CSC4050 CS capstone project information collection

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1. Name*

JUNFENG

2. How many students would you like to take?*

5

3. A brief description of the projects the students could work on*

Topic 1: SLAM Algorithm Design based on Array Radar and Low-cost IMU
Q3: Brief Description: Array LiDAR, known for its dense feature points, and low-cost IMU are widely used in mapping and 3D reconstruction scenarios. The calibration of sensor measurement data and uncertainty metrics play a decisive role in the algorithm.
The current SLAM algorithm in the laboratory is implemented based on Iterative Invariant Kalman Filter. The laboratory has handheld devices and corresponding sensors. We aim to design a more stable SLAM algorithm based on radar and IMU, leveraging the existing theoretical foundations, equipment, and algorithm in the laboratory.
Overall Objective: Real-time localization and mapping algorithm based on the laboratory's radar (Livox) and low-cost IMU.
Basic Tasks:
Preprocessing of raw data obtained from Livox mid sensor, understanding the structure of point cloud data. This includes distortion correction, data type conversion, and point cloud feature extraction.
Maintenance of local point cloud map, improving the data storage structure (ikd tree) of the map. The goal is to optimize the map storage structure and reduce memory usage.
Design adaptive algorithms to address degradation of performance caused by changes in radar scenes.
Optional:
Estimation of uncertainty in radar point cloud measurements.
Q4:Requirements:
Familiarity with data structures.
Proficiency in C++

Q5: Comments and suggestions
References: Task 1 Reference:
Livox Cloud Undistortion: https://github.com/Livox-SDK/livox_cloud_undistortion
Livox Mid 70 User Manual
Task 2 Reference:
Fast-lio2, Faster LIO, Direct LiDAR Odometry: Fast Localization With Dense Point Clouds, etc.

Topic 2: LiDAR-Visual-IMU Odometry Algorithm Design
Q3:Project Description:
Multi sensor fusion can expand the range of platform applications, and the LiDAR inertial odometry (LIO) can already achieve high accuracy. However, LiDAR may encounter some degradation scenarios, so it is necessary to incorporate visual information, namely Visual-IMU-Odometry. The specific approach for fusion is to utilize the laboratory's theoretical foundation and platform foundation, use the LIO based on Iterative Invariant Kalman Filter to obtain a 3D point cloud map, and implement the PnP algorithm for pose estimation using camera images.
Specific Tasks:
Learn and investigate the algorithm logic for photo and point cloud matching, understand the principles of PnP, and implement the code based on the open-source LIO platform.
Q4:Requirements:
Proficiency in C++.
Mastery of data structures.

4. Requirements (e.g. html or c++ skills)*

Topic3: Privacy Preserving NeRF
Q3: Project Description: Neural Radiance Fields (NeRF) stand as a significant breakthrough in novel view synthesis, driving advancements in 3D computer vision and graphics. Current NeRF technology products require users to upload pictures of their surroundings and camera parameters to a cloud server belonging to the product company, and the server can train NeRF models. However, training NeRF in this way will seriously compromise user privacy. The project's goal is study how to preserve the users' data privacy during the training process of NeRF.
Objective: Protect user privacy while ensuring NeRF training utility and training efficiency.
Q4:Requirements:
Good python programming skills.
Have deep learning project experience, code operation environment configuration experience, Linux server experience.
Knowledge of Deep learning and NeRF is a plus.
Q5: References: NeRF(https://dl.acm.org/doi/pdf/10.1145/3503250)
NeRF: Representing Scenes as Neural Radiance Fields for View Synthesis
Instant neural graphics primitives with a multiresolution hash encoding
A pytorch CUDA extension implementation of instant-ngp(https://github.com/ashawkey/torch-ngp)

Topic 4: Consistent camera pose estimation from points and lines (Yuchen Song, 宋语宸)

A brief description: There generally exist both point and line features in a camera image, and compared with utilizing only points or lines, fusing these two kinds of measurements can lead to a more accurate camera pose estimate. In this project, we hope to design a uniform framework to combine points and lines, and propose a consistent pose estimator which can make full use of dense features. Simulations and real image tests need to be conducted to verify the advantage of the proposed estimator.

Requirements: some mathematical background in probability and statistics; MATLAB or Python skill

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5. Other comments or suggestions

NO