Master's internship M2 2025

Feature enhanced LiDAR-SLAM on mobile mapping system

UGE/LASTIG/ENSG/IGN

©IGN Stéréoplis mobile mapping system

©IGN LiDAR scan of Stéréoplis

1 Keywords

Computer Vision, Photogrammetry, SLAM, 3D Points Clouds, feature extraction, feature matching

2 Contexte

Odometry and Simultaneous Localization and Mapping (SLAM) are critical to solve the location problem for robotics, computer vision, and photogrammetry communities. Image-based SLAM has been extensively studied, often combined with GPS, inertial measurement units (IMUs), or even multiple cameras [3]. LiDAR, a relatively newer sensor for positioning, has become more accessible due to advancements that have made the devices cheaper, and with higher point precision and density. With the rise of autonomous driving, LiDAR has gained widespread use and recognition. Consequently, LiDAR-based SLAM has emerged as a highly active area of research.

3 Introduction and goals

3.1 State of the art

SLAM and odometry are the main methods for accurately localizing a vehicle using vision. SLAM benchmarks [6] have made 3D SLAM widely used in autonomous driving. Compared to image-based SLAM [11], LiDAR-based SLAM offers advantages such as higher accuracy, reduced sensitivity to lighting conditions, and the ability to directly acquire 3D data. LiDAR-based SLAM is an important research topic in robotics.

The first notable framework, Google Cartographer [7], was developed for 2D SLAM. Subsequently, 2D LiDAR SLAM has been widely used in indoor mapping, with examples like the NavVis M3 Trolley [2]. From 2D to 3D SLAM, two main strategies are used to match successive LiDAR point clouds: Iterative Closest Point (ICP)-based methods [5, 14, 16] and feature-based methods [13, 17]. Deep

learning has also been integrated into SLAM [8] to calculate the pose or use the semantic information [4]. Its advantage lies in parallel processing; however, challenges remain in obtaining ground truth for training and handling unseen environments.

In this internship, we aim to investigate traditional methods in SLAM. Because ICP-based methods often encounter challenges with large point clouds, noisy data, and outliers, our focus will be on feature-based SLAM, so we will need a fast and efficient method to detect lines and planes [9] and a feature matching method such as LOAM [17]. Planar feature and edge feature will be used individually in a two-step optimization to estimate the six degrees of freedom (6DOF) [13].

As real time and robustness are an important issues in robotics, and both have been scarsely been addressed together in the literature, we will focus on fast and robust feature extraction, for instance by leveraging scan line analysis as proposed in [15].

3.2 Goals

The internship will focus on feature-enhanced LiDAR-based SLAM. The work will involve investigations using both open datasets, such as KITTI [6] and the Oxford RobotCar Dataset [10], as well as IGN Stéréopolis data [12]. A 3D-based SLAM pipeline using a multilayer scanner, such as LOAM [1], will be employed. Additionally, several other methods will be evaluated on both open datasets and Stéréopolis data. Profile-based analysis on LiDAR data will be explored, followed by the integration of fast and stable features, including corners, lines, and planes, into the SLAM pipeline. Finally, a comprehensive evaluation will be conducted to assess the performance of the newly developed method.

4 Organization

Duration: **5 months**, starting from March/April **2025**.

Workplace: LASTIG Lab, Institut National de l'Information Géographique et Forestière (IGN), SaintMandé (metro 1, station Saint Mandé) or Ecole Nationale des Sciences Géographiques (ENSG), Gustave Eiffel University, Champs-sur-Marne (RER A, station Noisy-Champs).

IGN (French Mapping Agency) is a Public Administrative Institution part of the French Ministry for Ecology and Sustainable Development. IGN is the national reference operator for the mapping of the territory; in particular, the agency is currently in charge of the 3D mapping program of France with LiDAR HD. The LASTIG is one of the research laboratories of IGN, attached to Ecole Nationale des Sciences Géographiques (ENSG) and Gustave Eiffel University (UGE) in Grand Paris area. It gathers about 100 researchers centered on geographical information sciences, 35 of them focusing in Image Analysis, Computer Vision, Artificial Intelligence, Photogrammetry and Remote Sensing.

5 Candidate profile

M2 Master's degree in computer science, robotic or computer vision (master or engineering school); good knowledge in image or 3D data processing, as well as strong skills in programming, having knowledge of C/C++ is highly recommended.

6 Application

Apply on Offres d'emploi AND send a mail to the contacts below with:

- CV
- motivation letter
- 2 recommendation letters, or persons to contact
- Transcript of grades from the last two years of study
- A list of courses followed and passed in the last two years

7 Contact

Bruno VALLET, senior researcher, LASTIG: bruno.vallet@ign.fr
Teng WU, researcher, LASTIG : teng.wu@ign.fr

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