Lucerne University of Applied Science & Architecture

ARIS - Data Fusion for a Sounding Rocket

Bachelor Thesis

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Declaration

Hereby, I declare that I have composed the presented paper independently on my own and without any other resources than the ones indicated. All thoughts taken directly or indirectly from sources are properly denoted as such. This paper has neither been previously submitted to another authority nor has it been published yet.

Horw, March 12, 2018

Abstract

This is the Abstract

Contents

Chapter 1

Introduction

Here comes the Introduction what is Aris what are the aims and why is a Data/Sensor fusion needed?

The Academic Space Initiative Switzerland (ARIS) is student group which tries too compete in the yearly Intercollegiate Rocket Engineering Competition (IREC). To aim for the right apogee (3000 m) a Control algorithm is implemented. This algorithm relays on the information of different sensors to determine the rockets actual state. Cause there are different sensors to measure the same value a algorithm which fuses those data would come in handy. With this fusion algorithm it should also be possible to be more accurate as with each sensor on its own. For this the problem as well as the desired solution will be defined in this chapter. After that the dynamics of the rocket as well as the parameter of the different Sensors are defined at beginning of chapter 2, the most suited algorithm will be chosen. Chapter 3 will then describe how this fusion algorithm implemented in a simulation in detail. To verify that the implementation is working as intended, the fused data will be held against the ground truth which are provided from this years test flights in chapter 4. In the last chapter 5 a summary of the achieved knowledge will be stated. The purpose of this thesis is to find and implement the algorithm which is most suitable for this task.

1.1 Purpose

The hardware as well as the most of the software parts that will be used for this competition is already defined. Also it is a suitable assumption that the sensors and the dynamics of the rocket will be stay more or less the same for the competitions coming. Therefore this thesis will mainly focus on finding a algorithm for this given surroundings, but it is also will try to find as modular solution as possible, so that achieved knowledge can be used in further competition.

1.2 Research

Write about the Papers/book you used: Kalman-filter Optimal state estimation The Master Thesis Sensor/-data fusion is an engineering field since the first rocket flights. Therefore there is already a lot of previous work which can be used in this thesis.

1.3 Problem

State the problem, what will be difficult ? For what is it ? where should it be improved

Problems found so far:

- How to calculate Height out of Pressure/Temp/Humidity Fabian version: $44330 * (1 - (\frac{pressure}{101325})^{\frac{1}{5.255}})$
- How to parameterize the different sensors (Measuring, Test Flight, Data Sheet) ?
- How to fuse together Data from Sensors that have different Taus, especially those who are slower than the Loop-Time ?
- How to integrate AirBreaks/Drag Force of Air/ Trust of Motor a input value?
- What are the different noise factors and when do they occur ?
- The up-flight is rather short: about 25 seconds, so the Fusion should have a small settling time
- The Micro-Chip on which it is used is no the fastest : 168 MHz clock

- The Ram on the Chip is not endless: Maximal space for the Sensor fusion is about 10kB
- The Sensor Fusion should be as modular as possible so that it also can be used in the next competition
- The Sensor Fusion has to be as sturdy as possible so that it will not fail if a problem occurs
- The Fusion should make a state Estimation as precise as possible.
- There are a lot of different variables: 3 Positions, 1 Speed, 3 Accelerations, 3 Lagen, Time, Pressure, Tempterature, Humidity, Up-/Downforce.
- Especially the Input Value u which is the force onto the rocket is difficult to define (Drag, Trust = acceloration depends on wheigt which changes over time).
- The different Sensor have different weaknesses:
  - Accelerometer: Offset, drift, weak to vibrations
  - Gyro: Weak to Vibrations
  - Barometer: Many uncertenties, unpercise
  - GPS: Slow (max 5Hz)

1.4 Requirements

These are the requirements which were drown out of the problems list.

Requirement	**Rating**	**Aim**	**Importance**
Precision	Error between estimation and ground truth	< 2m in Z	High
Reliability	Functioning Estimation with #failed sensors	Functions without 2-3 sensors	Medium
System Load	# Calculation steps per loop	< 1000	Critical
Non Linearity	# non linearity's in the algorithm	0	Desirable
Settling time	Time from ignition to optimal estimation	< 5 s	Critical
Modularity	Effort needed to change a sensors	< 10 h work	Desirable

Table 1.1: Requirements table

1.5 Desired Solution

Describe in quick terms what you are aiming for.

Chapter 2

Approach

How I want to get to the Solution and why I choosed it also how it works.

2.1 Possibilities

Which ones are there and what are their positives and negatives, in short how do they work

2.2 Choosing

Why i choosed Kalman Filter

2.3 Explenation

How it 'should' work in detail

Chapter 3

Implementation

How it will be Implemented

3.1 Sensor Model

3.2 System Model

3.3 Simulation

Chapter 4

Tests

Here come the tests

Chapter 5

Conclusion

5.1 Thanks

Thanks to the Aris Team espacially Thomas and Fabian Also Thanks to Lukas and Jossely

Bibliography

Appendices

This is the Appendix