



The SLAM Hive Benchmarking Suite

Yuanyuan Yang, Bowen Xu, Yinjie Li, Sören Schwertfeger

Lab website: <https://robotics.shanghaitech.edu.cn> | Email: yangyy2@shanghaitech.edu.cn

1. Introduction

Simultaneous Localization and Mapping (SLAM) is a basic function of many robotic systems. A lot of work has been published on SLAM, which often incorporates various types of sensors. Although the evaluation and research of SLAM algorithms is very important, there are too many configuration options from sensors and algorithms, resulting in fragmented benchmarking. So far, the huge parameter space of SLAM system and their evaluation is still to be explored.

SLAM Hive is an automated SLAM algorithms evaluation system, which is a **reproducible and automatic** way to evaluate **various SLAM algorithms** under many **different configurations** and with many **different datasets**. The system can display and analyze mapping results. The code is currently open source: <http://github.com/SLAM-Hive>

2. Workflow

1-Web Controller: Graphical user interface | Creation of mapping and evaluation tasks | Display results .

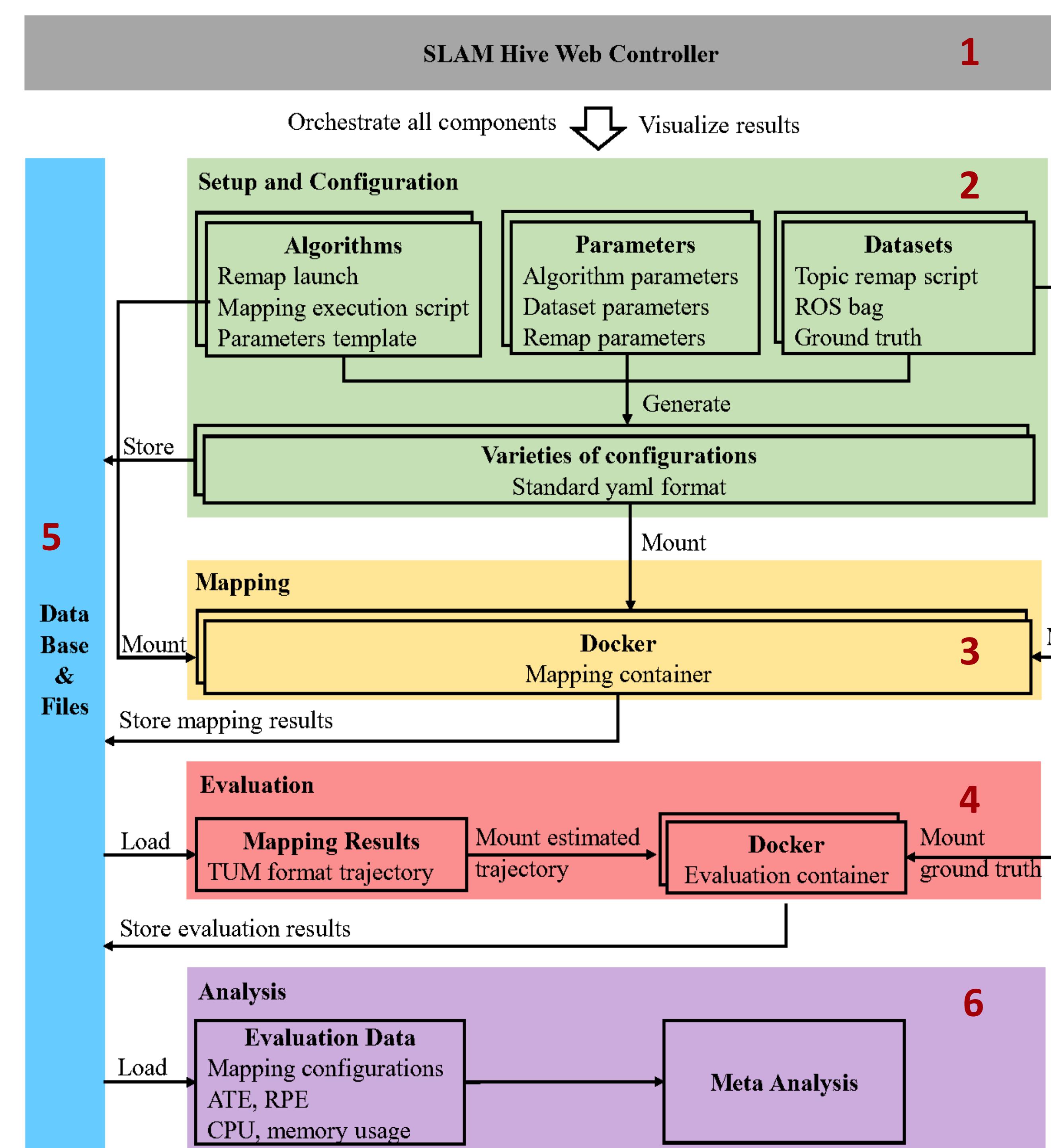
2-Setup & Configuration: Be able to generate unified configuration format.

3-Mapping: Use 2, algorithms Docker containers and datasets to execute mapping, which outputs estimated trajectory, CPU and memory usage.

