Tracking and Landing of a Quadcopter on a Moving Platform

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ABSTRACT

This report documents the process of tracking and landing the Parrot Mambo drone on a moving platform. Initially, the process was simulated using a digital twin model, which was then practically implemented. The digital twin, developed using Simscape physical modeling, allowed for virtual representation and testing of the quadcopter before real-world deployment. In the real-world scenario, the landing platform was mounted on a pre-programmed line-following robot to test the dynamic landing capabilities of the quadcopter.

1. INTRODUCTION

This paper aims to demonstrate how a dynamic landing control system for the Parrot Mambo Minidrone was implemented using MATLAB. Dynamic landing refers to the process of autonomously landing the drone while taking into account external factors such as wind, obstacles, and surface conditions. We will go over the MATLAB simulation, design, and implementation of the dynamic landing control system in this paper.

2. METHOD

The method followed to develop and implement this project is as follows:

1. Simulation Setup using Digital Twin Model:

Using Simscape physical modeling in MATLAB/Simulink, a digital twin model of the Parrot Mambo drone and the landing platform is created. This model precisely simulates the behaviour of the drone and the platform by integrating dynamics, sensors, and actuators. Additionally, a stateflow chart is implemented to model the landing logic, which includes tasks such as tracking the moving platform, adjusting altitude, and controlling descent.

2. Stateflow Chart Development:

In MATLAB/Simulink, a stateflow chart is made to show the drone's landing logic. In order to cover the numerous phases of the landing process, this chart defines the required states like "Take Off," "FollowTheTarget" and "Land." Next, using sensor inputs and ambient factors, the chart's transition conditions and actions are put into place to control the drone's behavior. In addition, the chart has logic to identify and track the moving platform, with the use of vision sensors or other onboard sensors.

3. Integration with Digital Twin Model:

The stateflow chart is integrated with the digital twin model of the drone and the landing platform to facilitate seamless communication between them. This integration ensures that there is a smooth interaction between the stateflow chart and the simulation environment, allowing for real-time control and monitoring of the drone's behavior. By linking the stateflow chart with the simulation, accurate representation of the drone's actions and responses to different scenarios can be achieved, enhancing the overall effectiveness of the dynamic landing system.

4. Parameter Tuning and Validation:

To maximize the landing logic's performance, the stateflow chart's and the simulation model's parameters are changed. This entails adjusting several settings to make sure that the system performs as intended and satisfies established performance standards. In order to ensure accuracy and dependability, the simulation results are then extensively verified against predetermined performance standards and predicted behaviour. The dynamic landing system's suitability for practical uses and efficacy must be confirmed through this validation procedure.

5. Real-World Implementation:

The developed landing logic is implemented on the physical Parrot Mambo drone, which comes equipped with onboard sensors. Additionally, the landing platform is mounted on a pre-programmed line-following robot to create dynamic landing scenarios. Subsequently, the landing procedure is executed in real-world conditions to evaluate the system's performance. This process allows for testing the effectiveness of the landing logic under varying environmental factors and provides valuable insights into its reliability and accuracy.

By following this methodology, we aim to develop and evaluate a dynamic landing system for the Parrot Mambo drone that can accurately and safely land on a moving platform under various conditions.

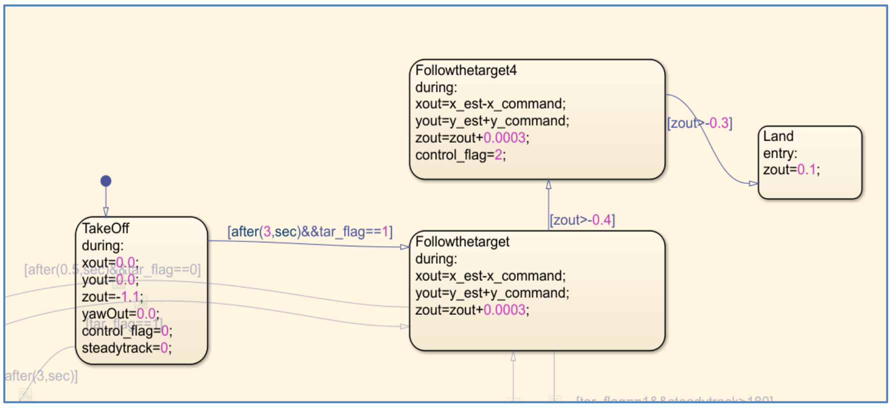

Figure 1: Stateflow Logic.

3. RESULTS

During the simulation phase, the drone was able to track and land on the moving platform under a variety of conditions thanks to the stateflow chart logic and fine-tuned parameters. These included various trajectories, platform speeds, wind speeds, and surface friction coefficients. Before the technology was implemented in the real world, significant testing and optimization were made possible by the usage of the digital twin.

The physical Mambo drone with the landing logic firmware showed strong tracking and landing skills when testing moved to the real world. With great efficiency, the line-following robot's onboard vision system located and locked onto the moving landing platform.

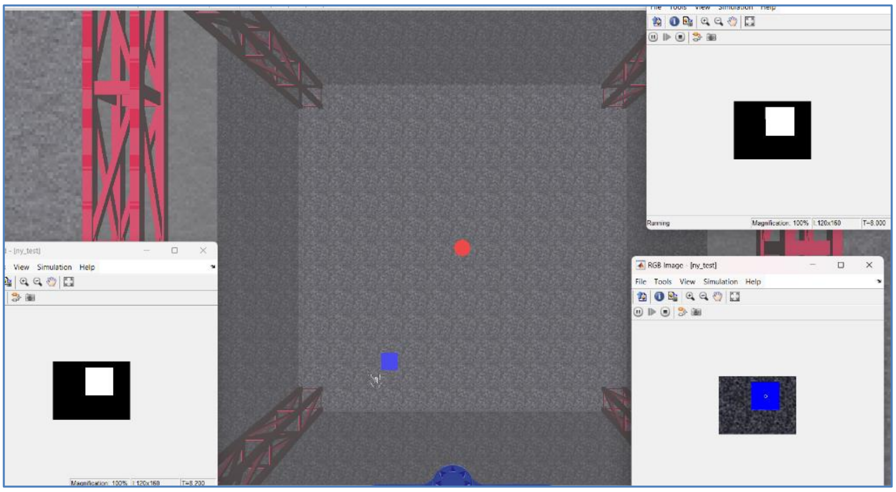

Figure 2 Simulation Results

4. CONCLUSION

This project successfully demonstrated the development and real-world implementation of an autonomous dynamic landing system for the Parrot Mambo drone on a moving platform. The key accomplishments include:

- Creation of a high-fidelity digital twin simulation model integrating drone dynamics, sensors, the landing platform and the landing stateflow logic.
- Design and tuning of the stateflow control logic for vision-based tracking, descent profiling and landing execution.
- Extensive virtual testing and validation of the landing system using the simulation model under diverse conditions.
- Real-world deployment achieving robust and accurate dynamic landings on a moving robot-mounted platform at various speeds.

The use of model-based design techniques and digital twin simulation allowed rapid prototyping, testing and optimization of the control system before deployment. This approach can significantly accelerate the development cycle for autonomous capabilities in drones and robotics.

With its dynamic landing capability, the Parrot Mambo drone can now potentially be used for applications like coordinating with ground vehicles, continuous operations using multiple battery swaps, integrating aerial and ground robotic systems and more. Further improvements to the vision tracking robustness and environmental adaptability can enhance the system's performance.