Controlling multiple drones autonomously inspired by birds ability to keep formation

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Bachelor Thesis

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Todo list

Abstract

Until now drones keeps getting bigger and larger to carry bigger batteries with more capacity and to lift heavier payloads. This leads to drones getting less efficient, less responsive and gets more dangerous. Instead it has become popular to make drones smaller and increase the number of drones needed to solve a task.

Materials & methods
This thesis describes how to make three drones follow a leader drone with a preprogrammed path as an example of drones cooperating. A Linux PC running MarkerLocator tracks each drones position and wirelessly transmits, using Xbee, the drones positions to all drones.The position of each drone is spoofed into the drone using the CAN-bus and thereby overwriting the onboard GPS. An outdoor test has been made using the onboard GPS to test the leader-follower algorithm in a bigger scale. A small PCB has been developed and mounted on each drone to route packages from the Xbee module to the CAN-bus of the drone and to measure the local altitude of the drone using a ultrasonic sensor. The PCB carries an AT90CAN128 as microcontroller which build-in CAN support making it obsolete to carry an external USB CAN-controller.

Results -> discussion
The accuracy of the vision based localisation is measured using a laser pointer pointing out the drones 2D position on the floor making it possible to measure the variance of the drones position. The leader-follower algorithm was also tested outside using the onboard GPS. The performance of the leader-follower algorithm is measured and discussed using plots that reveals the distance between the drones.

Conclusion -> perspective
It is shown that it is possible to implement the leader-follower algorithm using a vision and ultrasonic based positioning system. The distance between all drones when flying indoor was +/- 10 cm which is less than the maximum accepted error. It was possible to add 5 follower-drones without editing the code showing it is a generic system The system can further be used to indoor testing of navigation algorithms and explore the many possibilities drones has to offer. If drones at some point needs to fly indoor to help eg. Mobile robots navigating, vision might be a way to obtain a absolute indoor position for the drones.

Preface

Thanks to:

- Kjeld Jensen
- Anna ..
- Mads ...

Table of Contents

Reading Guide

Chapter 1

List of Abbreviations

AQ	AutoQuad

Chapter 2

Introduction

Drones are more and more used in different applications in different areas because they make it relatively easy to get a quick or more in depth overview of a situation. A less positive thing of the drones is the amount of energy they are capable of carrying. A drone designed with long time-flight flying in mind is capable of flying approximately 20 minutes depending on weather and payload. If the drone is equipped with a heavy camera or other kind of payload, then the flight time starts to decrease rapidly. So far the solution has been to increase the size of the drones to mount bigger batteries, but this might not be right way of doing it. Drones become less efficient, less responsive and gets more dangerous due to increase in weight.

By looking at the nature, one can easily see how small animals like ants and birds manage to cooperate and thereby build or move bigger things that they would not be able to do on their own. This way of small independent, decentralized units working together is called a swarm.

By making drones smaller, they get more efficient, their flight time increase and they get cheaper but of the cost of their ability to lift. Therefore it seems like an idea to make small drones cooperate to solve more complex tasks.

SDU is currently using a platform called AutoQuad which is supported by large and small drones. Solving a task as a swarm is complex, and is not in the scope of this project. This project intend to implement a Leader-follower principle inspired by birds flocking behaviour. The leader-drone will have a preprogrammed flight path and the follower-drones will have no knowledge about the flightpath. Each follow-drone will try to keep a distance of 50 cm within plus minus 10 cm to its neighbours and the leader-drone. A computer program will be written to control each drone and tell them where to go without colliding. This will be developed in an indoor controlled environment. Since GPS is unavailable indoor, this project will be using vision, e.g. Henrik Midtiby's MarkerLocator to get the location of each drone. When the Follow-leader has been implemented it should in theory work outside as well, though with larger distances due to GPS inaccuracy.

2.0.1 Related Work

2.0.2 Problem Statement

The current AutoQuad does not support vision as source of 2D position which is required for the indoor Leader-follower to work. The relative height of the drone is measured using the build-in barometer in each drone providing the third dimension to the drones position. In case the barometer turns out to be too inaccurate due to drift other sensors might be used e.g ultrasound. The computer has to send waypoints wirelessly to all of the drones. A PCB for each drone has to be developed for the drones to carry as payload. The PCB will be responsible for receiving messages from the computer and translate them into the CAN-bus of the drone. Hypothesis If each drone's 2D position is obtained using vision and spoofed into the drone using CAN, then it is possible for at least 3 drones to follow a leader drone with a preprogrammed flight path and keep a euclidean distance at 50 cm within plus minus 10 cm to the leader and its neighbours.

