Technische Universität München

Institute of Flight System Dynamics

Design, Implementation and Evaluation of an Incremental Nonlinear Dynamic Inversion Controller for a Nano-Quadrotor

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Entwurf, Implementierung und Evaluierung eines Inkrementellen Nichtlinearen Dynamischen Inversionsreglers für einen Nano-Quadrotor

Semesterarbeit

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April 2020

Statutory Declaration

I, Evghenii Volodscoi, declare on oath towards the Institute of Flight System Dynamics of Technische Universität München, that I have prepared the present Semester Thesis independently and with the aid of nothing but the resources listed in the bibliography.

This thesis has neither as-is nor similarly been submitted to any other university.

Garching,

Kurzfassung

Deutsche Kurzfassung der Arbeit.

Abstract

English abstract of the thesis.

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Table of Acronyms

Acronym	Description
ADF	Automatic Direction Finder
ADI	Automatic Direction Indicator

Table of Symbols

Latin Letters

Symbol	Unit	Description
F	N	Force
g	m/s^2	Gravitational acceleration

Greek Letters

Symbol	Unit	Description
α	rad	Angle of attack
ζ	–	Damping of a linear second order system

Indices

Symbol	Unit	Description
m		Variable related to pitch moment
W		Wind

1 Introduction

1.1 Motivation

1.2 Contribution of the Thesis

1.3 Structure of the Thesis

2 Theoretical Background

2.1 General Equations of Motion

General:
- Linear Momentum
- Angular Momentum
- Attitude differential equations
- Position differential equations
- External forces and moments

with some of the used assumptions

2.2 Nonlinear Dynamic Inversion

- Theory from Sieberling paper.

2.3 Incremental Nonlinear Dynamic Inversion

- Here only the general principle is provided, next subsections show the full derivation of the two controller loops.

2.3.1 INDI inner loop

- Derivation of the inner INDI loop (detailed equations).

2.3.2 INDI outer loop

- Derivation of the outer INDI loop (detailed equations).

3 Implementation

3.1 Research Quadrotor

- Some facts about Crazyflie hardware (foto, uC frequency, weight, length)

3.2 Simulink Model

3.2.1 Purpose

- Estimation of relevant components (Matrices...)
- Testing of the PD-gains
- Testing the filter

3.2.2 Structure

- Parameters
- Actuator dynamics
- Filter
- Images of the Simulink model

3.2.3 Simulation Results

3.3 Implementation on Hardware

3.3.1 Structure of the Code

3.3.2 Testing with contact Forces and Moments

4 Results

5 Discussion

Appendix