PERFORMANCE STUDY OF VIRTUAL FENCING USING WIRELESS SENSING NETWORK

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A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Electrical - Electronics & Telecommunications)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

JUNE 2014

ACKNOWLEDGEMENT

I wish to express my sincere appreciation to my supervisor, Professor Dr. Tharek bin Abd Rahman for his guidance and advices. I am also very thankful to Research Officer WCC UTM, Arsany bin Arsad for participating in the experiments. Liao Ji Hau, a PhD student in NCU, Taiwan also deserves special thanks for his assistance in supplying the relevant information and knowledge sharing. Without their continuous support and help, this thesis would not have been the same as presented here. I am also thankful to Universiti Teknologi Malaysia (UTM) and Wireless Communication Center UTM for funding this project. Last but not least, I am grateful to all my family members and friends for their love and support.

ABSTRACT

This project report presents the experiments and performance analysis of virtual fence unit consists of microwave motion detector and IEEE 802.15.4 wireless sensor network for maximum sensing range. In particular, the analysis is focusing on the maximum sensing range of virtual fence unit in terms of azimuth angle, elevation angle, height, sensitivity level for indoor and outdoor implementation. The WSN platform is developed using Octopus II sensor nodes while the microwave motion detector is HB100 which detect movement using Doppler effect. Results show the maximum sensing range is maximum at 0º angle in both azimuth and elevation. The maximum sensing range of virtual fence unit is decreasing as azimuth angle increasing. For elevation angle, a significant increment of maximum sensing range at 45º and 60º elevation angle in downwards direction compared to 45º and 60º elevation angle in upwards direction is observed. With high sensitivity level of virtual fence unit, the maximum sensing range of virtual fence unit is larger than the maximum sensing range of virtual fence unit at normal sensitivity level. However, high sensitivity level will not further increase the maximum sensing range if the virtual fence unit has reached its maximum sensing range. Results also show virtual fence unit behaves differently in indoor and outdoor environment and the virtual fence unit has longer maximum sensing range in indoor environment than outdoor environment.

ABSTRAK

Laporan projek ini membentangkan eksperimen dan analisis prestasi unit pagar maya yang terdiri daripada pengesan pergerakan gelombang mikro dan sensor rangkaian wayarles *IEEE 802.15.4* untuk mengkaji jarak pengesanan object yang maksimum . Khususnya , analisis ini memberi tumpuan kepada jarak pengesanan object maksimum dari segi sudut azimut , sudut dongakan, ketinggian , tahap sensitiviti untuk aplikasi dalaman dan luaran. Platform wayarles dibina dengan menggunakan sensor nod *Octopus II* manakala pengesan pergerakan gelombang mikro adalah *HB100* yang mengesan pergerakan menggunakan kesan *Doppler*. Keputusan menunjukkan jarak pengesanan object yang paling maksimum adalah pada sudut 0º untuk azimut dan dongakan. Jarak pengesanan objek maksimum unit pagar maya semakin berkurangan semasa sudut azimuth semakin meningkat. Untuk sudut dongakan, kenaikan yang ketara dalam jarak pengesanan objek maksimum dikesan pada sudut tunduk 45º dan 60º berbanding dengan sudut dongakan 45º dan 60º. Jarak pengesanan objek maksimum unit pagar maya dengan tahap sensitivity yang tinggi adalah lebih besar daripada unit pagar maya dengan tahap sensitivity di tahap sensitiviti biasa. Walau bagaimanapun, tahap sensitivity yang tinggi tidak akan meningkatkan pelbagai jarak pengesanan objek maksimum unit pagar maya jika unit pagar maya telah mencapai jarak pengesanan objek yang maksimum. Keputusan juga menunjukkan prestasi unit pagar maya berbeza dalam persekitaran dalaman dan luaran. Unit pagar maya mempunyai jarak pengesanan objek maksimum yang lebih jauh dalam persekitaran dalaman dibanding dengan persekitaran luar .

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LIST OF ABBREVIATIONS

ADC	-	Analog to Digital Converter
FMCW	-	Frequency Modulated Continuous Wave
IR	-	Infrared
LED	-	Light Emitting Diode
MMS	-	Multimedia Messages
PIDS	-	Perimeter Intrusion Detection System
PIR	-	Passive Infrared
RF	-	Radio frequency
RFID	-	Radio Frequency Identification
SBC	-	Single Board Computer
UTM	-	Universiti Teknologi Malaysia
WCC	-	Wireless Communications Center
WSN	-	Wireless Sensor Network

LIST OF SYMBOLS

c_o	-	Velocity of light
f_D	-	Doppler Frequency
F_d	-	Doppler Frequency
F_i	-	Incident Frequency
fo	-	Transmit Frequency
F_r	-	Reflected Frequency
v	-	Velocity of moving object
α	-	Angle between microwave beam and target's path

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CHAPTER 1

INTRODUCTION

1.1 Project Background

A wireless sensor network (WSN) consists of sensors equipped with wireless interfaces to communicate wirelessly with each other or base station to form a network. These sensors are small, lower cost than traditional network but with limited processing and computing resources. These sensor nodes can collect useful information from the physical environment they are deployed in, process the data and transmit the sensed data to the user based on the local decision process. The sensed data can be reported to one or multiple sink nodes which can process the received data and extract useful information.

