FINAL YEAR PROJECT PROPOSAL

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COMPARATIVE ANALYSIS OF CONTROL ALGORITHMS ON A QUADCOPTER FOR PERFORMANCE EVALUATION

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Comparative Analysis of Control Algorithms on A Quadcopter For Performance Evaluation

Introduction

A Quadcopter is a rotor-based, unmanned aerial vehicle. Quadcopters are becoming increasingly popular because of their small size and high maneuverability and find applications in diverse fields. Some of these applications are:

- Reconnaissance – used to gather military intelligence by scouting enemy territory. Because of their small size and minimal noise generated, they can move undetected.
- Aerial surveillance – road patrol, home security, law and order.
- Used in motion picture film making and photography for aerial shots and views.
- Assistance for search and rescue operations in disaster struck areas or in case of fire.
- Used in automation systems in industries for material handling purposes.
- Delivery of goods and items.
- Used for 3D modelling of terrains or large structures as well as thermal imaging.

Since the number and complexity of applications for such systems grows daily, the control techniques involved must also improve in order to provide better performance and increased versatility.

Historically, simplistic linear control techniques were employed for computational ease and stable hover flight. However, with better modelling techniques and faster on-board computational capabilities, comprehensive nonlinear techniques to be run on real-time have become an achievable goal. Nonlinear methodologies promise to rapidly increase the performances for these systems and make them more robust. This work presents several approaches to the automatic control of a quadrotor.

Related Work

Quadcopter modelling and controlling

A previous project is quadcopter flight mechanics models and control algorithms by Eswarmurthi Gopalakrishnan. This project aims at developing a quadcopter flight mechanics nonlinear model in MATLAB/Simulink and validate a set of basic and advanced control laws for its stabilization and guidance[2].

Another project done is modelling, simulation and complete control of a quadcopter by Abid Sulficar, Harikrishnan Suresh, Aravind Varma, and Arjun Radhakrishnan. It studies the implementation of a linear and nonlinear controller for attitude control of a quadcopter, and performs a comparative study for the controllers while developing a failure detection module to enable switching of controllers in order to ensure stability of the system[2].

Francesco Sabatino's project on Quadrotor control: modeling, nonlinear control design, and simulation focuses several approaches to the automatic control of a quadrotor in which selected linear and nonlinear control methods are designed accordingly to the system dynamics[3].

Also, a project on Quadcopter modelling and control with MATLAB/Simulink implementation by Muhammad Usman which focuses on the design of a Proportional, Integral and Derivative based controller in MATLAB/Simulink to achieve attitude control of the quadcopter[1].

Method and Implementation of Control Algorithms

This section aims to describe the method, software, packages and controllers to be used to design, analyze, and simulate this project work.

MATLAB/Simulink would be used to implement the quadcopter system dynamics, perform analysis of the linear and nonlinear control of the system and design the controllers to be used on the system.

The several control algorithms to be used in this project are:

- Proportional Control (P)
- Proportional-Integral Control (PI)
- Proportional-Differential Control (PD)

- Proportional Integral Differential Control (PID)
- Linear Quadratic Regulator (LQR)

1. Proportional-Integral Control (PI): One combination is the **PI-control**, which lacks the D-control of the PID system. PI control is a form of feedback control. It provides a faster response time than I-only control due to the addition of the proportional action. PI control stops the system from fluctuating, and it is also able to return the system to its set point. Although the response time for PI-control is faster than I-only control, it is still up to 50% slower than P-only control. Therefore, in order to increase response time, PI control is often combined with D-only control.

2. Proportional-Differential Control (PD): Another combination of controls is the PD-control, which lacks the I-control of the PID system. PD-control is combination of feedforward and feedback control, because it operates on both the current process conditions and predicted process conditions. In PD-control, the control output is a linear combination of the error signal and its derivative. PD-control contains the proportional control's damping of the fluctuation and the derivative control's prediction of process error. In this control, the purpose of the D-only control is to predict the error in order to increase stability of the closed loop system. P-D control is not commonly used because of the lack of the integral term. Without the integral term, the error in steady state operation is not minimized. P-D control is usually used in batch pH control loops, where error in steady state operation does not need to be minimized. In this application, the error is related to the actuating signal both through the proportional and derivative term.

