CHAPTER ONE
Introduction

1.1 Overview

The rising of human demand for machines capable of doing his work autonomously and precisely in most of his modern life's needs, manufacturing, aviation, military and transportation ...etc. has inspired scientists and engineers to develop autonomous control systems. Autonomous control has become a fascinating field for its endless applications which work in difficult areas that need a very precise and careful control scenario.[1]

One of the promising applications of the autonomous control systems is the quadcopter. The quadcopter is a multi-rotor helicopter that is lifted and propelled by four rotors. It represents an excellent platform for the autonomous control because it is a small, agile and maneuverable robot.

Quadcopter unmanned aerial vehicles are used in many civilian and military applications. They are considered as the best solution for intelligence, surveillance and reconnaissance by military and law enforcement agencies, as well as their use in suicidal missions. In addition they have lots of civilian applications such as search and rescue missions, precision agriculture/remote farming, inspection and transportation. [2]

The development of electronics has changed the simple (RC) aircraft into an intelligent automated drone, with Global Positioning System (GPS) enabling up-to-date location information. Furthermore, the advent of radio and video camera technologies has made live video streams possible in drones. Combining these technologies enables controlling the drone even Beyond Visual Line Of Sight (BVLOS), which facilitates breaking the range restriction of the old radio schemes. Obviously, one option is the 4th generation cellular network standard, Long Term Evolution (LTE) which has a low latency and high bit rate. The most versatile RC aircraft type nowadays is the multicopter. It is stable and easy to control, and allows a high payload for cameras and extra equipment. Furthermore, multicopters are getting more popular as hobby toys and in professional use. Thus, a multicopter is a natural choice as the research platform for this thesis.

1.2 Problem Statement

There are many limitations in the current method of controlling the quadcopter manually by human using radio controller (RC). RC has a limited range which makes it impossible to control the quadcopter out of that range.

1.3 Proposed Solution

Change the simple RC aircraft into an intelligent automated drone, with Global Positioning System (GPS) enabling up-to-date location information. Furthermore, the advent of radio and video camera technologies has made live video streams possible in drones. Combining these technologies enables controlling the drone even Beyond Visual Line Of Sight (BVLOS), which facilitates breaking the range restriction of the old radio schemes. Obviously, one option is the 4th generation cellular network standard, Long Term Evolution (LTE) which has a low latency and high bit rate.

1.4 Methodology

Several Steps towards Finalizing Research

1.4.1 Quadcopter Dynamic

The quadcopter consists of four motors that are mounted at the end of two perpendicular axes. Rotors at opposite ends of an arm turn in the same direction while motors on a perpendicular axis rotate in the opposite direction. When all four motors are spinning at the same speed, the motors create thrust that lifts the quadcopter into the air. As there are pairs of rotors spinning in opposite directions, the torque produced in each direction around the yaw axis cancels out and the yaw angle remains constant.[2]

1.4.2 The Control Architecture

- Perception and Data Fusion:

There are different sensors used to give the quadcopter information about the environment. The first one is IMU motion sensors; their readings are integrated (fused) by Kalman filter to measure the orientation of the drone in form of three angles (yaw, Roll and Pitch). The second one is the GPS sensor which is used to

localize the position of the robot in outdoor environments. The last one is the ranging sensors which are used to measure distances from the drone to the nearby objects. [3]

- Localization:

. It uses sensors' measurements to correct the position of the drone. This is accomplished by extracting features from the environment and re-observing them while the drone is exploring the environment. [3]

- Motion Planning:

Motion planning breaks down a desired movement task (goal state) into discrete motions that satisfy movement. Motion planning first calculates the direction to goal. After that it checks whether this direction is clean from potential collision or not; if it is clean then it sends this direction to the motion controller to drive the quadcopter toward that direction, but if it is not the motion planning finds an alternative path that drives the quadcopter away from collision. [3]

- Motion Control:

The motion control calculates a suitable motion to follow every sub-goal. Then sends these calculations to the Electronic Speed Controller (ESC) of each motor as PWM signal to alter the speed of the motors in a way making it perform the required motion. [3]

- On-board Computer:

Raspberry Pi 3 is used as the on-board computer; connected to USB LTE dongle that will be used to receive the goal state. Python is considered as the main programming language in the project.

1.5 Aim

The main aim of this project is to design quadcopter that can be controlled over internet in unlimited range.

1.6 Objectives

- Determine if it is possible to use LTE as the connection for the control scheme. At this point, the LTE controllable drones seem to still be non-existent on the market.
- Providing it is possible to establish the LTE connection, will be evaluating if the LTE channel quality is good enough for controlling a flying drone including low enough latency, jitter and Bit Error Rate.
- The LTE control research determines if the bit rate is high enough to stream a live video from the drone, which is required for flying BVLOS.
- To cover the topics surrounding an LTE controlled multicopter on a higher level.

1.7 Chapter Organization

Chapter One Proposed introduction for project also objective and aims.

Chapter Two Information about drones, such as multicopters, is delivered
By explaining how the terms are defined and what their main properties are.

Chapter Three Show the related work and basic component in project and discuss system design.

Chapter Four Shown the result of simulation work and calibration.

Chapter Five Proposed conclusions and recommendation.