2.0.3 Hypothesis

If each drone's 2D position is obtained using vision and spoofed into the drone using CAN, then it is possible for at least 3 drones to follow a leader drone with a preprogrammed flight path and keep a euclidean distance at 50 cm within plus minus 10 cm to the leader and its neighbours.

Chapter 3

Materials and methods

Chapter 4

Leader-followers

Chapter 5

Implementation

This chaptor conserns the most important parts about how this project has been implemented. It has been split into severel sections.

Mathias: Implementation: Write shortly about the implementation Chapter.

Mathias: Implementation: Less calculations on the drone, better to move to another computer/cluster with more power than the drone has available from its battery

Mathias: Implementation: Image of camera and drone seen from the side. Show what happens to the drones position estimation when it driftes down/up

5.1 Vision based localization

- Introduction to section(chapter)
- Why use vision as lozalization. cheap, no expensive sensors.
- About the MarkerLocator(out of scope), how it works,(Overview - not in depth, why it's slow, how window-mode works) how it's implemented, scalability.
- Quality meassure, why is it nessecary.
- How I arrived to a good way of meassureing the found marker.
- One drone detection
- Two drones detection, different ways of detecting orders.
- Implementation in ROS, splitting into different nodes. optimization

Mathias: Vision based localization: Red is above blue, not because the drone wasn't detcted

Mathias: Vision based localization: WIfi test distance, see what happens to latency

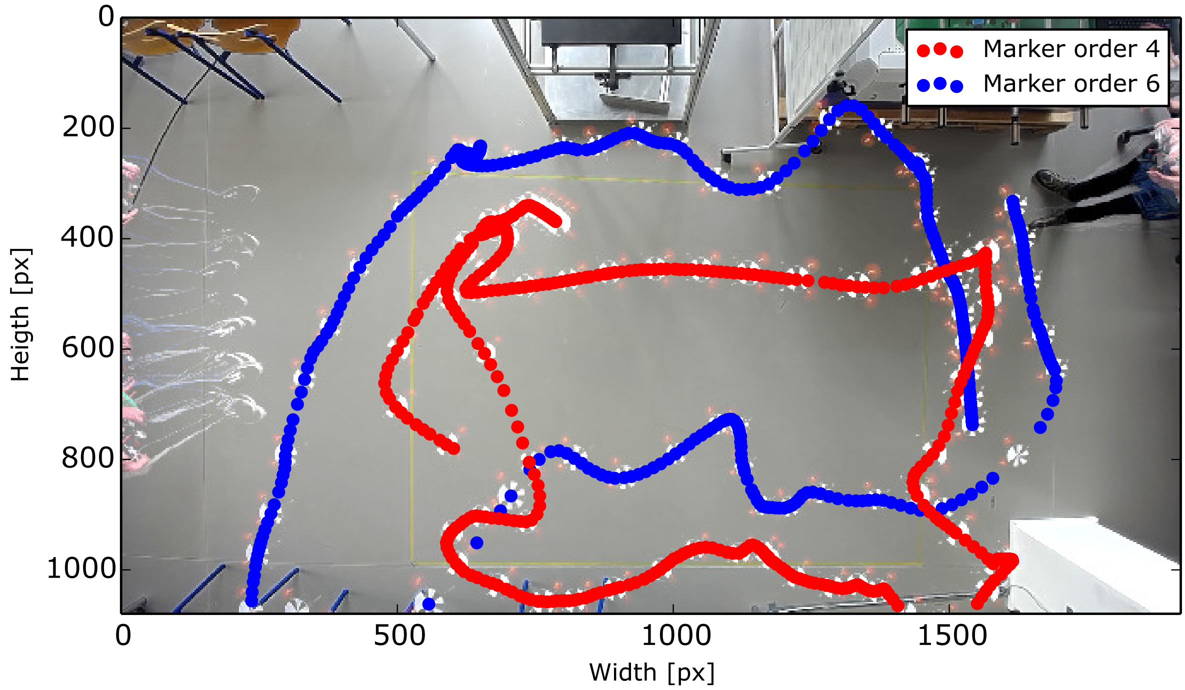

Figure 5.1 *Figure showing every 7'th frame merged into one frame combined with the tracked positions of the drones*

5.2 Hardware

5.2.1 Introduction

This secion will go in depth about the extentionboard created as ab addon to the AQ M4 board. The extentionboard was developed to act as a bridge between PC and the CAN-bus using wireless communication in order to send GPS coordinates from the PC to the Drones.

The block schematic shown in figure 5.2 was created by the auther of the report. It was then given to Carsten Albertsen who created the schematic and did rest of the creation of the PCB.

