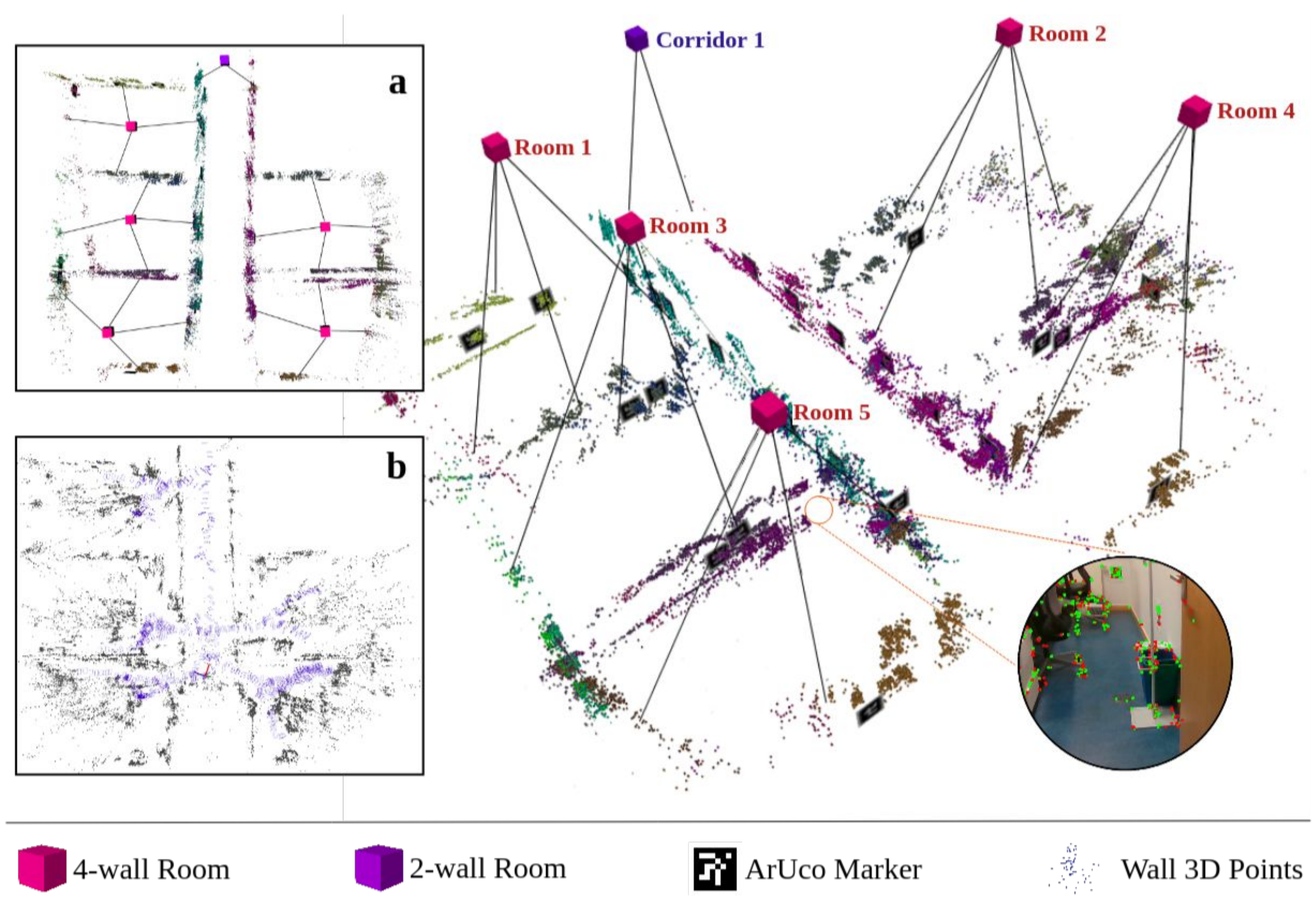
Abstract

Marker-based Visual SLAM (VSLAM) approaches utilize fiducial markers for improving feature detection in low-feature environments or incorporating loop closure constraints, generating low-level geometric maps prone to inaccuracies in complex environments. This work presents a VSLAM approach that uses a monocular camera and fiducial markers to **generate hierarchical representations** of the environment while **improving the camera pose estimates**. It detects **semantic entities** from the surroundings, including walls, corridors, and rooms encoded within markers, and adds existing **topological constraints**. Experimental results demonstrate that the proposed approach outperforms the traditional marker-based VSLAM baseline in terms of accuracy, despite adding new constraints while creating enhanced map representations.

