Aalto University
School of Science
Degree Programme in Computer Science and Engineering

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Scene Analysis based Bluetooth Low Energy Indoor Localization Methods

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Master's Thesis
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Supervisor: Professor Aki Vehtari
Advisor: D.Sc. (Tech.) Roland Hostettler

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ABSTRACT OF
MASTER'S THESIS

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The thesis aims at getting a proof of concept for solutions to the hybrid bluetooth low energy indoor positioning (BLE-IP) along with automatic node location identification (ANOLI). ANOLI is mainly aimed during the calibration phase which gives out the locations of the bluetooth low energy (BLE) beacons. The BLE beacons are present inside the luminaires. The luminaires might either be installed in the ceiling or tethered to it. The location of BLE beacons determined using ANOLI and received signal strength indicator (RSSI) together are used in the BLE-IP task. The factors influencing the RSSI values is also studied and based on the target environment and accuracy the model is decided. Simple applications like asset tracking is also implemented.

Keywords:	Indoor Positioning, Bayesian Filtering, Gaussian Processes, Fingerprinting
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With devotion life becomes beauteous.
And without, what is life but blemish.
"Rumi"

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Srikanth Gadicherla

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Chapter 1

Introduction

Self-Awareness is the one of the significant parts of human evolution and location awareness is one of its component. As the field of artificial intelligence is moving towards ubiquity, the location awareness of intelligent machines becomes much more vital.

1.1 Why Positioning?

1.2 Motivation

Indoor settings are complex and dynamic in nature coupled with the problems of signal propagation makes the modelling more harder and complex.

1.3 Indoor Positioning

1.4 Bluetooth Low Energy

Also called Bluetooth smart.

1.4.1 Different types of BLE

1.5 Problem

1.6 Goal of the thesis

1.7 Research question: if could be added

1.8 Outline of the thesis

Chapter 2

Related work or Location Fingerprinting

In this chapter, background on the indoor positioning methods would be presented. The chapter begins with the section 2.1, where in detailed discussion on data analysis of the RSSI values is provided. Section 2.2 discusses the various methodology used previously. Section 2.3 talks how Bayesian Filters and Sequential Monte Carlo methods [**FixMe: should we add 2.3 and 2.3.1 to 2.2**]. Section 2.3 describes the Bayesian Filtering techniques. Section 2.3.1 provides the applications of Gaussian Processes and the state-of-the-art indoor positioning methods.

Before we start exploring the different methods for solving the indoor positioning problem, the initial challenge lies in getting the right data model as the RSSI values vary due to various external factors like [**FixMe: add factors here or refer to previous sections**].

The probabilistic nature of our positioning solution would allow seamless integration of inertial sensor data for increased performance.

2.1 Data Analysis of RSSI values

2.2 Positioning Algorithms

The radio-signals based indoor positioning can be categorized as time-based, angle based and signal-strength based (**?**)

The indoor positioning algorithm's are usually mostly modeled either using Pathloss or Gaussian process model. !Fixme **add citation** Fixme!

2.3 Bayesian Filtering

Table 2.1: I'm your sample table

A	1	$e^{j\omega t}$
B	2	$\mathfrak{R}(c)$
C	3	$a \in \mathbb{A}$

2.4 Gaussian Processes

Gaussian processes (GPs) are extensively used semi-parametric [1] modelling techniques

[1] going by the definition of basic GP, mean of Gaussian is non-parametric, but the conditional distribution is Gaussian, i.e, parametric.

Chapter 3

Gaussian Process for Indoor Positioning

Gaussian processes being one of the probabilistic methods, gives out the uncertainty estimates of the location

Chapter 4

Methods & Materials

Chapter 5

Discussions

Chapter 6

Conclusion

Chapter 7

Future Work