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MULTI-SENSOR FUSION BASED UAV COLLISION AVOIDANCE SYSTEM

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Graphical abstract

Abstract

This paper presents the development of a quadrotor unmanned aerial vehicle (UAV) that is capable of detecting and avoiding collision with obstacles through the implementation of Kalman filter-based multi-sensor fusion and cascaded PID position and velocity controllers. Sensor fusion of ultrasonic (US) and infrared (IR) sensors is performed to obtain a reliable range data for obstacle detection which then fed into collision avoidance controller (CAC) for generating necessary response in terms of attitude commands. Results showed that sensor fusion provided accurate range estimation by reducing noises and errors that were present in individual sensors measurements. Flight tests performed proved the capability of UAV to avoid collisions with the obstacle that was introduced to it during flight successfully.

Keywords: UAV, collision avoidance, sensor fusion

1.0 INTRODUCTION

In recent decades, UAVs have been employed extensively for military and civilian applications such as aerial surveillance, remote sensing, aerial inspections as well as search and rescue operations. In order to operate safely and to accomplish specified missions, one of the key features required for the UAVs is the ability to avoid collisions with environmental obstacles.

Significant collision avoidance researches have been carried out for individual UAVs and been demonstrated using multi-rotor platforms. In 2009, Sobers *et al*. [1] developed quadrotor equipped with infrared sensors for indoor mapping and localization that is inclusive of collision avoidance. In 2012, Chee and Zhong [2] developed UAV quadrotor that is capable of autonomous navigation and avoiding obstacles along the trajectory without any pilot inputs in outdoor environment. Position controllers that generate roll and pitch commands were implemented to regulate the distance to obstacles which was measured using 4 infrared sensors.

Becker *et al*. [3] presented the development of active control system for quadrotor UAV to avoid collisions during the flight. Four US sensors were implemented on-board the platform for detecting obstacles. However, due to onboard sensor limitations, cruise speed obstacle avoidance controller (OAC) was not implemented and flight tests were performed only for hovering OAC which produced evasive maneuvers when an obstacle approached the quadrotor. Gageik *et al*. [4] presented a simple approach for obstacle detection and collision avoidance of an autonomous flying quadrotor using 12 low-cost US sensors and simple data fusion of those sensors for indoor applications.

Abovementioned researches were only focused on single type of sensors namely IR or, US for range sensing, each with its advantages and drawbacks. An US sensor has higher accuracy compared to IR sensor especially when used outdoors, however it has lower refresh rate which is around 13Hz to 20Hz. In cluttered environments, small movements of the US sensors results in 'noisy' readings due to varying strength of the sonar return from different objects [1]. Whereas, infrared sensor has a shorter range and narrow beam width than the US sensor but better resolution and higher refresh rate of 100-250Hz. However, it is more