

UNIVERSITY OF BERN

BACHELOR THESIS

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# Indoor positioning using Raspberry Pi with UWB

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*A thesis submitted in fulfillment of the requirements  
for the degree of Doctor of Philosophy*

*in the*

Communication and Distributed Systems  
Institute of Computer Science

July 19, 2018



## Declaration of Authorship

I, Mischa WENGER, declare that this thesis titled, “Indoor positioning using Raspberry Pi with UWB” and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed:

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Date:

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*“Thanks to my solid academic training, today I can write hundreds of words on virtually any topic without possessing a shred of information, which is how I got a good job in journalism.”*

Dave Barry



UNIVERSITY OF BERN

# *Abstract*

Faculty Name  
Institute of Computer Science

Doctor of Philosophy

**Indoor positioning using Raspberry Pi with UWB**

by Mischa WENGER

The Thesis Abstract is written here (and usually kept to just this page). The page is kept centered vertically so can expand into the blank space above the title too...





## *Acknowledgements*

The acknowledgments and the people to thank go here, don't forget to include your project advisor...



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# List of Abbreviations

**LAH** List Abbreviations **Here**  
**WSF** What (it) Stands For



# Physical Constants

Speed of Light  $c_0 = 2.997\,924\,58 \times 10^8 \text{ m s}^{-1}$  (exact)



# List of Symbols

|          |                   |                        |
|----------|-------------------|------------------------|
| $a$      | distance          | m                      |
| $P$      | power             | W (J s <sup>-1</sup> ) |
| $\omega$ | angular frequency | rad                    |



*For/Dedicated to/To my...*





## Chapter 1

# Introduction

### 1.1 Motivation

In the last twenty years, the number of mobile devices in use has tremendously increased. In the first quarter of 2018 more than 380 Million smartphones have been sold worldwide *Gartner Gartner Says Worldwide Sales of Smartphones Returned to Growth in First Quarter of 2018*. However, in the past few years, not only smartphones have been sold, but also a new market of mobile gadgets and connected devices, summed up as Internet of Things, has evolved. In 2017, more than 20 Billion devices were connected to the internet. Forecasts predict 30 Billion devices in 2020 and already more than 70 Billion in 2025. *Statista Internet of Things - number of connected devices worldwide 2015-2025*

This increase in mobile computing has also increased the demand of accurate real-time positioning systems which led to an active research mainly in indoor positioning system technologies, as there are established solutions for outdoor positioning.

#### 1.1.1 Indoor difficulties vs Outdoor

For outdoor applications, primarily the Global Positioning System (GPS) is in use. For indoor application in the other hand, GPS has limitations that make it almost useless. Due to the environmental conditions indoors, with heavy walls armoured with steel and other distractions, additional signal loss is encountered which makes it hard to detect and decode GPS signals. Kerem Ozsoy and Tekin, 2013 In addition, higher buildings in the neighborhood can reflect transmitted signals, which leads to false position estimations. As GPS is mainly applied as 2D positioning system, it will not provide 3D indoor information such as the current floor level. For this purposes we are forced to use an alternative technologies. There are many different approaches to do indoor positioning, which made it an attractive and active research field.

#### 1.1.2 Important Applications

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## 1.2 Ideas

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### 1.2.1 Ranging Positioning System with different Inputs

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## 1.3 Contributions

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### 1.3.1 Implementation of the System

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### 1.3.2 Comparison of three different implementations

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## Chapter 2

# Theoretical Background and Related Work

### 2.1 Range based localisation

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#### 2.1.1 Triangulation, Trilateration

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#### 2.1.2 Weighting

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### 2.2 UWB Theory

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## Appendix A

# Frequently Asked Questions

### A.1 How do I change the colors of links?

The color of links can be changed to your liking using:

```
\hypersetup{urlcolor=red}, or  
\hypersetup{citecolor=green}, or  
\hypersetup{allcolor=blue}.
```

If you want to completely hide the links, you can use:

```
\hypersetup{allcolors=.}, or even better:  
\hypersetup{hidelinks}.
```

If you want to have obvious links in the PDF but not the printed text, use:

```
\hypersetup{colorlinks=false}.
```



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Kerem Ozsoy, Ayhan Bozkurt and Ibrahim Tekin (2013). "Indoor Positioning Based on Global Positioning System Signals". In: 11.1.

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