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# Integrating Ranging Sensors into Finken Robots

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FAKULTÄT FÜR  
INFORMATIK

Some Department

Bachelor Thesis

# Integrating Ranging Sensors into Finken Robots

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**Sebastian Mai:** *Integrating Ranging Sensors into Finken Robots*  
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# 1 Prior Art

## 1.1 The Finken Robot Platform

The Finken project aims to create a swarm of autonomously flying quadcopters to research swarm intelligence behaviour on robots. Many algorithms 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 quadcopter. Like most quadcopters 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 quadcopter. However there are different components that can interfere with the new sensor that shall be integrated e.g. by disturbing the measurements 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-interference 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 The overall weight of the copter in the current configuration is about g with about g headroom for additional equipment

payload 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 based on other principles than multilateration<sup>1</sup>. [4]

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

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<sup>1</sup>The usual methods for positioning are: *multilateral*—which is what we are interested in because only ranging measurements 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 simmlar 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.

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[http://www.researchgate.net/profile/Bardia\\_Alavi/publication/224315086\\_Measurement\\_and\\_Based\\_Ranging\\_in\\_Indoor\\_Multipath\\_Environments/links/0912f50b396c340971000000.pdf](http://www.researchgate.net/profile/Bardia_Alavi/publication/224315086_Measurement_and_Based_Ranging_in_Indoor_Multipath_Environments/links/0912f50b396c340971000000.pdf)

find commercial so-  
lutions with  
better accu-  
racy

Another approach to provide an indoor GPS-like solution is iGPS. [http://www.nikonmetrology.com/de\\_EU/Produkte/Grossvolumige-Messaufgaben/iGPS/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](http://porto.polito.it/2438175/2/IJAMT_iGPS_and_LT.pdf)

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### 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

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.

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and lighth-  
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frightning

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

accuracy /  
price, mov-  
ing objects,  
medium  
access  
(number  
of nodes)

measure  
noise,  
PWM-  
frequency  
of speedcon-  
trollers

### 1.2.3 RSSI-based ranging

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 several 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](http://www.gnss.com.au/JoGPS/v9n2/JoGPS_v9n2p122-130.pdf)

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typical  
propaga-  
tion pattern  
picture

The main factor that rules out RSSI-based ranging is that radio-waves are not propagated equally in every direction. Antenna-orientation might have a much bigger impact on signal strength than distance. Additionally radio waves might be weakened 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

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## 2 Implementation

### 2.1 Hardware

### 2.2 Communication Protocol

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



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## 3 Evaluation

### 3.1 Method(s)

### 3.2 Result(s)





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## 4 Future Work



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