Thrust Balance System

Progress Report

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**Abstract**

**Thrust Balance** testbed is one degree of freedom(1-DOF) representation of a real quadrotor(12-DOF) system built for educational and academic purposes. This system can be used in various research fields related to quadrotors and we can test and develop control algorithms on real pseudo-quadrotor dynamic system in safe manners.

The main duty of this system is to provide a cheap and safe testbed for testing various types of fault effects that can’t be injected into a real flying quadrotor due to the uncontrollable nature of this machine. So, we can test fault tolerant control algorithms in this system and then develop them onto a real quadrotor system.

# Theorical Design

## Aero pendulum

The setup consists of a small dc electric motor driven by a 5-V

pulse-width modulated (PWM) signal. The motor is attached to

the free end of a light carbon rod, while the other end of the rod

is connected to the shaft of a low-friction potentiometer. The

potentiometer is ﬁxed on a plastic stand at a height where the

pendulum can swing freely (see Fig. 1). A 2-in propeller (model

U-80) is attached to the motor shaft to produce a thrust force in

order to control the angular position of the pendulum. A self-

calibrating step during the initialization allows the system to

automatically ﬁnd the vertical position (origin of the coordinate

system).

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The setup consists two brushless motors driven by a 12-V pulse-width modulated (PWM) signal that provided by an Arduino UNO through electronic speed controllers. The motors are attached to the free ends of a light carbon rod, while the centre of the rod is connected to the shaft of a low-friction pivot. The pivot is fixed on a plastic stand at a height where the rod can swing from -45 to +45 degrees (see Fig. 1). A propeller attached to each motor shaft to produce a thrust force in order to control the angular position of the pendulum. Angular movement of system is measured by an IMU (inertial movement unit) that connected to Arduino via I2C protocol.

A firmware is designed to link Arduino and computer to provide embedded coding with both MATLAB and ROS. With other ROS nodes we can develop high level control and fault tolerant control algorithms easily and monitor the system behaviour.

## Dynamical modelling

The main focus of dynamical modelling in this system is the dynamics of the pendulum because the dynamics of the electronic components and the dc motor are assumed fast and negligible for the sake of this experiment.

### newton’s second law

 The relationship between torque, moment of inertia and angular acceleration is given by

|  |  |
| --- | --- |
|  | 1-1 |

Where **I** is moment of inertia and **τ** is torque applied to the pivot and equal to

|  |  |
| --- | --- |
|  | 1-1 |

As with the translating systems, friction is the most difficult to model accurately and we will generally only consider viscous friction.  The constitutive equation relating angular velocity, torque and friction coefficient is

|  |  |
| --- | --- |
|  | 1-2 |

Finally, the system’s dynamic equation is

|  |  |
| --- | --- |
|  | 1-3 |

Resulting in a modified model

|  |  |
| --- | --- |
|  | 1-3 |

## System modelling

From last section we have

|  |  |
| --- | --- |
|  | 1-n |

By assuming  is control input we can rewrite the equation

|  |  |
| --- | --- |
|  | 1-n |

Finally, the state space of system is

|  |  |
| --- | --- |
|  | 1-n |

# MATLAB and Simulink simulation

# ROS development

# Actual system