A WSN has design constraints and resource constraints. Resource constraints are limited energy, short communication range, small bandwidth besides limited processing and storage in each node. Design constraints are size of the network, the deployment structure and the network topology. For indoor environments, fewer nodes are required to form a network in a limited space while outdoor environments may require more nodes to cover a larger area.

Infrastructure and site surveillance is imperative with the increasing concern on security and safety. The best way to prevent disruption to a facility is creating an interactive perimeter that able to detect the intruders and alerts on the potential threats are sent before the break in occur. Detection of people attempting to cut through or climb over fences as shown in Figure 1.1 is not available with conventional fence.

Figure 1.1 Conventional Fence

There are two main problems when a conventional fence is used to safe guard a building or a site. Conventional fence has a physical barrier to allow an intruder to hide before breaking into the building or the protected site and there is no notification when an intruder crossed the physical barrier. The problems can be overcome by virtual fencing using wireless sensor network which can detect and localize the intrusion. The virtual fence is designed to serve as an enclosure or a boundary without physical barrier. The system replaces the need for building a fence, installation of multiple cameras and hiring security guards to walk around the perimeters. It has no weather or other environmental limitations. Virtual fence is invisible and thus it is difficult to defeat. Intruders are unaware of the existence of the virtual fence but intrusion can be detected once intruder is moving through the barrier as indicated in yellow circle as shown in Figure 1.2.

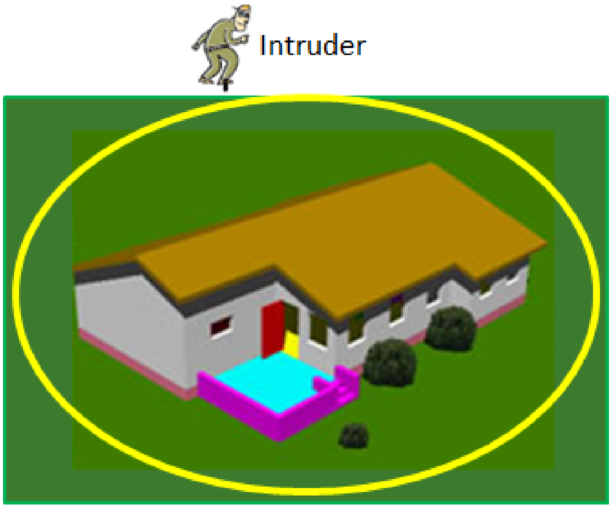

Figure 1.2 Virtual Fence

1.2 Problem Statement

Virtual fence system using wireless sensor network is built from a collection of virtual fence unit. Virtual fence unit plays an important role in overall performance of virtual fence system using wireless sensor network. However, performance of virtual fence unit is different in different environment and orientations.

1.3 Objectives

This main objective of this project is study the performance of virtual fence unit of virtual fence system using wireless sensor network.

Other objectives of this project are:

- To determine the maximum sensing range of virtual fence unit in terms of azimuth angle, elevation angle, height and sensitivity for indoor and outdoor environment.
- To detect and localize the intrusion.

1.4 Scopes

In this project, WSN platform is made up with Octopus II sensor node while microwave motion sensor HB100 is used as the motion detector. Test environments of this project are ground floor of Wireless Communication Center (WCC) Universiti Teknologi Malaysia (UTM) as indoor environment and rooftop of WCC UTM as outdoor environment. The maximum sensing range of virtual fence unit is evaluated from 0^0 to 180^0 azimuth angle and from 0^0 to 90^0 elevation angle when it is set at 30cm, 60cm and 90cm height with normal and high sensitivity level of virtual fence unit in indoor and outdoor environments.

1.5 Thesis Outline

This thesis is divided into five chapters to describe the project works. Chapter 1 provides an overview of the project. Chapter 2 presents the literature review on related researches that have been done. Chapter 3 describes the methodology of this project starting from setting up the virtual fence unit until the data collection. Measurement results are shown and discussed in the Chapter 4. Chapter 5 covers the conclusion and future works of this project.

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