Sebastian Mai

Integrating Ranging Sensors into Finken Robots

Some Department

Bachelor Thesis

Integrating Ranging Sensors into Finken Robots

Author:	Sebastian Mai	Your Term	The Year
Professor:	Your Professor		
Tutor:	Your Tutor		

Sebastian Mai: *Integrating Ranging Sensors into Finken Robots*
Bachelor Thesis, Otto-von-Guericke-Universität
Magdeburg, The Year.
Some Chair- Some Department

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Contents

1 Prior Art

1.1 The Finken Robot Platform

The Finken project aims to create a swarm of autonomously flying quadrocopters to research swarm intelligence beheaviour on robots. Many algorithems in swarm intelligence are based on distance-values. For this reason it is reasonable to search for a sensor that is capable to measure distances and integrate it into the Finken robots.

source

1.1.1 Actuators and Dynamic

The Finken Robot is a quadrocopter. Like most quadrocopters the Finken Robots are propelled by four rotors that are directly attached to a brushless motor. In combination the motors can be controlled to change the direction of the thrustvector (pitch and roll), to change the overall amount of lift generated (thrust) and to change the orientation of the airframe (yaw). The speed of each motor is controlled by an the LisaMX 2.1 autopilot-board[2] using the opensource autopilot firmware Paparazzi[3].

1.1.2 Environment

The Finken Robots fly in an area of 2m by 3m that can be expanded to about 4m by 3m and in 50cm to 1m height. The flight area is enclosed by netting and ultrasound-reflecting foil. It is possible to create virtual environmental factors by using a projector and an rgb-sensor mounted on top of the robots. This virtual environment can be used assign a certain task to the robot, e.g. finding the brightest spot.

1.1.3 Sensor Concept

1.1.4 Hardware interfering with ranging

There are different ranging technologies that might be used in a Finken quadrocopter. However there are different components that can interfere with the new sensor that shall be integrated e.g. by disturbing the measurments made by the new sensor.

Sonar Sensors Sonar sensors to measure distances of the nearest object in four directions (front, back, left, right)

Motors Four brushless motors that may cause RF-interfercene and noise

Telemetry BTLE-/Zigbee modules to exchange data with the ground station

RC-Control 2.4GHz based Radio Control to manually control the robots

fink3?

Supply Lithium polymer batteries with nominally 6.6V output voltage that is converted to 5V and 3.3V by the power distribution hardware

weight

payload

Payload The overall weight of the copter in the current configuration is about g with about g headroom for additional equipment

Size The copter has a rotor to rotor distance of 10cm, and a sensor tower that is about 4cm by 4cm wide to use the existing mounting holes would be favourable

1.2 Evaluation of Existing Ranging Solutions

There are some technologies that can be used for ranging, however the usual application for most of those technologies in research is positioning. For that reason it is interesting to search for positioning applications that use range measurements, however many of those positioning technologies are base on other principles than multilateration[1]. [4]

The usual technologies used for ranging are based on time of flight measurments, signal strength, optical tracking, and phase diffence measurments in signals.

[1]The usual methods for positioning are: *multilateral*—which is what we are interested in because only ranging measurments are used, *multiangular*—which is no use to us, because angle measurements are used and by *orientating in a map* with different factors like beacon-positions–which is also no use to us.

1.2.1 Indor Time of Flight

The obvious approach for replacing the GPS signal that is aviable outdoors is to use a simmilar approach indoors. http://robotics.eecs.berkeley.edu/ pister/290Q/Papers/Location/Lanzisera%20RF%20TOF%20WISES06.pdf states, that an accuracy of $2.6m_{RMS}$ was achieved indoors. With an operating area only $2m$ wide this approach is not suited for our robots. However this research is focused on using cheap sensor-nodes.

quellify

find commercial solutions with better accuracy

http://www.researchgate.net/profile/Bardia_Alavi/publication/224315086_Measurement_and_
Based_Ranging_in_Indoor_Multipath_Environments/links/0912f50b396c34097100000.pdf

Another approach to provide an indoor GPS-like solution is iGPS. http://www.nikonmetrology.com/de_EU/Produkte/Grossvolumige-Messaufgaben/iGPS/iGPS however is not ranging-based but uses angulation as underlying technology and is therefore useless to us. * IGPS http://porto.polito.it/2438175/2/IJAMT_iGPS_and_LT.pdf

quellify

quellify

1.2.2 Cricket / Active Bat

A very clever approach to ranging is used by ranging solutions like cricket and active bat. RF-Signals travel at the speed of light and therefore you need to be able to measure very short timings in time of flight scenarios. Sound however travels at a speed much slower than RF. Cricket and Active Bat use this to measure the time difference an RF-signal and an ultrasound pulse need to travel from transmitter to reciever to calculate the range between two sensor nodes.

Quelle, Quelle

thunderstorm and ligthning very very frightning

There are two big problems with this approach that stem from the current setup of the Finken-Robots. The Finken Robots use ultrasound sensors to measure the distances to nearby objects. Those technologies would interfere with the ultrasound sensors already used and a replacement would be needed.

accuracy / price, moving objects, medium access (number of nodes)

Another problem is the noise created by motors and propellers. The sound made by the quadrocopters is not ending in the hearable spectrum but also extends to the ultrasound range.

measure noise, PWM-frequency of speedcontrollers

1.2.3 RSSI-based ranging

quelle

quelle

quelle

quellify

typical propagation pattern picture

A property that can be used to do RF-based ranging is signal strength. The further the source of the signal is away the weaker the signal gets. RSSI-based ranging is done for serveral different technologies: Bluetooth, WLAN, RFID– There are even approaches using maps created of different RSSI-ranging sources. http://www.gnss.com.au/JoGPS/v9n2/JoGPS_v9n2p122-130.pdf

The main factor that rules out RSSI-based ranging is that radio-waves are not propageted equally in every direction. Antenna-orientation might have a much bigger impact on signal strength than distance. Additionally radio waves might be weakend when travelling through the Finken-Robots and by doing so passing wires and electronic components.

1.2.4 External Tracking

1.2.5 Atmel RTB, Dresden Elektronik, Meterionic

2 Implementation

2.1 Hardware

2.1.1 Ranging Hardware

2.1.2 Autopilot

2.2 Interconnect

There are diffrent solutions to connecting the ranging board to the Paparazzi autopilot.

2.2.1 Pulse width modulation / Analog value

Using a single GPIO pin or analog value is completely impractical, but a good example to explain the problems the honest solutions need to address. First of all there is a limited number of GPIO or ADC-pins on both boards. On the autopilot board those pins are quite rare, especially because they cannot be shared easily between components. The second problem is that we do not only need to read a range value from the sensor but we also need to tell the sensor which value to fetch. Therefore some kind of bidirectional communication between autopilot and sensor need to take place. The big advantage of using a GPIO pin would be that only one single wire[1] would be needed to connect autopilot and sensor.

[1] Plus two wires for voltage supply

2.2.2 UART

2.2.3 SPI

2.2.4 CAN bus

2.2.5 I2C

"TWI", "Phillips-I2C", "..."

2.3 Communication Protocol

3 Evaluation

3.1 Method(s)

3.2 Result(s)

4 Future Work

Bibliography

[1]

[2] Lisa/MX V2.1 Autopilot.

[3] PaparazziUAV.

[4] Multilateration, July 2015. Page Version ID: 670629691.

[5] Center for History and New Media. Zotero Quick Start Guide.