EÖTVÖS LORÁND UNIVERSITY

FACULTY OF INFORMATICS

MASTER THESIS TOPIC DECLARATION FORM

Name of Student: **Eliyas Kidanemariam Abraha**

Neptun code: **P6013D**

Training: **Full-Time**

Technical major: **Intelligent Field Robotic Systems (IFRoS)**

Email Address: **eliyaskidane@gmail.com**

Phone Number: **+34637845121**

Name of ELTE supervisor: **Professor Zoltán Istenes**

Department**: Eötvös Loránd University Faculty of Informatics**

Contact (email, phone): istenes@inf.elte.hu

Name of Industrial supervisor: Professor Mohammad Aldibaja

Department: **Smart Mechatronics and Robotics, Saxion**

Contact (email, phone): **m.a.j.aldibaja@saxion.nl**

Phone: **+33641832724**

Information about the internship

Name of the company: Saxion University of Applied Science, SMART

Starting date of internship: 15/01/2025

Closing date of internship: - 1/06/2025

Weekly schedule: 40 hours per week

The purpose of the admission declaration is to certify that the student of the MSc in Intelligent Field Robotics System at ELTE Faculty of Informatics may complete the mandatory internship in the selected institution within the framework detailed hereby and in accordance with the learning outcomes required by the program.

Title of the thesis

Lidar-Based map-observation Localization Module for Autonomous Navigation

Topic of the thesis (1 – 1,5 pages)

Motivation

High-precision and robust localization in GNSS-denied areas is crucial for autonomous vehicles and robots. Most state-of-the-art localization methods are based on simultaneous localization and mapping (SLAM) with a camera or light detection and ranging (LiDAR). However, SLAM will suffer from drifting during long-term running without loop closure or prior constraints. Lightweight, high-precision environmental maps have gradually become an indispensable part of future autonomous driving. In order to solve the problem of real-time global localization for autonomous vehicles and robots, precise and robust LiDAR localization system based on a pre-built map is mandatory. While this approach has proven effective, challenges arise with large-scale maps, dynamic environments, and the need for real-time performance. Addressing these challenges requires exploring the effects of different scan-to-map matching methods and map representations on localization efficiency and accuracy.

Objective

1. **Development of a LiDAR Localization System Using a Pre-Built Map**: Design and implement a robust LiDAR-based localization system that leverages pre-built maps to achieve improved localization accuracy
2. **Design and Implementation of LiDAR Scan-to-Map Matching Techniques:** Develop and evaluate efficient scan-to-map matching techniques for precise alignment of LiDAR scans with the pre-built map.
3. **Integration of Sensor Fusion for Enhanced Localization:** Design and implement a sensor fusion framework that integrates LiDAR-based map observations with complementary sensor data, such as LiDAR-inertial odometry or wheel odometry
4. Evaluating the performance of different scan-to-map matching techniques, including their accuracy, computational efficiency.

Research Questions

1. How the integration of map-based localization improves the accuracy of localization.
2. What scan-to-map matching techniques can be developed to improve alignment accuracy and computational efficiency in LiDAR localization?
3. What optimization techniques can be applied to scan-to-map matching algorithms to improve accuracy and efficiency of localization for autonomous vehicles?
4. How different LiDAR scan-to-map matching techniques affect localization efficiency and scalability?

Methodology, Approach and Tools

1. **Literature Review**:
   Studying state-of-the-art LiDAR localization techniques, including SLAM, LiDAR-inertial odometry, and prebuilt map-based localization approaches then identify strength and limitations including state estimation and scan matching.
2. **Framework Design**:

- Implement LiDAR-inertial odometry or wheel odometry to estimate the vehicle's motion.
- Incorporating sensor fusion technique with map-observation matching methods using prebuilt maps to optimize localization.
- Improve localization by optimizing scan to map matching

3. **Tools and Programming Languages**: Ros,Gazebo,Rviz,Python,C++

4. **Result and Analyse**:
   - A localization module for localizing robots inside maps.
   - Insights into the effectiveness of scan-to-map matching techniques to improve localization accuracy against GPS.

Keywords: *Localization, Scan-to-map matching, Light detection and ranging (LiDAR), Point Cloud ,* Autonomous Navigation

Encryption of the topic is necessary: **YES/NO**

I ask for the acceptance of my thesis topic.

Budapest, 6./.1./202

Eliyas Kidanemariam Abraha

Student

I approve of the suggested topic of the Master's Thesis:

Budapest, 10/.1../2025 .....

ELTE supervisor

I approve of the suggested topic of the internship, and in the name of the institution (organization, company) above I agree, that the named student will carry out his/her internship along the conditions detailed above:

Netherlands, 16/12/2024 .....

Industrial supervisor

The topic of the thesis and internship is approved by the Dean of Faculty of ELTE Informatics

Budapest, …./…./202

Kozsik Tamás

Digitally signed by Dr. Kozsik Tamás
Date: 2025.01.15 00:03:35 +01'00'

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Dr. Tamás Kozsik

Dean of Faculty of Informatics