UNIVERSITY OF BERN

BACHELOR THESIS

Indoor positioning using Raspberry Pi with UWB

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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:

Date:

"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

Bachelor of Science in Computer Science

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

GPS	**G**lobal **P**ositioning **S**ystem
IMU	**I**nertial **M**easurement **U**nits
IoT	**I**nternet **o**f **T**hings
M2M	**M**achine **2**(to) **M**achine
UWB	**U**ltra **W**ide**B**and

Physical Constants

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

List of Symbols

a	distance	m
P	power	W ($\mathrm{J\,s^{-1}}$)
ω	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 quater 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 mainy 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 alternative technologies that provide even higher accurracy indoors than GPS would achieve outdoors. There are many different approaches to do indoor positioning, which made it an attractive and active research field.

1.1.2 Important Applications

There are various possible use cases for devices that track their indoor position. These use cases can be grouped into two groups. On the one hand applications for pedestrians with a smartphone and on the other hand real machine to machine (M2M) applications.

Some examples for Smartphones:

Location of person in need For emergency services every second counts to get to the position of persons in need. An accurate positioning system that indicates additional information such as the floor level could save lifes.

Security Guards Real time tracking of security guards on their patrol. A security system can check autonomous if all security guards are on the right tracks.

Museum guidance Tourists visiting a museum could easily be guided through the museum with customized location based information.

Examples for Machine to machine (M2M):

Logistic An autonomous storage system can find articles in a big storehouse according to the exact position of the carrier vehicle. Numerous vehicles can be in use at the same time.

Cleaning An autonomous cleaning machine keeps track of its position, such that the floor can efficiently be cleaned.

Indoor post roboter An autonomous roboter can collect letters in the building and bring them to the internal post office.

1.2 Idea

For an object in space, there are several basic ideas to keep track of its current location. We can define a starting position and keep track of every move the device registers. E.g. every visitor in the museum starts at the entrance and will then walk through the building. Alternatively the object can be tracked by defining at least three triangulation points and periodically measure the distance from these points to the device. There are various ways to measure this distance, some with higher and some with lower accuracy.

1.2.1 Ranging Positioning System with different Inputs

Our idea was to not only use one of the mentioned approaches, but to combine them to in one alorithm. We would use a range positoning system combined with motion detection of the device and even integrate environmental restrictions, given by floor topologies like walls. By combining different methods we hope to compensate measurement errors and thus minimize the overall errors.

1.3 Contributions

In this thesis we present a real-time indoor positioning system on Raspberry Pi based on a particle filter implementation in smartphones, developed in previous works of the University of Bern. Neto, 2018 We adapted the inputs of the particle filter to range-based localization using ultra wideband (UWB) instead of Wi-Fi and added motions measured by inertial measurement units (IMU) of the target. We expound results of our experiments, where we tested different variants of our implementation and other algorithms in a real test scenario and compared the accuracy of the estimated position.

Our main contributions are:

- We implemented a real-time localization system on raspberry pi using UWB and IMU sensors.
- We compared our implementation to an UWB based localization system provided by Uniset Company on complex indoor trajectories.

1.3.1 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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