# - Introduction

## Unmanned Aerial Vehicles (UAVs)

## The Miniature Quad-rotor Unmanned Aerial Vehicle

## Anatomy of the Quad-rotor Helicopter

### Frame

### Landing Gear

### Motors and Propellers

### Battery

### Sensors

### Flight Control Board

### Transmitter and Receiver

## Basic concepts of the quad-rotor helicopter

### Throttle

### Roll

### Pitch

### Yaw

## Applications of Miniature Quad-rotor Helicopters

### Border Patrol

### Disaster Management/ Search and Rescue

### Wild fire detection

### Photography

### Military and Law enforcement

### Research

### Agricultural and Industrial applications

## Chapter Summary

# - Literature Review

## Previous works on the quad-rotor helicopter

## The basic concepts of Artificial Neural Networks

### Applications of Artificial Neural Networks in Aircraft Control

## The basics concepts of PID controller

### Applications of PID controller

## Aim and Objectives of the research project

## Control Tuning Technique

### Ziegler Nicolas method

### Trial and error

## Contributions of this work (to be finalised)

## Thesis layout

## Chapter Summary

# - Working Principles and Analytical Dynamic Model of Quad-copter

## The Newton-Euler model

### Coordinate Frames

### Quad-rotor Modelling Assumptions

### Quad-rotor Helicopter State Variable definition

### Direction Cosine Matrix

### Quad-rotor Kinematics

### Quad-rotor Dynamics

### Quad-rotor Aerodynamic Forces

### Quad-rotor Moments (Torques)

### Quad-rotor Moments of Inertia

### Equations of Motion

## Actuator Dynamics (DC-motor)

### Voltage and Angular Velocity of Propeller

### Voltage and Thrust

### Rolling Moment

### Pitching Moment

### Yawing Moment

### Acceleration along the x-axis

### Acceleration along the y-axis

### Acceleration along z-axis

## Chapter Summary

# - Simulation of Quadcopter Model in Matlab/Simulink and 3D animation

## Matlab/Simulink Software

## Model Implementation in Matlab/Simulink

### Summary of equations of motion

### Actuator Subsystem

### Roll Subsystem

### Pitch Subsystem

### Yaw Subsystem

### X-Motion Subsystem

### Y-Motion Subsystem

### Z-Motion Subsystem

## Running the Simulation

### Calibration and Preliminary Calculations

### Hover

### Throttle (Vertical Motion)

### Roll

### Pitch

### Yaw

## 3D animations (in progress)

### 3D Quadcopter model

### Euler rotation

### Quaternion

### Animation Results

## Chapter Summary

# - Publications

1. *Abdelkader Fareha; Amar Bousbaine; Ajay K. Josaph* “An Integration of 6DOF Quadcopter MATLAB/Simulink Controller Algorithm onto a PIXHAWK Autopilot”, The 10th International Conference on Power Electronics, Machines and Drives, PEMD, 15 - 17 December 2020 | Online Conference.
2. Emmanuel Okyere1, Amar Bousbaine, Gwangtim T. Poyi, Ajay K. Joseph, Jose M. Andrade*,” LQR controller design for quad-rotor helicopters” The Journal of Engineering,* ISSN 2051-3305, doi: 10.1049/joe.2018.8126 , pp4003-4007, 17th June 2019.
3. Bousbaine, A. Bamgbose, G.T. Poyi and A. K. Joseph "Design of Self-tuning PID Controller Parameters Using Fuzzy Logic Controller for Quad-rotor Helicopter" Published in International Journal of Trend in Research and Development (IJTRD), ISSN: 2394-9333, Vol. 3, Issue-6 , December 2016.
4. *Ajay K Joseph; Amar Bousbaine; Abdelkader Fareha, “A Wireless communication system for a quadrotor helicopter”, 2018 53rd International Universities Power Engineering Conference (UPEC),* 4-7 Sept.  *2018, Glasgow* **DOI:**[10.1109/UPEC.2018.8542040](https://doi.org/10.1109/UPEC.2018.8542040).
5. *Abdelkader Fareha; Amar Bousbaine; Ajay K. Josaph, “ Experimental Characterisation of quad rotor controller based on Kalman Filter”, 53rd International Universities Power Engineering Conference (UPEC),* 4-7 Sept. 2018, Glasgow, **DOI:**[10.1109/UPEC.2018.8541858](https://doi.org/10.1109/UPEC.2018.8541858).

# Work to be completed

Ø  Abstract

Ø  Table of content

Ø  List of figures

Ø  List of tables

Ø  Nomenclature

# – Controller Design Methodology (Kalman Filter and PID) (A rough content of the chapter)

## Linearization and State Space Representation for system

### Vertical system

### Directional

### Latitudinal

### Longitudinal

### Controllability and Observability of the systems

## Flight control Algorithm

### Control Technique

## Kalman Filter Algorithm

### Altitude

### Directional

### Latitudinal

### Longitudinal

## Experimental Identification of the physical Parameters

### Moment of Inertia – Bifilar pendulum

### Motor Torque – Load cell

### Parameters’ extraction procedure

### Parameters extraction

## Software implementation and Simulation Results

### Model Implementation

### Pre-existing Model

### Flight controller modelling

### Kalman filter modelling

#### Trajectory generator model

#### Noise Generator

#### Quadcopter Mixer

#### PWM Scaling

### Simulation Results

## Summary

# - Sensor Fusion and Wireless Communication Systems

## Different types of Sensors and Communication systems

### Sensors

#### Ultrasonic

#### IMU

#### Camera

### Communication Systems

#### UART

#### I2C

#### Bluetooth (HC-05)

#### TCP/UDP

## Arduino (incorporate sensors)

### Bluetooth (HC-05)

### Ultrasonic modules

### IMU 6050

### I2C programming

### UART communication

### CRC for error correction

### Result of sensor fusion

## Raspberry Pi 3 (RPI 3)

### Ultrasonic sensors

### I2C in RPI

### UART in RPI

### UDP Protocol

### Camera module

### Results of sensor fusion

# - Conclusions and further work

# - Two papers