



**UNIVERSITI PUTRA MALAYSIA**

**NUMERICAL STUDY ON ATTITUDE AND ALTITUDE CONTROL  
OF MULTI-ROTOR ROTORCRAFTS**

**LIM ANN**

**FK 2012 85**

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ALTITUDE CONTROL OF MULTI-ROTOR  
ROTORCRAFTS**

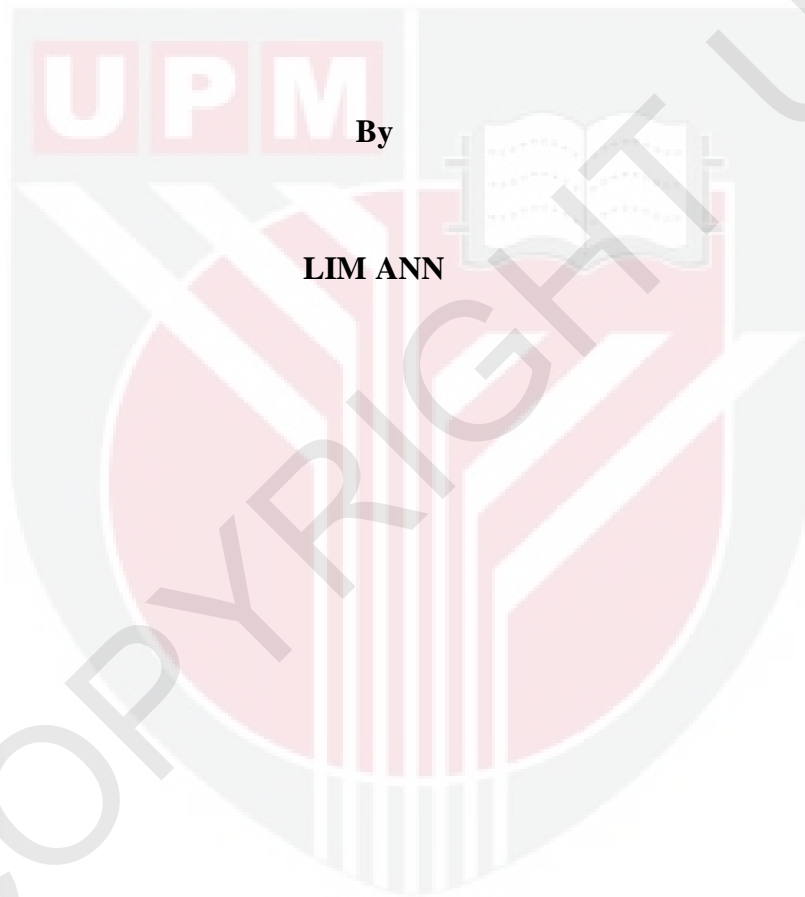
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**MASTER OF SCIENCE**

**UNIVERSITI PUTRA MALAYSIA**

**2012**

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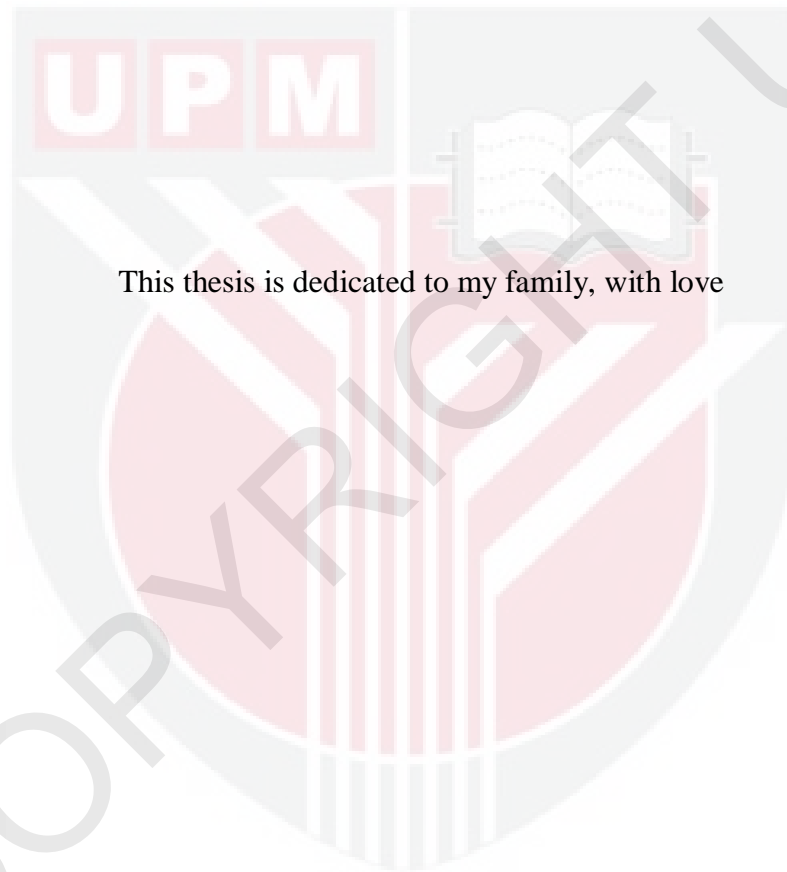


