

Ben-Gurion University of the Negev Faculty of Engineering Science

School of Electrical and Computer Engineering Dept. of Electrical and Computer Engineering

Fourth Year Engineering Project

PDR

# Simulator-for-LIDOR-with-ALExA

Simulator for Logical Infrastructure for Drone Optimization and Research with Adaptive Layered Exploration Architecture

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| **Project number:** | **p-2025-124** |
| **Students  (name & ID):** | **Shaked Basa, 206310781 Yevgeniy Gluhoy, 336423629** |
| **Supervisors:** | **Omer Gurewitz** |
| **Submitting date:** | **17/11/2024** |

Contents

[**1. Abstract 3**](#_heading=h.30j0zll)

[1.1. English Abstract 3](#_heading=h.1fob9te)

[1.2. Hebrew Abstract 4](#_heading=h.3znysh7)

[**2. Spec Sheet 5**](#_heading=h.2et92p0)

[2.1. The Main Problem 5](#_heading=h.tyjcwt)

[2.2. Literature Review 5](#_heading=h.3dy6vkm)

[2.3. Project's Goal 5](#_heading=h.1t3h5sf)

[2.4. Solution Approach 5](#_heading=h.4d34og8)

[2.5. Project extensions. 5](#_heading=h.3rdcrjn)

[**3. Bibliography 6**](#_heading=h.17dp8vu)

# Abstract

## English Abstract

Simulator-for-LIDOR-with-ALExA

Students Names: Shaked Basa, Yevgeniy Gluhoy  
[*gluhoy@post.bgu.ac.il*](mailto:gluhoy@post.bgu.ac.il)

[*basashak@post.bgu.ac.il*](mailto:basashak@post.bgu.ac.il)Adviser: Omer Gurewitz

Our project focuses on developing a simulator for autonomous drones using the OMNeT++ framework. With the rapid advancements in autonomous drone technology, simulation environments have become essential tools for testing, optimization, and performance evaluation. Our simulator aims to provide a virtual platform for designing, deploying, and analysing various drone behaviours and interactions in different scenarios. The project includes implementing drone movement models, communication protocols, and collision-avoidance algorithms. By leveraging OMNeT++'s modular architecture, our simulator enables the testing of complex autonomous flight patterns, network connectivity, and cooperative task execution among drones. This simulation environment allows researchers and developers to experiment with different configurations and assess the impact of variables such as signal interference, battery limitations, and environmental constraints on drone performance. Our project ultimately contributes to advancing the capabilities of autonomous drones by providing a reliable and flexible simulation platform for future innovations.

**Keywords:** simulator, autonomous, drones, OMNeT++, optimization, signal interference, battery limitations, reliable and flexible simulation.

## Hebrew Abstract

**סימולטור רחפנים אוטונומיים מבוסס OMNeT++**

סטודנטים: שקד בסה, יבגני גלוחוי   
[*gluhoy@post.bgu.ac.il*](mailto:gluhoy@post.bgu.ac.il)

[*basashak@post.bgu.ac.il*](mailto:basashak@post.bgu.ac.il)

מנחה: עומר גורביץ

הפרויקט שלנו מתמקד בפיתוח סימולטור לרחפנים אוטונומיים על בסיס OMNeT++. עם ההתקדמות המהירה בטכנולוגיית הרחפנים האוטונומיים, סביבות סימולציה הפכו לכלי חיוני לבחינה, אופטימיזציה והערכת ביצועים. הסימולטור שלנו נועד לספק פלטפורמה וירטואלית לתכנון, פריסה וניתוח של התנהגויות ותגובות שונות של רחפנים בתרחישים מגוונים. הפרויקט כולל יישום של מודלים לתנועת רחפנים, פרוטוקולי תקשורת ואלגוריתמים למניעת התנגשות. באמצעות הארכיטקטורה המודולרית של OMNeT++, הסימולטור שלנו מאפשר לבחון דפוסי טיסה אוטונומיים מורכבים, קישוריות רשת וביצוע משימות שיתופיות בין רחפנים. סביבת הסימולציה מאפשרת לחוקרים ולמפתחים להתנסות בתצורות שונות ולהעריך את השפעתם של משתנים כמו הפרעות באות, מגבלות סוללה ומגבלות סביבתיות על ביצועי הרחפנים. הפרויקט שלנו תורם לקידום היכולות של רחפנים אוטונומיים על ידי מתן פלטפורמת סימולציה אמינה וגמישה לפיתוחים עתידיים.