3. Proportional-Integral-Differential Control: Proportional-integral-derivative control is a combination of all three types of control methods. PID-control is most commonly used because it combines the advantages of each type of control. This includes a quicker response time because of the P-only control, along with the decreased/zero offset from the combined derivative and integral controllers. This offset was removed by additionally using the I-control. The addition of D-control greatly increases the controller's response when used in combination because it predicts disturbances to the system by measuring the change in error. On the contrary, as mentioned previously, when used individually, it has a slower response time compared to the quicker P-only control. However, although the PID controller seems to be the most adequate controller, it is also the most expensive controller. Therefore, it is not used unless the process requires the accuracy and stability provided by the PID controller.

4. Linear Quadratic Regulator: The Linear Quadratic Regulator (LQR) is a well-known method that provides optimally controlled feedback gains to enable the closed-loop stable and high performance design of systems.

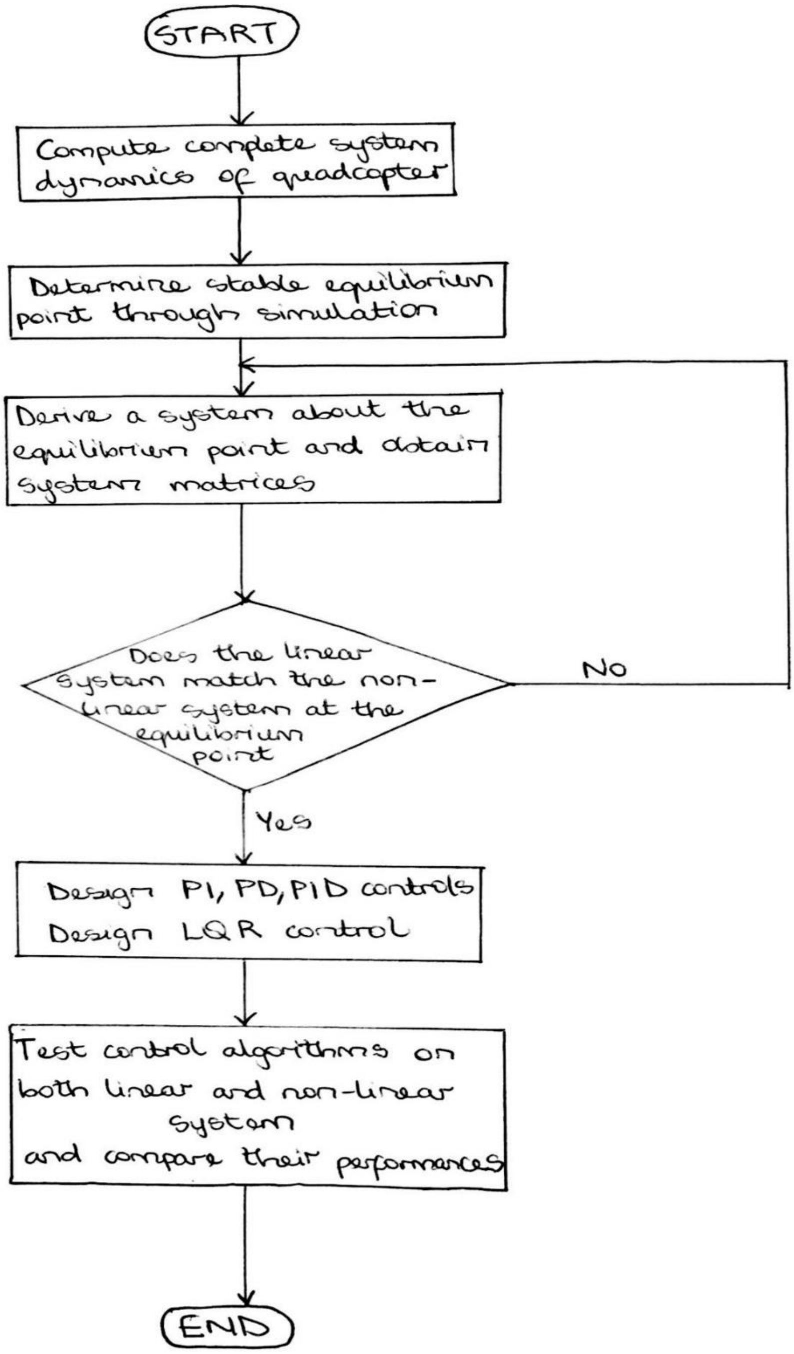

Figure 1: Flowchart of Proposed Project Process

Conclusion

Recent advances in sensor, in microcomputer technology, in control and in aerodynamics theory have made quadcopter applications like small Unmanned Aerial Vehicles (sUAV) a reality. The small size, low cost and maneuverability of these systems have made them potential solutions in a large class of applications.

This project would help to determine the choice of controllers to provide optimum performance.

References

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