**By**

**LIM ANN**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in  
Fulfilment of the Requirements for the Degree of Master of Science**

**February 2012**



This thesis is dedicated to my family, with love

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Abstract of this thesis presented to the Senate of University Putra Malaysia as partial fulfillment of the requirement for the degree of Master of Science.

**NUMERICAL STUDY ON ATTITUDE AND ALTITUDE CONTROL OF  
MULTI-ROTOR ROTORCRAFTS**

**BY**

**LIM ANN**

**February 2012**

**Chairman: Abdul Aziz Bin Jaafar, Phd**

**Faculty: Engineering**

UAV is an acronym for Unmanned Aerial Vehicle, which is an aircraft with no pilot on board. UAVs can be remote controlled by a pilot at a ground control station, or it can fly autonomously based on pre-programmed flight plans or more complex dynamic automation systems. UAVs are widely used for a number of missions, including reconnaissance and attack roles. Motivation that drives UAVs research is due to its usefulness in many industries, such as agriculture, telecommunications, and military and also to overcome major challenges faced by designer especially in aspect of design and control strategy.

The research carried out in this thesis is to design quadrotor and trirotor prototype for flight behavior study. The main mission profile for the rotorcrafts is to stabilize at certain altitude and attitude. There are two specific objectives for this study, first is to

develop simulations which including dynamic for quadrotor and trirotor systems with given parameters; second is to stabilize the systems by applying controller on each subsystem and tune it to meet stability requirements. Stability is evaluated in aspect of rise time, settling time, overshoot and steady-state error.

The previous works of other researchers in multirotor rotorcraft are studied. Quadrotor and trirotor designed by other researchers are used as reference for developing simulation using Matlab Simulink. Control techniques are penetrated intensely for their applications, advantages and weakness. Equations of motion, actuator dynamics and controller equations are figured out and modified reasonably.

Controller tuning are carried out to obtain optimum gain which can compensate system error and perform multiple task action. Controller gain is then manipulated to examine behavior of the system. Comparisons with other researchers work are presented. Weaknesses of systems are identified and some suggestions are proposed to improve the system.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia  
sebagai memenuhi sebahagian keperluan untuk Ijazah Master Sains.

**KAJIAN BERANGKA KAWALAN ORIENTASI DAN KETINGGIAN  
UNTUK PESAWAT ROTOR YANG BERBILANG ROTOR**

Oleh

LIM ANN

Februari 2012

**Pengerusi: Abdul Aziz Bin Jaafar, Phd**

**Fakulti: Kejuruteraan**

UAV adalah pesawat udara yang tiada juruterbang di atas kapal. UAV boleh dikawal oleh juruterbang di stesen bumi, atau diterbangkan secara autonomi berdasarkan pelan penerbangan, atau dikawal dengan sistem autonomasi yang dinamik lebih kompleks. UAV digunakan secara meluas untuk beberapa misi, termasuk peranan tinjauan dan serangan. Motivasi yang mendorong UAV penyelidikan adalah disebabkan kegunaannya dalam banyak industri, seperti pertanian, telekomunikasi, dan tentera dan juga untuk mengatasi cabaran-cabaran utama yang dihadapi oleh pereka terutama dalam aspek reka bentuk dan strategi kawalan.

