MPhil Research Thesis

DYNAMIC OBSTACLE AVOIDANCE FOR LOW ALTITUDE AUTONOMOUS UAVS USED IN PRECISION AGRICULTURE

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Abstract

Unmanned aerial vehicles (UAVs) have numerous applications, including in the fast-developing precision agricultural domain. Most of these applications require UAVs to fly at low altitudes for optimal operation. The complex dynamic nature presented by moving obstacles in agricultural fields, increases collision risk for law altitude UAVs, which is a safety issue not only for UAV but also for workers, infrastructure, and machinery in the field. Although obstacle avoidance by autonomous UAVs has been a research topic throughout the past decade, the development of systems for collision avoidance with dynamic obstacles has not progressed to a level required for implementation in real-world complex environments where multiple obstacles are present. Therefore, this research was carried out to develop an obstacle avoidance system for low-altitude autonomous UAVs to avoid collisions in the presence of multiple dynamic obstacles. Furthermore, the research is contributing to the field of UAV obstacle avoidance by addressing two critical challenges: proper environmental perception to achieve safe navigation in cluttered environments with narrow gaps and dynamic obstacle avoidance considering their future trajectories. The developed UAV obstacle avoidance system mainly consists of two subsystems as Environmental Modeling Subsystem and Collision Avoidance Subsystem. The Environmental Modeling Subsystem uses ellipsoidal bounding box approximation based approach to model the environment. Collision Avoidance Subsystem is developed based on collision cone method that considers the obstacle future trajectory estimation to detect collisions and plan collision avoidance maneuver. Results of the experiments proved the developed obstacle avoidance system is capable of successfully avoiding collisions in a highly cluttered environment with moving obstacles due to modeling obstacles in the environment closer to its true dimensions and the careful consideration of estimated future trajectory of obstacles for collision detection and avoidance planning.

Keywords:

UAV, Collision avoidance, Dynamic, Obstacle detection, Obstacle avoidance, Precision Agriculture

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List of Abbreviations

Abbreviation	Description
WSN	wireless sensor network
OA	Obstacle avoidance
IMU	Inertial Measuring Unit
IR	Infrared
LiDAR	Light Detection and Ranging
Radar	Radio detection and ranging
Sonar	Sound navigation and ranging
FOV	Field of view
MM	Millimeter
APF	Artificial Potential-field Methods
SITL	Software in the loop
BB	Bounding box
PCL	Point Cloud Library
FCU	Flight Controller Unit