University of Technology Sydney

Faculty of Engineering and IT

School of Electrical and Data Engineering

Development and Optimisation of Wireless Indoor localisation for the IoT Solutions

Doctoral Candidate: Yu, Zheng yu

CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Zheng yu Yu declare that this thesis, is submitted in fulfilment of the requirements for the award of a degree of Doctor of Philosophy, in the Faculty of Engineering and IT at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

This research is supported by the Australian Government Research Training Program.

Signature:

Production Note:
Signature removed prior to publication.

Date:

19/07/2020

ACKNOWLEDGMENTS

I would first like to express thanks to my PhD supervisors, Dr Zenon Chaczko and Prof Robin Braun. I have collaborated with my supervisors on several projects for the past four years. Dr Chaczko, you have been more than a supervisor to me all these days, and you have been with me every step of the way throughout this research. Thank you for your kind support during, at times, very stressful moments that I have experienced. I really appreciated your clear guidance and feedback very much.

Also, I appreciate support and help received from the Faculty of Engineering and IT staff and academics, especially that of Prof David McGloin. Thank you so much for organising series of insightful research seminars and providing comments related to my research in those past years. I have learned so much and adopted many of the most up-to-date research information and technology from these presentations.

Lastly, to my family and friends those who always support and encourage me, thank you for being with me all the time. I could not have got this far today without you. I wish for everyone's dream to come true and that you will all lead a happy life.

Contents

List of Figures

List of Tables

Acronyms used in the thesis

ABS	Active Badge System
AoA	Angle of Arrival
AP	Access Point
APS	Ad-Hoc Positioning System
AR	Augmented Reality
BLE	Bluetooth Low Energy
CF	Curve Fitting
CFKF	Curve Fitted Kalman Filter
DV-HOP	Distance Vector Hop
EPG	Electronic Program Guide
FM	Frequency Modulation
GPS	Global Positioning System
HVAC	Heating, Ventilating, and Air Conditioning
IMU	Inertial Measurement Unit
IoT	Internet of Things
KF	Kalman Filter
LBS	Location-Based Service
LSBA	Link State-Based Annulus
MEMS	Micro-Electro-Mechanical-Systems
NFC	Near-Field Communication
NLOS	None Line of Sight
PVR	Personal Video Recorder
QR	Quick Response
RFID	Radio-Frequency Identification
RMSE	Root Mean Squared Error

RP	Reference Point
RSS	Received Signal Strength
RSSI	Received Signal Strength Indicator
RWLS	Residual-Based Weighted Least Square
SSE	Sum of Squares Due to Error
TDOA	Time Difference of Arrival
ToA	Time of Arrival
ToF	Time of Flight
UUID	Universal Unique Identifier
UWB	Ultra-Wide Band
WLAN	Wires Local Area Network
WSN	Wireless Sensor Network

ABSTRACT

Traditional indoor localisation technologies are based on beacon technology, ultrasonics, laser range localisation, or Ultra-Wide Band (UWB) system, and others. Recently, some of these localisation techniques are used in the industry by developers of iBeacon systems for finding the position of an object with Bluetooth sensors. There are various advantages of using the iBeacon-like systems, such as low-cost, a simple signalling process, and the ease of set-up and maintenance. However, using the iBeacon-based system is marked with poor accuracy. With current technology, it is difficult to obtain highly accurate localisation for indoor objects or to perform their tracking. Also, iBeacons are highly susceptible to environmental noise interference and other radio signals. To solve these issues, this research work involves investigation and development of the error modelling algorithms that can calibrate the signal sensors, reduce the errors, mitigate noise levels and interference signals. This thesis presents a new family of error modelling algorithms based on the Curve Fitted Kalman Filter (CFKF) technique. As a part of the research investigation, a range of experiments were executed to validate the accuracy, reliability and viability of the CFKF approach. Experimental results indicate that this novel approach significantly improves the accuracy and precision of beacon-based localisation. Validation tests also show that the CFKF error modelling method can improve the localisation accuracy of UWB-based solutions.