EXTENDED KALMAN FILTER AND STEREOSCOPIC VISION BASED AUTONOMOUS FLYING SYSTEM FOR QUADCOPTERS

Amila Sandaruwan Somasiri

(149364C)

Degree of Master of Science

Department of Electrical Engineering

University of Moratuwa
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Jahapu Appuhamilage Amila Sandaruwan Somasiri

(149364C)

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DECLARATION OF THE CANDIDATE & SUPERVISORS

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J.A.A.S Somasiri Date

The above candidate has carried out research for the Masters Dissertation under our supervision.

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Dr. D.P. Chandima Date

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Dr. A.G.B.P Jayasekara Date

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Abstract

This thesis can be divided into two main modules. First module is implementation of an Extended Kalman filter and introduce into existing flight control algorithm which is used to control multi-rotor unmanned vehicles. Purpose of this implementation is to improve flight performance and reliability of the system. Second module is implementation of an obstacle avoidance system based on stereo vision and fuzzy logic for same flight control algorithm to avoid crashes and avoid obstacles during navigation. In this thesis Chapter 1 introduce basic modules of this implementations and explain about flight control algorithm and its major components which is used in here. This chapter also explains the theory behind the Extended Kalman Filters, stereo vision systems and fuzzy logic. Chapter 2 described literature survey about existing implementation of Extended Kalman filters on multi-rotor platforms, stereo vision system implementations and related obstacle avoidance implementations like artificial potential field and fuzzy logic. First section of chapter 3 focused into implementation details and experimenting results of Extended Kalman filter and also explained how Extended Kalman filter outputs are combined to Attitude and Position controllers of flight control algorithm. Second section of chapter 3 focused into implementation and experimenting results of the stereo vision system. This section explained detail implementation of stereo vision system like stereo camera calibration, image rectification, disparity map generation and depth calculation. Mainly OpenCV was used in this implementation. Third section of chapter 3 focused into explained implementation of fuzzy decision-making system. In here described deciding of fuzzy inputs and outputs using depth image, creation of fuzzy inference system, selection of membership functions and combined fuzzy decision-making system with flight control algorithm. Flight testing and experimental results of Extended Kalman filter and obstacle avoidance system were described in chapter 4, both systems were tested on outdoor environments and improvement of the performance and reliability was discussed in this chapter. Chapter 5 is the final chapter of this thesis and it includes conclusion of the thesis, recommendations and further works.

Keywords: Quadcopters, Kalman Filters, Obstacle Avoidance, Stereo Vision, Fuzzy Logic.

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LIST OF ABBREVIATIONS

Abbreviation	Description
BM	Block matching
CPU	Central processing unit
EKF	Extended Kalman Filter
ESC	Electronic speed control
FIS	Fuzzy Inference system
GCS	Ground control station
GPU	Graphical processing unit
GPS	Global Positioning system
GUI	Graphical user interface
HAL	Hardware Abstraction Layer
MEMS	Microelectromechanical systems
NCC	Normalized cross correlation
OpenCV	Open source Computer Vision
PWM	Pulse Width Modulation
RTOS	Real-time operating system
SGBM	Semi-Global block matching
SAD	Sum of absolute difference
SSD	Sum of square difference
UAV	Unmanned Aerial Vehicle
UDP	User Datagram Protocol
USB	Universal Serial Bus

LIST OF APPENDICES

Note: Appendices are available on the provided compact disk (CD).