EÖTVÖS LORÁND UNIVERSITY

FACULTY OF INFORMATICS

MASTER THESIS TOPIC DECLARATION FORM

Name of Student: Liviu-Daniel Florescu

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Training: Full-time

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Name of Industrial supervisor: Maximilian Fenkart

Company: Sodex Innovations GmbH

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Information about the internship

Name of the company: Sodex Innovations GmbH

Starting date of internship: 13/01/2025

Closing date of internship: 09/05/2025

Weekly schedule: 32 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 Odometry and Mapping Beyond RTK Accuracy

Topic of the thesis

Out of the five basic senses that humans use to experience the world, vision accounts for 80% of the information input that our brains operate with [1]. Naturally, robotics research aims to replicate this and develop systems that can not only collect high-quality visual data but also create rich artificial representations of the world, enabling autonomous systems to confidently reason about their environment.

This work will focus on the use of 3D Light Detection and Ranging (LiDAR) sensors in outdoor settings. When mounted on an arbitrary mobile base and moved around a target environment, the sensor collects information about the geometry of the scene, which can be merged in order to create a general 3D model. However, this process depends on accurate displacement measurements that are not trivial to obtain. An existing solution relies on Global Navigation Satellite System (GNSS) localization, corrected using Real-Time Kinematic positioning (RTK), and orientation from an Inertial Measurement Unit (IMU). Together, these create an Inertial Navigation System (INS) whose output can be interpreted as the 3D transformation between sensor poses at discrete time steps. Even though this represents the state-of-the-art technology for outdoor localization, with centimeter-level position error, its accuracy is unsatisfactory when it comes to high-quality pointcloud registration. Additionally, this is not feasible for all outdoor scenes, because GNSS accuracy varies heavily depending on surroundings and signal strength.

We will investigate methods that address the limitations of the INS-based registration, by using the visual information in the scene, such that the system is less reliant on a sensor with fluctuating uncertainty. Previous research in this area [2] indicates that visual cues alone should be enough to achieve reliable displacement estimation, enabling the computation of odometry from LiDAR data, as well as creating a 3D map of the explored environment. A comparison between LiDAR odometry and GNSS localization is also within the scope of this work. The research questions that we aim to answer are the following:

- What metrics exist for measuring the accuracy of pointcloud registration?
- Can methods that use only visual information achieve higher quality pointcloud registration (3D mapping) than RTK-based merging?
- To what extent is LiDAR-based odometry an alternative to GNSS localization?

The work will be carried out in collaboration with Sodex Innovations GmbH, who provide the sensor rig (LiDAR, RGB cameras, GNSS + RTK + IMU) as well as several existing datasets consisting of sensor data collected while exploring outdoor rural environments. The project will span approximately 15 weeks, and is tentatively structured as shown below, subject to change brought by results at different stages.

Stage	Estimated Duration	Description
Introduction	2 weeks	Familiarization with the existing sensors, datasets and related processes
Background investigation	3 weeks	Exploring existing solutions, initial experimentation on available data
Design and Development	4 weeks	Iterative implementation and testing of new approaches
Analysis	4 weeks	Evaluation and comparison between the solutions developed at different iterations
Final write-up	2 weeks	Reporting methods, implementation and results

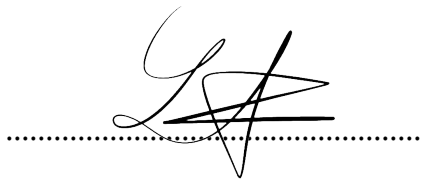
Keywords
LiDAR odometry, LiDAR mapping, pointcloud registration, GNSS, RTK

References
[1] Man, Dariusz & Olchawa, Ryszard. (2018). The Possibilities of Using BCI Technology in Biomedical Engineering. 10.1007/978-3-319-75025-5_4.
[2] Lee, Dongjae & Jung, Minwoo & Yang, Wooseong & Kim, Ayoung. (2024). LiDAR odometry survey: recent advancements and remaining challenges. Intelligent Service Robotics. 17. 1-24. 10.1007/s11370-024-00515-8.

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

I ask for the acceptance of my thesis topic.

Budapest, 25/11/2024



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Student

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

Budapest, …./…./202

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ELTE supervisor

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

Budapest, …./…./202

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Industrial supervisor

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

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Dr. Tamás Kozsik

Dean of Faculty of Informatics