Penyelidikan yang dijalankan dalam tesis ini adalah untuk membina prototaip quadrotor dan trirotor untuk kajian kelakuan penerbangan. Profil misi utama untuk pesawat berbilang rotor tersebut adalah untuk mencapai kestabilan pada ketinggian

tertentu dan orientasi .Terdapat dua objektif khusus bagi kajian ini, pertama ialah untuk membangunkan simulasi untuk dinamik quadrotor dan trirotor dengan parameter yang diberikan; kedua ialah menstabilkan sistem dengan mengaplikasikan pengawal dalam setiap subsistem dan menalanya untuk memenuhi keperluan kestabilan. Kestabilan sistem dinilai dalam aspek masa peningkatan, masa menetap, keterlanjakan dan ralat dalam keadaan mantap.

Kerja-kerja penyelidik lain dalam bidang pesawat rotor berbilang rotor dikaji. Quadrotor dan trirotor direka oleh penyelidik lain telah digunakan sebagai rujukan bagi membangunkan simulasi dengan menggunakan Matlab Simulink. Teknik kawalan dikaji dalam aspek aplikasi, kebaikan dan kelemahan. Persamaan gerakan, dinamik penggerak dan persamaan pengawal dicapai dan diubahsuai dengan munasabah. Penalaan pengawal dijalankan untuk mendapatkan pemalar yang optimum yang boleh membaiki ralat sistem dan melaksanakan beberapa tugas. Pemalar Pengawal kemudiannya dimanipulasikan untuk mengkaji ciri-ciri sistem. Perbandingan dengan kerja penyelidik lain dibentangkan. Kelemahan sistem dikenal pasti dan beberapa cadangan dikemukakan untuk memperbaiki sistem.



## ACKNOWLEDGEMENTS

First and foremost, I would like to express my deepest thanks and appreciation to my supervisor, Dr. Abdul Aziz Jaafar, and co-supervisor Dr. Fairuz Izzuddin Romli for their advise, guidance and encouragement throughout my thesis writing. They help me greatly by giving suggestion for my experiment method and offering insightful comments, which make this thesis a reality.

I would like to thank Mr. Azizul and Mr Lee J.S. from Aerospace Engineering who have helped me to prepare the apparatus for my thesis experiment. I am appreciate for their patience on describe the function and using method of the apparatus. They also give me some useful advises on the experiment method.

Besides, I would like to express my heartfelt thanks to my dearest family for their constant support, love and encouragement throughout my study period. I thank in particular my dear soul mate, Mr. Dan J.X., who share my burden constantly and continuously give encouragement and full support to me in completing my study and thesis.

Once again, I would like to thank for all UPM staff, their cooperation and services that contribute to success in this thesis. Last but not least, I am sincerely appreciate for who have ever given help, advise, guiding and support to me.

I certify that a Thesis Examination Committee has met on 28th February 2012 to conduct the final examination of Lim Ann on his thesis entitled “Numerical Study on Attitude and Altitude Control of Multi-rotor Rotorcraft” in accordance with the Universities and University College Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The committee recommends that the student be awarded the degree of Master of Science.

