Scan Context-Based Loop Closure for Real-Time LiDAR Odometry and Mapping.

Piyush Kumar - 230752
Research Project Abstract
Mentor: Prof. Salil Goel, Assistant Professor, IIT Kanpur

1. Introduction

Loop closure detection is a critical component in **SLAM systems** to correct accumulated drift and achieve globally consistent maps. This project implements a **Scan Context-based method** for robust **loop closure detection** using **LiDAR** data, particularly effective in large-scale environments due to its rotation-invariant and place-recognizable descriptors. By leveraging **KD-tree-based** fast nearest neighbor search, the system efficiently identifies previously visited locations, enabling correction of trajectory errors and improving overall map accuracy for reliable navigation.

2. Objectives

To develop and evaluate a **loop closure** detection framework based on the **Scan Context method**, integrated within a **ROS-based** system on **Ubuntu**, aimed at enabling accurate recognition of revisited locations using LiDAR data. The goal is to mitigate pose drift and improve global consistency in **SLAM**, thereby enhancing autonomous robot localization and navigation in large-scale environments.

3. Related Work

Loop closure detection has been explored through both vision-based and LiDAR-based approaches. **Vision-based** methods like **FAB-MAP** and **Bag-of-words** rely on image features but often fail in low-light or dynamic environments. **LiDAR-based** methods, such as **Scan Context** and **ICP**, offer greater robustness by using geometric information. Among them, Scan Context stands out for its **rotation-invariant** descriptors and efficient **KD-tree search**, making it well-suited for large-scale environments.

After reviewing these approaches, I selected the **Scan Context** method for its robustness and scalability. I am currently implementing a C++ version of this method, integrated with ROS on Ubuntu, to support reliable loop closure detection for LiDAR-based SLAM.

4. Applications

The implemented **Scan Context**-based loop closure detection system enhances the **accuracy** of LiDAR-based SLAM by **reducing drift** over time. This is crucial for **reliable autonomous navigation** and **localization** in applications such as mobile robotics, autonomous vehicles, warehouse automation, and UAV mapping in **GNSS-denied environments.**

5. Conclusion

This work presents the implementation of a **Scan Context**-based loop closure detection method integrated with ROS on Ubuntu. By leveraging **LiDAR data** and efficient **KD-tree search**, the system enables robust and scalable detection of revisited locations, significantly improving **SLAM accuracy** and supporting reliable autonomous navigation in large-scale environments.

6. Keywords

Scan Context, Loop Closure, LiDAR.