شبكة المعلومات الجامعية

التوثيق الإلكتروني والميكروفيلم

# بسم الله الرحمن الرحيم


HANAA ALY

# شبكة المعلومات الجامعية

# التوثيق الالكتروني والميكروفيلم

HANAA ALY

شبكة المعلومات الجامعية

التوثيق الإلكتروني والميكروفيلم

# جامعة عين شمس

# التوثيق الإلكتروني والميكروفيلم

# قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات

# يجب أن

تحفظ هذه الأقراص المدمجة بعيدا عن الغبار

HANAA ALY

Ain Shams University
Faculty of Engineering
Public Works Department

# Outdoor Aided Navigation Using Smart Devices Sensors

A Thesis submitted in partial fulfilment of the requirements of the degree of Doctor of Philosophy in Civil Engineering (Public Works )

by

**Eng. Mohamed El-Sayed Ahmed Shebl**

Master of Science in Civil Engineering (Public Works )
Faculty of Engineering, Ain Shams University, 2014

Supervised By

**Prof.Dr. Mohamed El-Hosseiny Abdel-Khalek El-Tokhey**

Professor of Surveying and Geodesy
Faculty of Engineering, Ain Shams University, Cairo, Egypt

**Prof.Dr.Tamer FathyFath-Allah Ahmed**

Professor of Surveying and Geodesy
Faculty of Engineering, Ain Shams University, Cairo, Egypt

**Prof.Dr.Mohamed Mamdouh El-Habiby**

Professor of Surveying and Geodesy
Faculty of Engineering, Ain Shams University, Cairo, Egypt

**Dr.Yasser Mustafa Mogahed**

Associate professor of Surveying and Geodesy
Faculty of Engineering, Ain Shams University, Cairo, Egypt

**Cairo - 2022**

Ain Shams University
Faculty of Engineering
Public Works

# Outdoor Aided Navigation Using Smart Devices Sensors

by

**Eng. Mohamed El-Sayed Ahmed Shebl**
Master of Science in Civil Engineering (Public Works )
Faculty of Engineering, Ain Shams University, 2014

Examiners 'Committee

| Name and Affiliation | Signature |
|---|---|
| **Prof.Dr. Mohamed E.A. El-Tokhey**<br>Professor of Surveying and Geodesy<br>Faculty of Engineering, Ain Shams University | …….. |
| **Prof.Dr.Naser El-Sheimy**<br>Professor of Geomatics<br>Schulich School of Engineering, University of Calgary | …….. |
| **Prof.Dr.Ayman Ragab**<br>Professor of Surveying and Photogrammetry<br>Faculty of Engineering, Ain Shams University | …….. |

**Date: Jan. 2022**

# Dedication

This work took years from my life. I wish to dedicate it to those who suffered to educate, prepare and help me to be as I am,

# Statement

This thesis is submitted as a partial fulfillment of Doctor of Philosophy in Civil Engineering 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.

**Eng. Mohamed El-Sayed Ahmed Shebl**

**Signature:**……..…….

**Date:** 15 January 2022

# Researcher Data

| | |
|---|---|
| **Name:** | Mohamed El Sayed Ahmed Shebl |
| **Date of birth:** | 22/2/1984 |
| **Place of birth:** | El Qalyubia |
| **Last academic degree:** | Master degree |
| **Field of specialization:** | Surveying |
| **University issued the degree:** | Faculty of Engineering<br>Ain Shams University |
| **Date of issued degree:** | 2014 |
| **Current job:** | Teacher Assistant |

# Abstract

The demand for navigation systems is rapidly increasing, especially in GNSS-denied environments. The ubiquitous use of smart mobile devices equipped with various sensors encouraged many researchers to investigate their use in improving indoor navigation, where GNSS is not available.

Dead reckoning (DR) application depends on measuring the traveled distance and the orientation from the known position to the unknown one. Inertia navigation sensors installed in mobile devices are normally low-cost and drift significantly. Consequently, there is a need for auxiliary systems to aid the navigation process, which can be achieved using external sensors or additional information extracted from, for example, base maps.

This thesis represents a new technique for distance estimation during dead reckoning navigation depending on the proximity sensor. The new technique is based on the proximity sensor for step counting in case of pedestrian dead reckoning (PDR) or cycle counting in cycle dead reckoning (CDR). The new technique has accuracy in distance measurement equal to 1.34% and 0.53% in PDR and CDR, respectively.

As for the orientation (heading), the common technique is the sensor fusion concept through the use of gyroscope rate by integration with accelerometer and magnetometer data through Extended Kalman Filter (EKF). But this thesis is targeted towards improving the accuracy of heading estimation for pedestrian

navigation in GNSS-denied environments by innovatively using the maps. The map directions were used in dead reckoning to improve the low-accuracy directions derived from portable device sensors. This method is significantly computationally efficient compared to traditional geospatial map-matching algorithms. The new approach replaces the conventional geospatial database with a list of street directions and paths used as Map Heading Constraints (MHC) when navigating in straight directions. The applied algorithm improved the navigation solution with an average positional error of 1.23%, where the drift had been reduced with a percentage exceeding 80%.

## Keywords:

Pedestrian Dead Reckoning, Cycling Dead Reckoning, Micro-Electromechanical System, Step &Cycle Counting, Kalman Filter, GNSS-Denied Environment, Map Heading Constraint