

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

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Degree of Master of Science

Department of Electrical Engineering

University of Moratuwa
Sri Lanka

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Dissertation submitted in partial fulfilment of the requirements for the
degree Master of Science in Industrial Automation

Department of Electrical Engineering

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DECLARATION OF THE CANDIDATE & SUPERVISORS

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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.

TABLE OF CONTENTS

DECLARATION OF THE CANDIDATE & SUPERVISORS	i
ACKNOWLEDGMENTS	ii
Abstract	iii
TABLE OF CONTENTS	iv
LIST OF FIGURES	vi
LIST OF ABBREVIATIONS	ix
LIST OF APPENDICES	x
1 INTRODUCTION	1
1.1 Flight control algorithm	2
1.1.1 Hardware Abstraction Layer	2
1.1.2 State estimation	3
1.1.3 Attitude control & Position control	3
1.1.4 Communication protocol	3
1.1.5 Key features of the flight control algorithm	5
1.2 Kalman filter	6
1.2.1 Extended Kalman filter	7
1.3 Stereoscopic Vision	8
1.3.1 Camera calibration	8
1.3.2 Image rectification	10
1.3.3 Disparity	11
1.3.4 Pixel correlation (Block matching)	12
1.3.5 Disparity calculation (Stereo correspondence) algorithms	12
1.3.6 Depth calculation	14
1.3.7 Fundamental problems in stereo correspondence	15
1.4 Fuzzy Logic	16
1.4.1 Membership functions	16
1.4.2 Fuzzy inference system	16
2 LITERATURE REVIEW	17
2.1 Related quadcopter states estimator implementations	17
2.2 Related stereo vision implementations	17
2.3 Related obstacle avoidance implementations	18
3 METHODOLOGY	19
3.1 Development of the Extended Kalman filter	19
3.1.1 Inputs and outputs of the filter	19

3.1.2	Extended Kalman filter equations	20
3.1.3	Hardware selection and assembling of the Quadcopter	25
3.1.4	Experimental results of the filter	29
3.1.5	Introduce Extended Kalman filter outputs to flight control algorithm	34
3.2	Development of the stereo vision system	36
3.2.1	Selection of the stereo camera	36
3.2.2	Stereo camera calibration	38
3.2.3	Image rectification	40
3.2.4	Disparity calculation	40
3.2.5	Manual calibration of the depth image	44
3.2.6	Testing of stereo vision system on outdoor environment	45
3.3	Development of the fuzzy decision-making system	47
3.3.1	Analyzing the Depth Image	47
3.3.2	Calculation of size of sub regions	47
3.3.3	Calculation of normalize depth values of sub regions	49
3.3.4	Determination of fuzzy inputs and outputs	49
3.3.5	Determination of fuzzy rules	50
3.3.6	Selection of input and output membership functions	52
3.3.7	Selection of defuzzification method	53
3.3.8	Introduce fuzzy inference system output to flight control algorithm	54
3.3.9	Testing of the fuzzy system on outdoor environment	55
4	EXPERIMENTAL RESULTS AND ANALYSIS	58
4.1	Flight test and result analyzing of Extended Kalman filter	58
4.1.1	Hardware setup	58
4.1.2	Experimental procedure	58
4.1.3	Results	59
4.1.4	Position controller error variation with Extended Kalman filter	64
4.1.5	Problems encountered during flight tests	67
4.2	Flight tests and results analyzing of obstacle avoidance system	68
4.2.1	Hardware setup	68
4.2.2	Experimental procedure	68
4.2.3	Results	69
4.2.4	Problems encountered during flight tests	70
5	CONCLUSIONS	71
6	RECOMMENDATIONS AND FURTHER WORKS	72
	REFERENCES	74
	APPENDICES	76

