VSLAM RTABMAP

1 Introduction to SLAM

Visual SLAM (Simultaneous Localization and Mapping) is a technology that enables vehicles to create a map of an unknown environment while simultaneously keeping track of their location within that environment. RTAB-Map (Real-Time Appearance-Based Mapping) is a popular perception tool used for Visual SLAM.

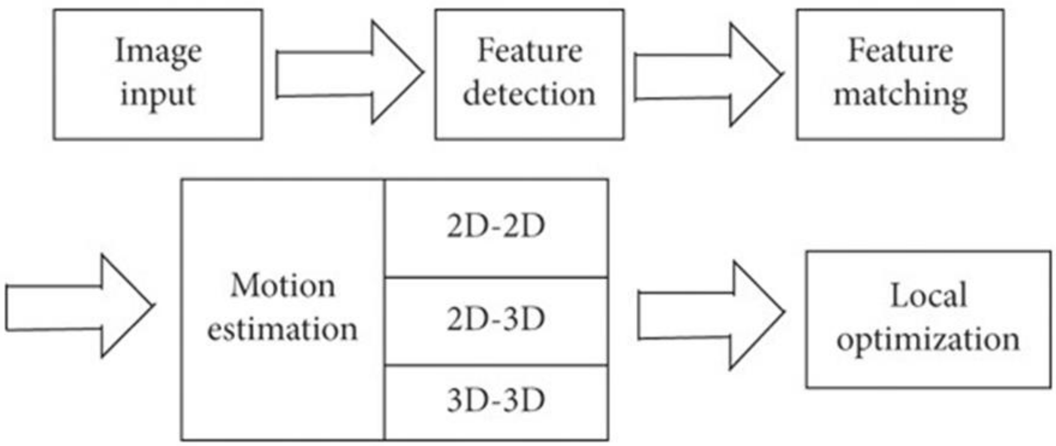

Fig: SLAM Basic elements

The SLAM aimed to create a self-driving system for the Suzuki Solio Bandit using Visual Simultaneous Localization and Mapping (V-SLAM). We combined RTABMAP and the ZED 2i stereo camera to make a detailed map. Real-time poses of the car were tracked through Robot Operating System (ROS) topics, helping us keep the car in the right place on the map. Our navigation system, controlled by a set of parameters like steer gain, bearing difference, heading, speed, turning factor, and steer output, ensures the car moves autonomously and smoothly. This integration of V-SLAM, real-time location tracking, and a well-tuned navigation system makes our Suzuki Solio Bandit capable of navigating on its own. This VSLAM successfully combines these technologies to create an autonomous driving system. This work opens up possibilities for safer and more efficient self-driving cars in the future.

Cloudy and Sunny Weather: Between 3 AM to 5 AM: Luminosity ranges from 110 to 130 units. Between 10 AM to 1 PM: Luminosity varies between 90 to 100 units. Between 3 PM to 5 PM: Luminosity typically falls within the range of 100 to 115 units. Rainy Weather:

Regardless of the time of day, during rainy conditions, luminosity exhibits a wider range, spanning from 95 to 170 units.

Camera captures visual data for mapping & localization Front-end (Image Acquisition): Image capture & preprocessing (noise reduction, distortion correction) Back-end (State Estimation): Estimates system's position, orientation & parameters Incorporates visual info & other sensor data (odometry, IMU)