# Spec Sheet

## The Main Problem

The lack of a flexible and accurate simulation platform for autonomous drones limits the ability to test and optimize drone behaviours, especially in complex or large-scale environments. Existing tools often fall short in simulating interactions, communication, and safety measures critical for real-world applications. Our project aims to bridge this gap by developing an OMNeT++-based simulator that supports comprehensive testing of autonomous drone systems, enabling reliable performance analysis and safer deployment.

## Literature Review

Modern algorithms for drone trajectory planning, such as multi-drone 3D trajectory planning [1], path planning in complex 3D environments using the Improved Bat Algorithm [2] and optimizing spectral efficiency with NOMA in multi-user scenarios [3], require precise simulation frameworks. These algorithms depend heavily on realistic modelling of drone dynamics, complex 3D environments, and detailed communication channels.

Existing simulators like Adigar [5], FANET [6] and SwarmLab [4] fall short in several critical aspects:

Limited support for detailed and dynamic 3D obstacle interactions and realistic environmental modelling, Lack of sophisticated simulation models for communication channel models, such as using different signal propagation models: Free-space path loss, Two-ray ground-reflection model, Knife-edge diffraction model. Additionally, absence of comprehensive models for energy consumption and battery management under varying operational conditions.

The simulator should additionally calculate signal loss and packet loss during data transmission, support various types of drones (e.g., Quadcopters, Hexacopters and Octocopters) and communication methods (e.g., radio signal and Wi-Fi), and integrate their direct impact on both signal quality and battery consumption.

This diversity in drone configurations directly affects their communication capabilities, signal strength, and energy consumption, making it essential for the simulator to account for these variations.

## Project's Goal

To create a flexible OMNeT++ based simulator that allows for the development and testing of autonomous drone technologies under various scenarios and environmental constraints.

## Solution Approach

To develop a comprehensive drone coordination simulator with a multi-layered architecture, the system design is divided into three layers: Physical Layer, Basic Protocol Layer, and User Layer. Each layer is designed to provide distinct functionalities while maintaining seamless integration with the other layers. The simulator is implemented in OMNeT++ to leverage its modular and discrete event simulation capabilities.

1. Physical Layer: Models drone-specific parameters (rotor count, weight, battery size) to simulate energy consumption and optimize energy efficiency. It calculates remaining battery charge and adjusts behaviours based on energy models.

2. Basic Protocol Layer: Provides core communication protocols for drone-to-drone and drone-to-operator interactions. Key features include navigation commands (move, hover, ascend), status updates (battery, position), and coordination commands (formation, obstacle avoidance).

3. User Layer: Enables users to script and test custom behavioural protocols using the Basic Protocol Layer. This allows for simulation of diverse scenarios like search-and-rescue or area coverage.

Additional Features: The simulator includes terrain modelling with altitude variations for realistic movement and tools to analyse energy efficiency and communication stability across different protocols.

## Project extensions

Future enhancements could include Improvement of existing drone swarm behaviour algorithm: Task Coordination Models for multi-drone operations, such as area coverage, object tracking, and search-and-rescue missions. Payload Management for delivery drones, addressing weight capacity and battery usage and Emergency Protocol Simulations for real-time responses to system failures or unexpected obstacles

These extensions will expand the simulator’s capabilities, supporting a broader range of autonomous drone applications.

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