Ain Shams University

Faculty of Engineering

Electronics Engineering and Electrical Communications

Design of Indoor Localization Systems with the Application of Sensor Fusion

A Thesis submitted in partial fulfillment of the requirements of the degree of

Master of Science in Electrical Engineering

(Electronics Engineering and Electrical Communications)

by

AbdelRahman Yahia Ali Mohamed El-Naggar

Bachelor of Science in Electrical Engineering

(Electronics Engineering and Electrical Communications)

Faculty of Engineering, Ain Shams University, 2013

Supervised By

Prof. Dr. Khaled Mohamed Wagih Sharaf

Prof. Dr. Amr Galaleldin Ahmed Wassal

Cairo - (2020)

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Statement

This thesis is submitted as a partial fulfillment of Master of Science in Electrical Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Ain Shams University

Faculty of Engineering

Electronics and Communications

Thesis title: **Design of Indoor Localization Systems with the Application of Sensor Fusion**

Submitted by: **Abdelrahman Yahia Ali Mohamed Elnaggar**

Degree: **Master of Science in Electrical Engineering**

Abstract

Localization in an indoor environment is a very promising domain due to its many applications in many fields especially in human and robotic indoor navigation and tracking.

This thesis focuses on the development of an indoor positioning system based on consumer handheld devices. It reviews research in the domain of indoor positioning followed by a detailed discussion of a proposed system based on the sensor fusion of the wireless positioning data and the inertial measurement unit data.

Wireless positioning discussed is based on the widely used WiFi networks and is independent of infrastructure variations or the need of a recalibration phase which is usually needed in most of wireless positioning technologies.

Inertial measurement data is used to calculate the mobile device position relative to an initial position by integrating the acceleration in a certain direction.

However, there are challenges for both wireless positioning and inertial sensors positioning each on its own. For the wireless positioning, the main challenge is the high noise due to reflections and the distortion of the wireless signal. On the other hand, the inertial sensors drift due to the integration of noise leads to position errors on the long term. Sensor fusion techniques are introduced to enhance the performance of both positioning techniques combined.

Specifically, an estimation filtering algorithm is used for sensor fusion to calculate the position of the overall system. Simulated testing verified that sub-one-meter accuracy can be achieved, which is sufficient for indoor navigation systems.

Also, the proposed technique is promising for future indoor navigation systems that can be scalable and require minimal infrastructure installation depending on the available wireless signals in the indoor environment.

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Thesis Summary

This thesis has six chapters in addition to the tables of contents and the lists of symbols, figures, tables and references.

Chapter 1:

This chapter is an introduction that describes briefly the motivation and the objective of this thesis, it also summarizes the thesis flow and structure.

Chapter 2:

In this chapter, an introduction that reviews different positioning approaches and technologies, comparing their performance of these technologies and the pros and cons of each of them.

Chapter 3:

This chapter introduces the different sensor fusion techniques and their use as estimation filters such as Kalman filters. It illustrates how they work and their effect on the overall system performance.

Chapter 4:

In this chapter, the proposed indoor positioning system is discussed indicating its main technologies implementation. It provides both simulation results as well as results from real-life experiments using the WiFi and inertial navigation.

Chapter 5:

The use and implementation of sensor fusion is described in this chapter, showing the performance enhancement achieved in both simulation and real-life experimental results.

Chapter 6:

Chapter 6 concludes the thesis by highlighting the contributions and outcomes. It also discusses recommendations and suggestions for future work.

Key words:

Indoor positioning; inertial sensors; localization; WiFi; trilateration; Kalman Filters.

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Abdelrahman Elnaggar

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CONTENTS