EECE 5554 – Robot Sensing and Navigation

Final Project Report

About ORABSLAM3

ORB-SLAM3 is a state-of-the-art visual SLAM (Simultaneous Localization and Mapping) system that can operate in various environments using monocular, stereo, and RGB-D cameras. When collecting data using a car and camera, the algorithm involves several key steps to process the input images and perform SLAM.

Key Components of ORB-SLAM3

1. Initialization:

System Initialization: Start the SLAM system, initialize essential variables, and set up data structures.
Camera Calibration: Load intrinsic parameters (focal length, principal point, and distortion coefficients) for precise image processing.
First Frame Processing: Detect ORB features in the initial frame and establish the initial pose to create the initial map.

2.Tracking:

Feature Detection: Detect ORB features in each new frame.
Feature Matching: Match these features with those from the previous frames or keyframes to find correspondence.
Pose Estimation: Estimate the camera pose relative to the previous frame or map using the Perspective-n-Point (PnP) algorithm.
Local Map Tracking: Minimize the reprojection error of map points observed in the current frame to track the camera pose.
Relocalization: If tracking is lost, use a place recognition module to attempt relocalization and re-establish tracking.

3.Mapping:

Keyframe Insertion: Determine when to insert a new keyframe based on the number of tracked map points, the distance traveled, or significant view changes.
Local Mapping:
Map Point Creation: Triangulate new map points from matched features between keyframes.
Map Point Culling: Remove redundant or poorly tracked map points.
Local Bundle Adjustment: Optimize the poses of recent keyframes and map points to minimize reprojection errors.

4.Loop Closure:

Loop Detection: Detect loops by comparing the current keyframe with past keyframes using place recognition.
Pose Graph Optimization: Correct drift by optimizing the global pose graph when a loop is detected.
Full Bundle Adjustment: Optionally perform a global bundle adjustment to refine the entire map after loop closure.

5.Output:

Trajectory and Map: Continuously output the estimated camera trajectory and the 3D map of the environment.
Visualization: Provide real-time visualization of the trajectory and map for monitoring purposes.
Key Parameters used as inputs for ORB-SLAM3:

Number of Features: 25,000

Scale Pyramid Levels: 12

Scale Factor: 1.2

Initial FAST Threshold: 20

Minimum FAST Threshold: 7

Results:

ORB-SLAM3 on NUance Stereo Data: Performance Overview

General Results: ORB-SLAM3 provided decent results for most parts of the dataset, with good feature tracking and map construction in areas with sufficient texture.

Challenges: Feature Loss in Low-Texture Areas: In regions with minimal texture (e.g., open spaces or areas with few distinguishing features), the system struggled to extract and track features.

Speed-Related Issues: When the car was driving faster, the lower frame rate (8 Hz) led to feature loss and reduced tracking accuracy.

ORB Parameters Used:

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Initial FAST Threshold: 20

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Conclusion: While the system performed well in textured environments, adjustments like higher frame rates or enhanced feature extraction techniques may be needed for challenging scenarios.