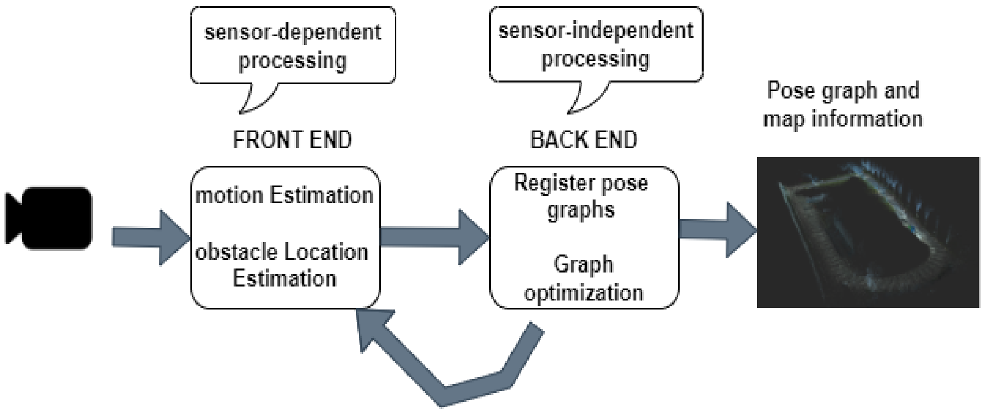

Fig : VSLAM Architecture

2 Hardware requirements

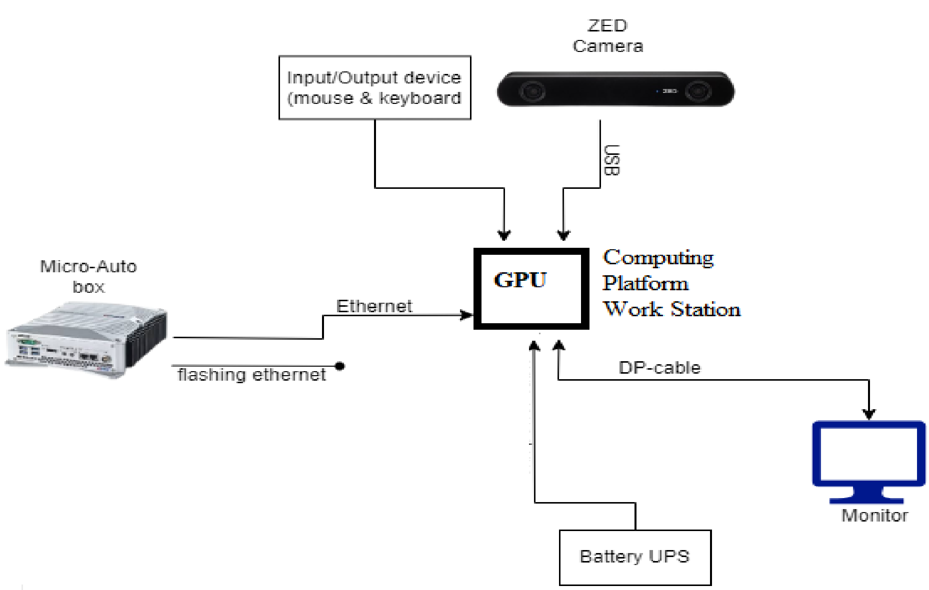

Fig : Hardware Requirement

The setup includes a ZED Camera positioned at the top and connected to a GPU via a USB connection. The GPU is integrated with several other components: it connects to a Micro-Auto Box via an Ethernet cable and to a Computing Platform Work Station through an unspecified type of connection. Additionally, a monitor is linked to the GPU via a DisplayPort (DP) cable and is connected to a battery-operated Uninterruptible Power Supply (UPS) for power backup. The Input/Output devices, including a mouse and keyboard, are connected to the Computing Platform Work Station.

3 Software requirements

RTAB-Map (Real-Time Appearance-Based Mapping) is an open-source Visual SLAM (Simultaneous Localization and Mapping) library designed for 3D environment mapping and localization. It uses a ZED Camera, to capture the visual and depth information necessary for creating detailed maps of the surroundings.

System Dependencies

- If you have **ROS** (Robot Operating System) already installed, the dependencies should be satisfied. You can follow the instructions on the rtabmap_ros page.
- If ROS is **not** installed, you'll need to install the following system dependencies based on your Ubuntu version:

  sudo apt-get update

  sudo apt-get install libsqlite3-dev libpcl-dev libopencv-dev git cmake libproj-dev libqt5svg5-dev

Download the latest source from GitHub.