4-Evaluation: Use evaluations Docker containers to evaluate the mapping results from 3.

5-Database & Files: Save configurations, parameters, estimated trajectories, CPU and memory usage...

6-Analysis: Load information from 5 to analyze performance of algorithms.



Supported SLAM methods & datasets

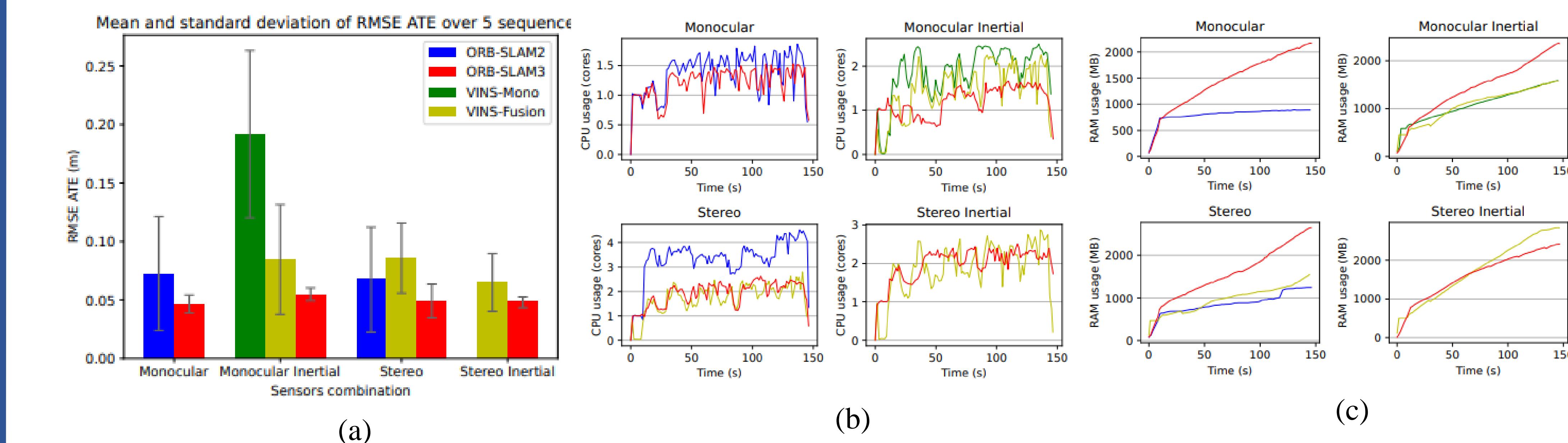
| Method | Monocular | Monocular Inertial | Stereo | Stereo Inertial | RGBD | Lidar Inertial | Year |
|------------------|-----------|--------------------|--------|-----------------|------|----------------|------|
| ORB-SLAM2 [16] | ✓ | | | ✓ | | | 2017 |
| VINS-Mono [17] | | ✓ | | | | | 2018 |
| VINS-Fusion [18] | | ✓ | ✓ | ✓ | | | 2019 |
| ORB-SLAM3 [19] | ✓ | ✓ | ✓ | ✓ | ✓ | | 2021 |
| LIO-SAM [20] | | | | | | ✓ | 2020 |

| Dataset | Grayscale camera | RGB camera | RGB-D camera | IMU | GPS | Lidar | Groundtruth | Year |
|--------------|------------------|------------|--------------|-----|-----|-------|-----------------|------|
| TUM RGBD [5] | 2 | 2 | 1 | ✓ | ✓ | ✓ | Tracking System | 2012 |
| KITTI [3] | | | | ✓ | ✓ | ✓ | Pose via GPS | 2013 |
| EuRoC [4] | | | | ✓ | ✓ | ✓ | Tracking System | 2016 |

3. Main components of SLAM Hive

- Visual Web Controller:** provides the graphical user interface, which is built by the lightweight web application called Flask. It is the control center responsible for the creation of mapping and evaluation tasks.
- Standard Interface:** defined standard containers, unified configuration format, algorithm execution scripts, dataset component, standard trajectory format.
- Multiple Configurations Mechanism:** varieties of configurations can be easily generated by selecting algorithms, datasets and inputting algorithm parameter values, dataset parameter values and remap topic. These configurations are recorded in the database for further performance analysis.

4. Experiments



(a) Mean and standard deviation of RMSE ATE over 5 sequences on EuRoC dataset.
(b) and (c) are the CPU and memory usage change over time. Both of them are different methods under the same sensors combination on one of sequence on EuRoC dataset: *MH_03_medium*.

5. Conclusions

- Defining and implementing a framework performing mapping runs of various SLAM Algorithms in Docker containers, using various configurations and datasets.
- Implementing a framework for evaluation of the results of these mapping runs using (different) evaluation algorithms implemented in Docker containers.
- Providing a Web interface, implemented as a Docker container, to view, configure and run the SLAM Hive system and mapping runs.
- To do: configure and run thousands of such mapping runs with different permutations of configurations automatically in a cluster.*
- To do: perform meta analysis of these mapping runs to evaluate them under various aspects.*