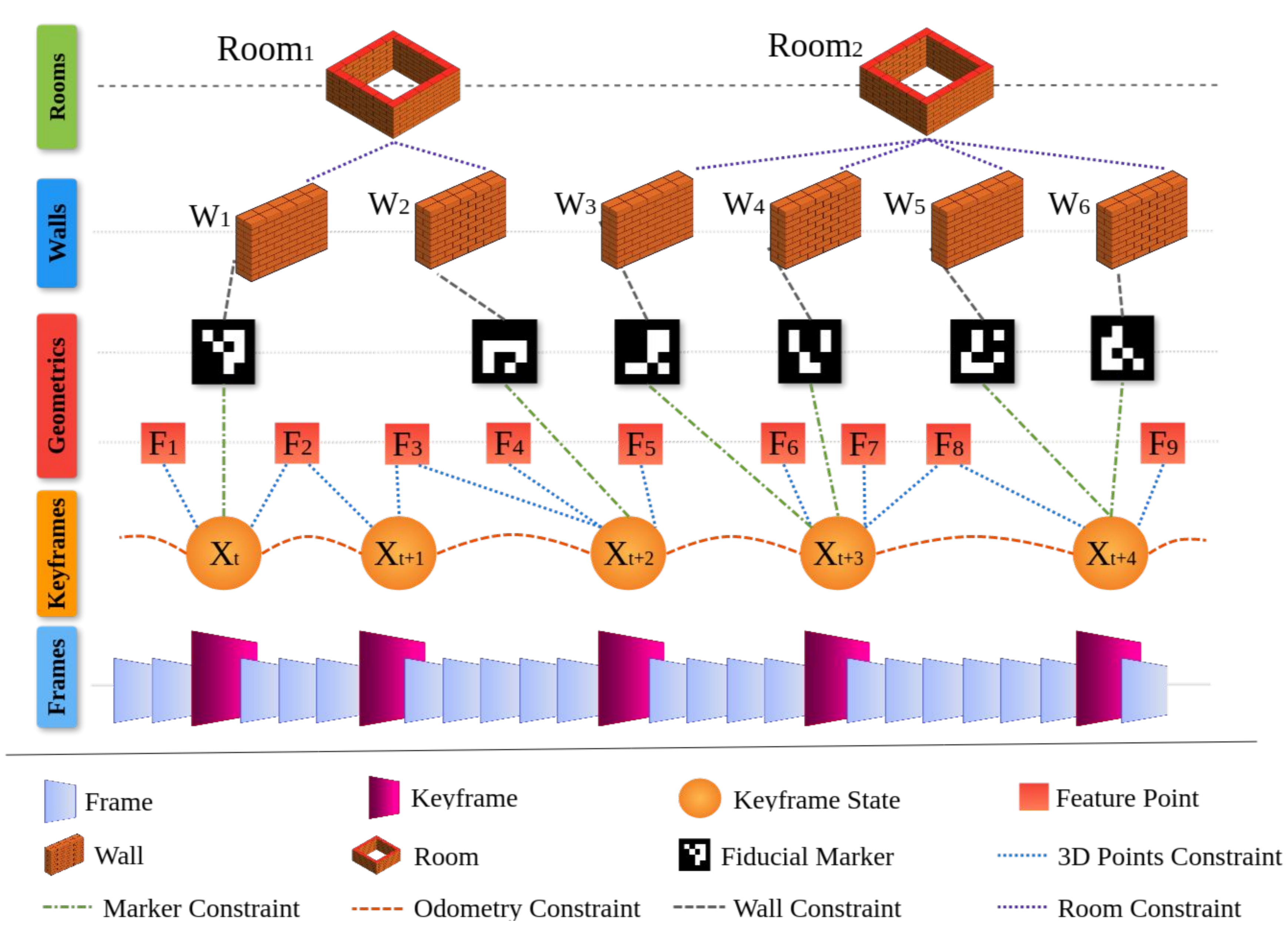
Contributions

- An extension of marker-based VSLAM (i.e., UcoSLAM) to reconstruct environmental maps with **high-level semantic features**
- The design of novel **geometric constraints**, namely marker-to-wall and wall-to-room, to improve the map quality
- Validation of the proposed method using a **real-world indoor dataset** showing improved performance over marker-based VSLAM baseline