Unzip it and navigate to the rtabmap/build directory: cd rtabmap/build

Build RTAB-Map:

cmake ..

make -j4

sudo make install

Optional dependencies

- If you want SURF/SIFT features enabled in RTAB-Map, build OpenCV from source with nonfree module support.
- Install g2o (a graph optimization library) and GTSAM (version >= 4) if needed.

4 Map Generation and optimization

The Stereo Vision Camera captures stereo images and provides visual data to the SLAM system. The RTABMAP SLAM module performs the following tasks:

Visual Odometry: Estimates the pose (position and orientation) of the camera/vehicle by tracking visual features in the images.

3D Mapping: Triangulates the 3D positions of visual features from the stereo images and constructs a point cloud map of the environment.

IMU Integration: Fuses data from the Inertial Measurement Unit (IMU) with the visual data to improve the accuracy and robustness of pose estimation and mapping. The Autonomous Actuation module subscribes to the localization poses estimated by RTABMAP SLAM, performs path planning, and generates control commands for the vehicle. The Vehicle executes the autonomous motion based on the control commands received from the Autonomous Actuation module.

5 Data Collection and Path planning

Data Collection: The ZED-ROS-Examples toolkit was utilized to record ROS bags, enabling the capture of data from various sensors, including the ZED stereo camera. The recorded ROS bags contain a comprehensive dataset with diverse topics, such as raw data, depth information, RGB images from both cameras, IMU data (orientation and acceleration), pose data, and point cloud data.

Data Analysis: The RTABMAP simulation was employed for mapping the environment using the collected data. The primary objectives of the data analysis include: Evaluating the accuracy of the generated maps. Assessing the performance of localization within the mapped environment. Identifying potential limitations or areas for improvement. Validating the robustness and reliability of the overall system.

Successful Map Creation: The system demonstrated the ability to create highly detailed and accurate 3D maps of the test environment. These maps accurately captured the layout, contours, and intricate details of the surroundings.

Precise Localization: The system exhibited remarkable precision in localizing the vehicle's position within the mapped environment. The localization data obtained from the RTABMAP SLAM algorithm proved highly accurate and reliable.

Autonomous Actuation: A custom code was developed and seamlessly integrated with the SLAM system, enabling autonomous actuation of the vehicle. This code bridged the gap between the SLAM algorithm localization data and the vehicle's control system. Through this integration, the system achieved successful autonomous navigation of the vehicle within the mapped environment.

- ❖ Successful real-time creation of detailed 3D maps
- ❖ Accurate representation of the environment's layout and contours
- ❖ Precise localization within the mapped environment Integration with custom code for autonomous vehicle actuation