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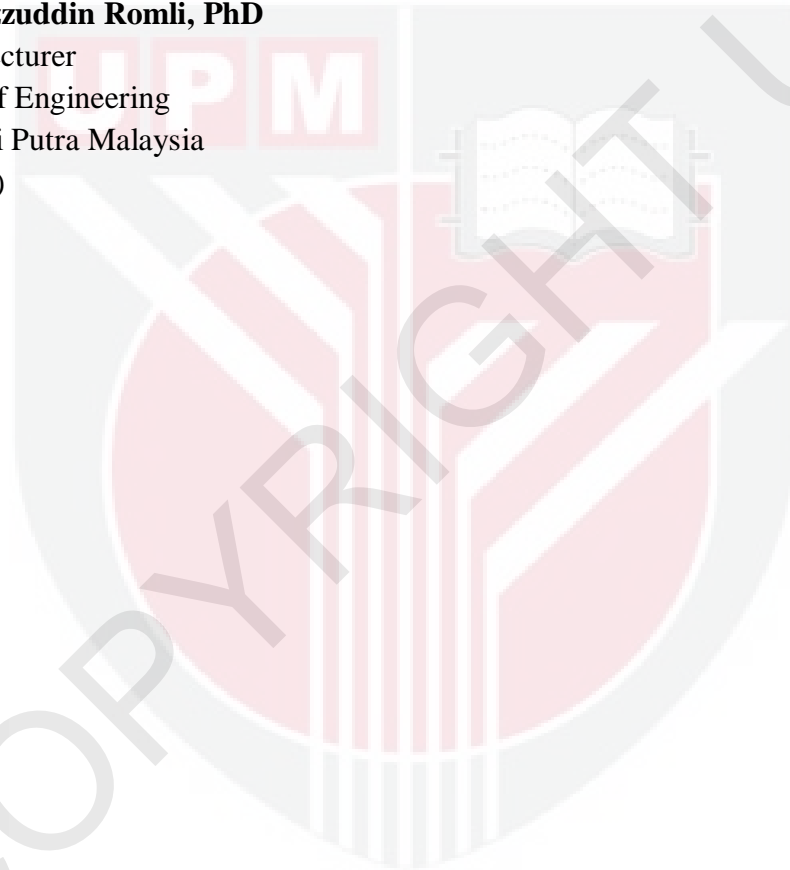
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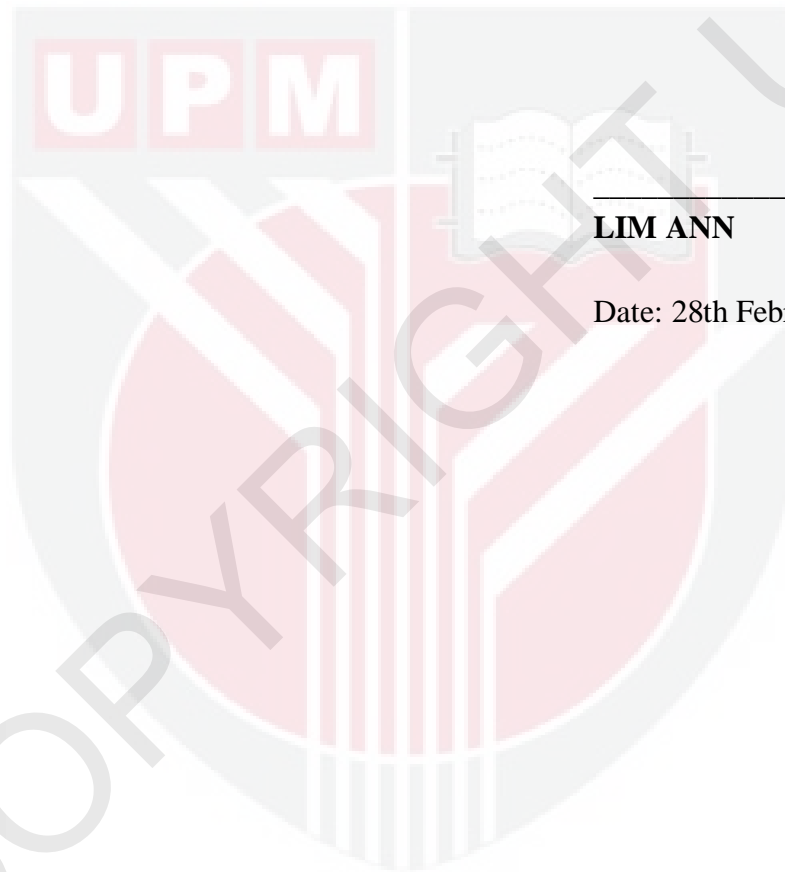
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## DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously and is not concurrently, submitted for any other degree at University Putra Malaysia or at any other institution.



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**LIM ANN**

Date: 28th February 2012

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