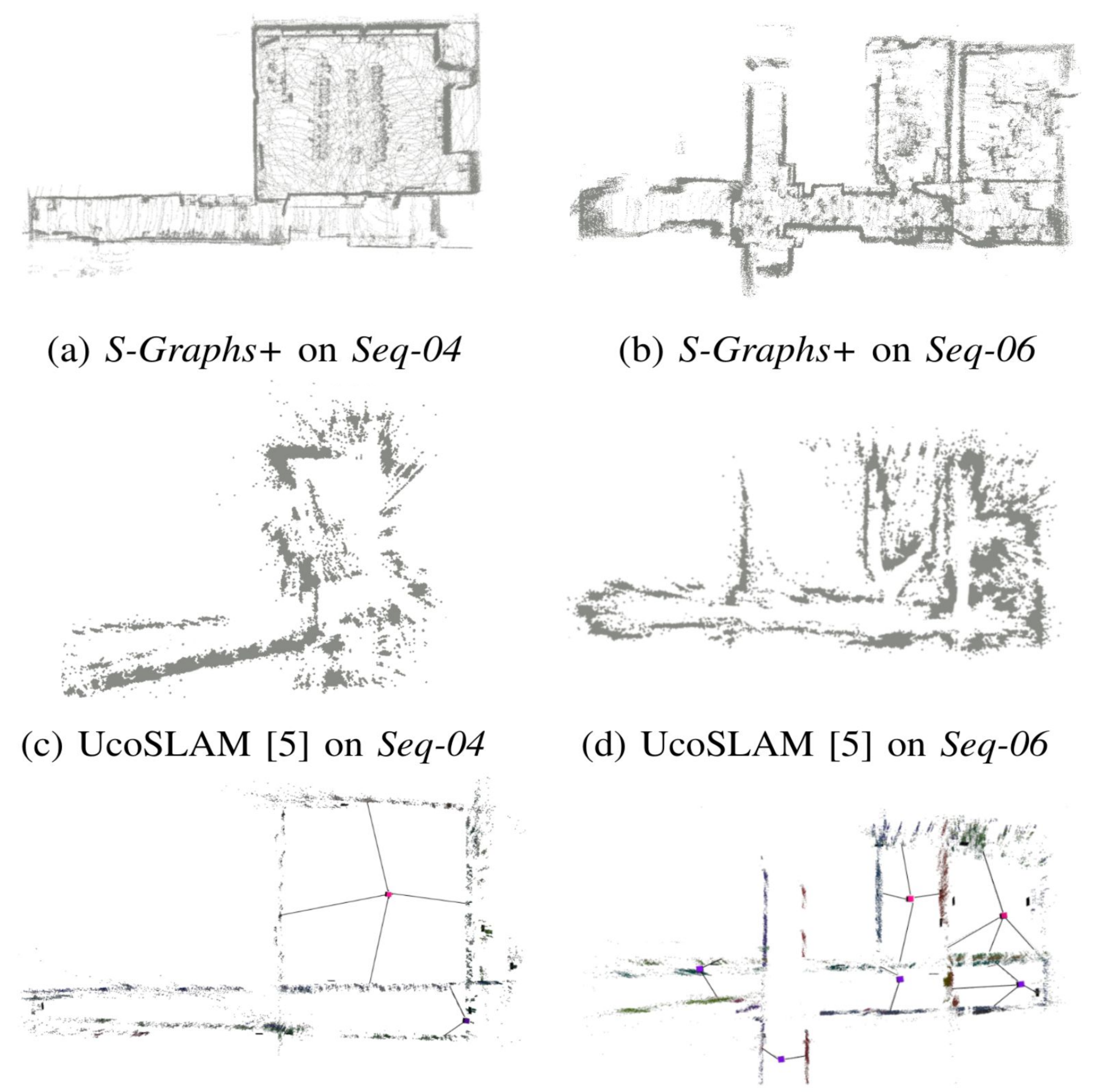
You can see the reconstructed map of the environment using the proposed method in a hierarchical representation: a) the top view of the map represented in 2D, b) keypoints and robot trajectory records.

Proposed Method



Experimental Results

Various real-world tests were performed using the proposed method, *UcoSLAM* as the baseline, and *S-Graph+* as a LiDAR-based approach for providing ground truth measurements on a dataset.collected by a monocular camera mounted on a legged robot in an indoor environment.



(a) *S-Graphs+* on *Seq-04*

(b) *S-Graphs+* on *Seq-06*

(c) UcoSLAM [5] on *Seq-04*

(d) UcoSLAM [5] on *Seq-06*

(e) Proposed method on *Seq-04* showing only wall 3D points

(f) Proposed method on *Seq-06* showing only wall 3D points

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