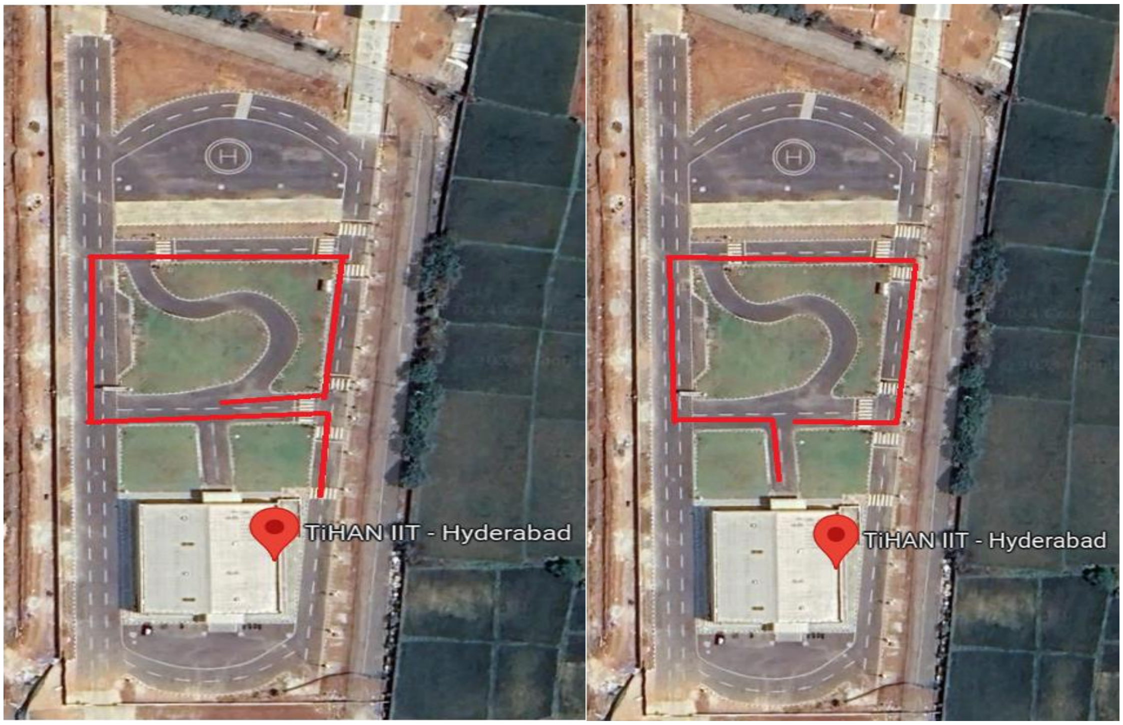

Fig : Maps for final Demo

6 Code to run (Ros Topics)

simulation and mapping

step: 1

roslaunch rtabmap_launch rtabmap.launch rtabmap_args:="--Vis/CorFlowMaxLevel 35 --Stereo/MaxDisparity 200 --Mem/ImagePreDecimation 2 --Mem/ImagePostDecimation 2 --RGBD/OptimizeMaxError 07.0 --Rtabmap/LoopThr 0.0014" stereo_namespace:=/zed2i/zed_node right_image_topic:=/zed2i/zed_node/right/image_rect_gray stereo:=true visual_odometry:=true frame_id:=base_link imu_topic:=/zed2i/zed_node/imu/data wait_imu_to_init:=true localization:=true

step :2

rosbag play --clock 1.bag

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localization

step :1

roslaunch rtabmap_launch rtabmap.launch rtabmap_args:="--Vis/CorFlowMaxLevel 35 --Stereo/MaxDisparity 200 --Mem/ImagePreDecimation 2 --Mem/ImagePostDecimation 2 --RGBD/OptimizeMaxError 07.0 --Rtabmap/LoopThr 0.0014" stereo_namespace:=/zed2i/zed_node right_image_topic:=/zed2i/zed_node/right/image_rect_gray stereo:=true visual_odometry:=true frame_id:=base_link imu_topic:=/zed2i/zed_node/imu/data wait_imu_to_init:=true use_sim_time:=true \ localization:=true

Step :2

rostopic echo /rtabmap/localization_pose | tee -a 3db.txt

step :3

rosbag play --clock 1.bag

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vehicle actuation

Step :1

Desktop>open terminal

step :2

roslaunch zed_wrapper zed2i.launch

step :3

roslaunch rtabmap_launch rtabmap.launch rtabmap_args:="--Vis/CorFlowMaxLevel 35 --Stereo/MaxDisparity 200 --Mem/ImagePreDecimation 2 --Mem/ImagePostDecimation 2 --RGBD/OptimizeMaxError 07.0 --Rtabmap/LoopThr 0.0014" stereo_namespace:=/zed2i/zed_node right_image_topic:=/zed2i/zed_node/right/image_rect_gray stereo:=true visual_odometry:=true frame_id:=base_link imu_topic:=/zed2i/zed_node/imu/data wait_imu_to_init:=true localization:=true