LIST OF FIGURES

Figure 1.1 Basic components of simple Multi-copter	4
Figure 1.2 MAVLink communication protocol block diagram	4
Figure 1.3 Graphical user interface use to communicate with quadcopter	5
Figure 1.4 Radial distortion	8
Figure 1.5 Tangential distortion	9
Figure 1.6 Rectification of a stereo pair.	10
Figure 1.7 The Tsukuba stereo image pair:	11
Figure 1.8 Relationship between depth of a point and disparity of same point	15
Figure 1.9 Block diagram of a fuzzy inference system.	16
Figure 3.1 Navio2 flight shield connected with Raspberrypi 3 computer board.	26
Figure 3.2 Selected 850KV brushless dc motor and 20Amp ESC	26
Figure 3.3 Selected transmitter and receiver	27
Figure 3.4 Selected Radio telemetry	27
Figure 3.5 Selected lithium-polymer battery	28
Figure 3.6 Actual hardware set-up of the system	28
Figure 3.7 Connections of the hardware components	29
Figure 3.8 GPS position vs EKF position for Latitude direction	30
Figure 3.9 Zoom version of Figure 3.8	30
Figure 3.10 GPS position vs EKF position for Longitude direction	31
Figure 3.11 Zoom version of Figure 3.10	31
Figure 3.12 GPS velocity vs EKF velocity for Latitude direction	32
Figure 3.13 GPS velocity vs EKF velocity for Longitude direction	32
Figure 3.14 Barometer height vs EKF height	33
Figure 3.15 Barometer climb rate vs EKF climb rate	34
Figure 3.16 Attitude control of quadcopter	35
Figure 3.17 Position control of quadcopter	35
Figure 3.18 Normal USB web camera.	36
Figure 3.19 Stereo camera build using two normal USB web camera	36
Figure 3.20 ZED stereo camera with Nvidia Jetson TX1 computing platform.	38
Figure 3.21 Stereo calibration using a 7×10 chessboard pattern	39

Figure 3.22 Raw images (Top) Rectified images (Bottom)	40
Figure 3.23 User interface for block matching algorithm	42
Figure 3.24 Effect of changing number of disparities.	42
Figure 3.25 Disparity maps for different SAD window sizes	43
Figure 3.26 Input raw images and corresponding depth map	44
Figure 3.27 Moment of manual calibration of depth image	45
Figure 3.28 Quality of the depth image in different scenarios	46
Figure 3.29 Depth map's division in nine windows.	47
Figure 3.30 Visible image plane of the stereo camera	48
Figure 3.31 Dimension of each sub regions	49
Figure 3.32 Navigation direction deciding based on depth image.	50
Figure 3.33 Input membership function of desired velocity input (V_{in}).	52
Figure 3.34 Input membership function of normalize depth value of one region (D_{lu})	52
Figure 3.35 Output membership functions of V_x, V_z	53
Figure 3.36 Output membership function of V_y	53
Figure 3.37 Fuzzy inference system	53
Figure 3.38 Combination of stereo vision system, fuzzy inference system with flight control algorithm	54
Figure 3.39 Code architecture runs on Nvidia Jetson TX1	55
Figure 3.40 Outdoor testing of fuzzy decision-making system.	56
Figure 3.41 Variation of depth values of fuzzy decision-making system.	56
Figure 3.42 Variation of velocities of fuzzy decision-making system.	57
Figure 4.1 Final assembled quadcopter	58
Figure 4.2 Quadcopter flying on open field	59
Figure 4.3 Barometer measured height vs EKF estimated height	60
Figure 4.4 Barometer measured climb rate vs EKF estimated climb rate	60
Figure 4.5 GPS measured Latitude position vs EKF estimated Latitude position	61
Figure 4.6 GPS measured Longitude position vs EKF estimated	62
Figure 4.7 Zoom version of GPS measured Longitude position vs EKF estimated Longitude position between data point 6600 and 67000	62
Figure 4.8 GPS measured Latitude velocity vs EKF estimated Latitude velocity	63

Figure 4.9 GPS measured Longitude velocity vs EKF estimated	63
Figure 4.10 Actual height variation vs desired height variation	64
Figure 4.11 Height error variation	65
Figure 4.12 Actual position variation vs desired position variation in	65
Figure 4.13 Position error variation in Latitude direction	66
Figure 4.14 Actual position variation vs desired position variation in Longitude direction	66
Figure 4.15 Position error variation in Longitude direction	67
Figure 4.16 Overall hardware setup including stereo camera.	68
Figure 4.17 Quadcopter fly over tree	69
Figure 4.18 Quadcopter fly to a wall.	70

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

Appendix	Description
Appendix - A	MATLAB Symbolic Implementation of Extended Kalman Filter.
Appendix - B	C++ Implementation of Extended Kalman Filter.
Appendix - C	C++ Implementation of Stereo Vision System.
Appendix - D	C++ Implementation of Fuzzy Decision-making System.
Appendix - E	Extended Kalman filter ground test data.
Appendix - F	Extended Kalman filter flight test data.
Appendix - G	Obstacle avoidance system ground test data.
Appendix - H	Video evidence of system test.

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