UNIVERSITI TEKNOLOGI MARA

DEVELOPMENT OF A DYNAMIC ADAPTIVE CONTROLLER FOR AN AUTONOMOUS UNMANNED AERIAL VEHICLE PRECISION LANDING SYSTEM ON A MOVING PLATFORM

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ABSTRACT

Precision landing for Unmanned Aerial Vehicles (UAVs) is an essential feature in modern UAV systems. Currently, the Return-to-Launch (RTL) method allows UAVs to land autonomously by referencing their initial GPS-based take-off coordinates. However, this approach is often inaccurate, particularly during long flight durations, as GPS data is not real-time and lacks precision. This inaccuracy in landing position can lead to potential UAV crashes, posing risks to the surroundings and incurring high costs This research proposes a new precision landing system on a moving platform to address these issues and enhance landing accuracy. The primary objective was to develop a dynamic adaptive controller that utilizes both GPS data and computer vision to achieve precise landings. Various UAV models were analyzed, with the H480 hexacopter chosen for its superior stability and responsiveness. An autonomous Husky rover, modified with a landing platform, served as the moving target. Both models were tested in the Gazebo simulator, allowing for the development, refinement, and validation of the adaptive control algorithm. The system uses GPS and vision-based inputs to guide the UAV, with pitch and roll adjustments helping it navigate smoothly toward the landing target by processing the inputs in the proposed adaptive control system. The control system's gain coefficients were optimized to maximize landing accuracy, offset reduction, stability, responsiveness, and flight path efficiency. The fusion of GPS and vision sensors significantly improved accuracy and expanded UAV range compared to the previous literature. Simulations demonstrated that for a platform speed of 5 m/s, the proposed method achieved an average success landing rate of 90% with an average landing duration of 40 seconds and an average offset of just 0.3 meters. These results confirm the effectiveness of the adaptive controller combined with GPS and camera sensor fusion in achieving precision landings on a moving platform with significant improvement on the autonomous range, increased landing platform speed and landing accuracy. Future research should focus on fabricating this prototype to further validate the findings through experimental testing.

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TABLE OF CONTENTS

CHAPTER 1
INTRODUCTION

1.1 Introduction

This chapter presents an introduction to the research. Sections 1.2, 1.3, 1.4, and 1.5 provide motivation, problem statement, objectives, and research hypotheses. Next, Sections 1.6, 1.7, 1.8, 1.9 and 1.10 discuss the significance of the study, knowledge contribution, research process, the scope of work, and research outlines.

1.2 Research Motivation

Autonomous Unmanned Aerial Vehicles (UAV) are self-navigated vehicles capable of moving in six degrees of freedom (DoF) [1]. They execute flight missions through either pre-programmed instructions or real-time commands, with a fully autonomous UAV performing tasks from take-off to landing. Among these phases, landing is particularly critical. Commercial UAVs typically employ return-to-launch (RTL) features that utilize GPS for safe landings; however, this approach is inadequate for landing on moving platforms where take-off positions may shift [2]. The reliance on GPS for landing leads to significant inaccuracies, exacerbated by external factors such as weather, wind, and obstacles, particularly on moving platforms. Given that long-duration flights often result in discrepancies between take-off and landing locations, this research aims to improve landing accuracy to enhance safety for all UAV operators, including beginners.

To investigate this, a quadcopter is selected as the test vehicle due to its prevalence in UAV applications and its reported vulnerabilities during landings. Quadcopter designs offer remarkable manoeuvrability and require minimal clearance for operation, enabling rapid changes in speed and direction, which is advantageous for precision landing. This research aims to leverage these features by developing an adaptive controller system utilising both GPS data and image processing inputs to facilitate dynamic precision landing on moving platforms. Further details on the adaptive controller system will be presented in Section 3.3.