

UNIVERSITI TEKNOLOGI MARA

**SLIDING MODE CONTROL DESIGN
USING LINEAR MATRIX
INEQUALITY FOR
UNMANNED AERIAL VEHICLE**

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ABSTRACT

Unmanned aerial vehicles (UAVs) have gotten a lot of attention over the last few decades. The use of Unmanned Aerial Vehicles (UAVs) has continued to increase. UAVs are now used for more than just military purposes, with applications ranging from crop surveys and harvesting to tourism. Nonetheless, dealing with the UAVs complex, highly nonlinear dynamics is challenging and difficult. This study focuses on a type of UAV known as a "quadrotor". It has six Degrees of Freedom (DOF) but only four actuators. Due to this, quadrotor is highly nonlinear, multivariable system which is very difficult to control due to the nonlinear coupling between the actuators and the degrees of freedom. Thus, it is crucial to have a suitable and effective control system in order to operate the quadrotor system effectively. The performance of any quadrotor flight experiment is determined primarily by the feedback control scheme used, and the most important components of this feedback system is the controller design. Many control approaches, including proportional-integral-derivative control, backstepping control, and fuzzy control schemes, have been found in the literature. However, these control approaches have a lot of drawbacks, including high computation, a large amount of training data, approximation error, and the presence of uncertainty. These drawbacks affect the quadrotor system performances. To address these issues, a Sliding Mode Control (SMC) with Linear Matrix Inequality (LMI) method is proposed in this study. In the proposed method, LMI will be used to derive sufficient conditions for the existence of a linear sliding surface. The nonlinear differential equations of quadrotor dynamics are first transformed into state-space representations, and the final equation of forces and torques from a single rotor is derived. The presented model is a detailed model, which includes aerodynamic effects and rotor dynamics that are omitted in many literatures. Afterward, three different control approaches to control the altitude, attitude, heading, and position of the quadrotor in space are developed. The first approach is based on the nonlinear Sliding Mode Controller (SMC) with Pole Placement method. The second control approach is based on the Full State Feedback Controller. The third developed controller is a nonlinear Sliding Mode Controller with Linear Matrix Inequality (LMI) method. Simulation based experiments were conducted to evaluate and compare the performance of the three developed control techniques in terms of dynamic performance, stability and the effect of possible disturbances. The simulation works were performed using MATLAB/SIMULINK software. Numerical simulations show the effectiveness of the developed quadrotor solutions. The results demonstrate that the proposed quadrotor control scheme is effective; not only it has good robustness, with almost no chattering and fast-tracking dynamic performance, but it also has the ability to maintain stability in the presence of external disturbances and parameter uncertainties.

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TABLE OF CONTENTS

	Page
CONFIRMATION BY PANEL OF EXAMINERS	i
AUTHOR’S DECLARATION	ii
ABSTRACT	iii
ACKNOWLEDGEMENT	iv
TABLE OF CONTENTS	v
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF SYMBOLS	xiv
LIST OF ABBREVIATIONS	xviii
CHAPTER ONE INTRODUCTION	1
1.1. Research Background	1
1.2. Problem Statement	3
1.3. Research Objectives	5
1.4. Scope of Research	5
1.5. Contributions of the Research Works	6
1.6. Thesis Layout	7
CHAPTER TWO LITERATURE REVIEW	9
2.1 Unmanned Aerial Vehicle (UAV)	9
2.1.1 History of Unmanned Aerial Vehicle (UAV)	10
2.1.2 The First Practical Flight	11
2.1.3 History of Quadrotors	13
2.1.4 Quadrotor Application	17
2.1.5 Advantages of Quadrotor System	20
2.1.6 Disadvantages of Quadrotor System	22
2.2 Variable Structure Systems	22

2.3	An Overview of Sliding Mode Control	24
2.3.1	Linear Control Law	30
2.3.2	Reachability of the Sliding Surface	32
2.3.3	Properties of Sliding Mode Control	35
2.4	Design of The Sliding Mode Controller	35
2.4.1	The Regulation Case in the Discrete-Time Approach	38
2.4.2	The Regulation Case in the Continuous-Time Approach	39
2.4.3	The Tracking Case	40
2.5	Other Control Techniques of a Quadrotor	41
2.5.1	Proportional-Integral-Derivative (PID) Controller	41
2.5.2	Backstepping Controller	43
2.5.3	Fuzzy Logic Controller	46
2.6	An Overview of Linear Matrix Inequality (LMI)	48
2.6.1	LMI in Control Theory	49
2.6.2	Linear Matrix Inequalities	50
2.7	Evaluation of Existing Quadrotor Control Methods	56
2.7.1	Proportional-Integral-Derivative (PID)	57
2.7.2	Backstepping Algorithm	57
2.7.3	Fuzzy Logic Control	58
2.7.4	Summary	60
CHAPTER THREE RESEARCH METHODOLOGY		62
3.1	Introduction	62
3.2	Quadrotor System Modelling	63
3.2.1	Group of Elements in Quadrotor System	64
3.2.2	Arms	66
3.2.3	Power Distribution Board	66
3.2.4	Skids	67
3.2.5	Kinematic Model	69
3.2.6	Dynamics Model	72
3.2.7	Translational Equations of Motion	77
3.2.8	Aerodynamic Effects	78