Mathias: Introduction: Create schematic appendix

Mathias: Introduction: Add GPS, WIFI, PCB, PC to forkortelses liste

Mathias: Introduction: Thanks to Carsten Albertsen for PCB development

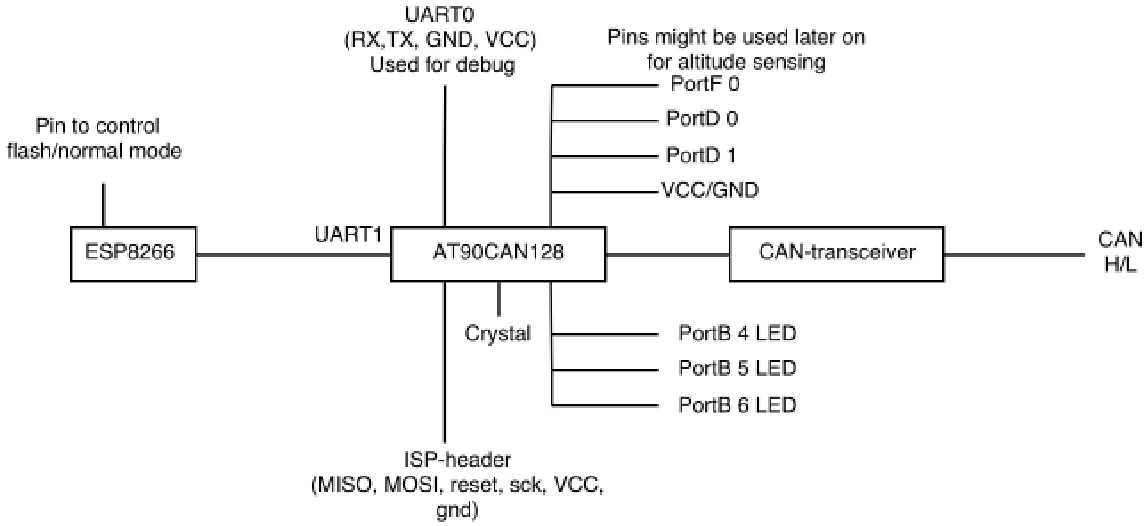

Figure 5.2 *Block schematic of the WIFI-extentionboard developed to AQ M4*

ATmega

Wireless Communication

An important part of the hardware is the wireless communication used between the PC and the drones. The wireless communication has severel requirements it needs to fulfill in order to make the whole system work as expected. A comparesion-table has been made in table 5.1 to find the sensor that is best suited.

Product	Size	Price	Usability	Power consumption	Range	Score
ESP8266						
EMW3165						
nRF51822						

Table 5.1 *Comparisontable used to compare different wireless communication modules*

Pins

A few pins where made available through solder pads for easy access if needed later on.

The following pins where available as solder pads:

- PortF 0 - Alternative function as ADC, channel 0
- PortD 0 - Alternative function as interrupt, INT0
- PortD 1 - Alternative function as interrupt, INT1

In case the onboard baromter isn't accurate enough, an alternative distance could be used to measure the drones altitude with respect to the ground. PortF0 has been made available since

some distance sensors give output as an analogue value. An example of such sensor is an Infrared proximity sensor.[1]
As an alternative type of distance sensor, a ultrasoinc could be used such as HCSR04. As output it gives a binary output with high-time proportional with the distance.[2]. To detect the high-time, one of PortD1/0 would be useful.

Which type of sensor suits best as a distance sensor to provice altitude information to the drone is ouf of the scope of this report. The PCB has just been made ready to different types of sensors.

Debug/ISP

In the final schematic UART0 and ISP pins where combined in one pinheader for easy access through one cable.

Mathias: Debug/ISP: Refer to image of board

To program the AtMega the ISP pins where required to be easy accessable. UART0 was made accessable to be used as debug and programming of the ESP8266 board. The plan was to setup the AtMega as UART passthrough from UART0 to UART1. Due to a mistake[3] in the final schematic, both UART0 and UART1 where made accessable trough the ISP/debug header. This ended up making it easier to program the ESP8266-board without using the AtMega as UART passthrough.

[1] http://www.sharpsma.com/webfm_send/1208
[2] http://www.micropik.com/PDF/HCSR04.pdf
[3] The wrong pair of MISO/MOSI pins where made available in the ISP-header. The correct pair of MISO/MOSI is also RXD0/TXD0 as alternative function

Chapter 6

Test Descriptions

Mathias: Test Descriptions: Maybe a chapter called "Test Descriptions here"

Chapter 7

Results

Chapter 8

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Chapter 9

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Chapter 10

Future work

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