3DGS-based SLAM in Dynamic Systems: Improving Dynamic Object Filtering and Efficiency

Description

In modern robotics, Simultaneous Localization and Mapping (SLAM) plays a crucial role in enabling robots to navigate and map environments autonomously. However, most SLAM algorithms face significant challenges when operating in dynamic environments, where moving objects can lead to erroneous pose estimations and degraded map quality. To address this, various methods have been proposed to filter out dynamic objects, yet there is still room for improvement in both the accuracy of dynamic object filtering and the computational efficiency of the systems.

This project focuses on 3DGS-based SLAM, which leverages a 3D Gaussian Splatting (3DGS) to handle dynamic scenes. The goal is to enhance the performance of dynamic object filtering, building on existing methods to make SLAM more robust in highly dynamic environments. Additionally, this research seeks to optimize the computational efficiency of the approach, ensuring that the system can operate in real-time or near real-time settings, even with a significant presence of dynamic objects.

Students will investigate state-of-the-art techniques for filtering dynamic objects and develop novel algorithms to refine the current 3DGS-based SLAM method. The project involves analyzing loss functions and rendering loss flows to better distinguish dynamic objects from static components, as well as improving computational efficiency to increase system responsiveness in dynamic environments.

Tasks

As a thesis student, you will work collaboratively with our team to advance the current 3DGS-based SLAM method, focusing on two key objectives: improving dynamic object filtering and enhancing overall system efficiency. Your tasks will include:

- Conduct an in-depth analysis of existing 3DGS-based or NeRF-based SLAM methods, with a particular focus on the accuracy and shortcomings of dynamic object filtering.
- Enhance our current 3DGS-based SLAM method (with code) for more effective filtering of dynamic objects, aiming to reduce the impact of these objects on pose estimation and map quality.
- Benchmark the performance of the developed algorithms against SOTA SLAM methods, with a focus on dynamic object handling in various environments.
- Explore strategies for optimizing the computational efficiency of 3DGS-based SLAM, focusing on reducing latency, improving processing speed.
- Design and conduct experiments using real-world robotic platforms to validate the performance of the improved method.

This project provides the opportunity to deepen your understanding of SLAM in dynamic environments while working on cutting-edge techniques to improve both accuracy and efficiency. You will gain valuable experience in developing and implementing SLAM algorithms, along with a strong foundation in real-time robotic perception and dynamic object handling.

Technische Universität München

TUM School of Computation, Information and Technology

Lehrstuhl für Robotik, Künstliche Intelligenz und Echtzeitsysteme

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Supervisor:
Prof. Dr.-Ing. Alois Knoll

Advisor:
Long Wen, M.Sc.

Research project:
MANNHEIM-CeCaS

Type:
SA/MA

Research area:
Simultaneous Localization and Mapping (SLAM), Dynamic Object Filtering, Robotics, 3D Gaussian Splatting (3DGS)

Programming language:
Python, C++

Required skills:
Programming skills in Python or C++ (must have); Experience with SLAM algorithms (nice to have); Knowledge of 3D Gaussian representations (nice to have); Familiarity with dynamic object filtering (nice to have).

Language:
English

For more information please contact us:

E-Mail: long.wen@tum.de

Internet: www.ce.cit.tum.de/air