Faculty of Electronic and Computer Engineering

OPTIMIZATION METHOD USING MODIFIED HARMONY SEARCH FOR COVERAGE AND ENERGY EFFICIENCY IN WIRELESS SENSOR NETWORK

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Master of Science in Electronic Engineering

2018

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A thesis submitted
in fulfillment of the requirements for the degree of Master of Science
in Electronic Engineering

Faculty of Electronic and Computer Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

DECLARATION

I declare that this thesis entitled "Optimization Method Using Modified Harmony Search for Coverage and Energy Efficiency in Wireless Sensor Network" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature :

Name : NURUL HAMIMI BINTI HALIM

Date :

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Electronic Engineering.

Signature :

Name : ASSOC PROF DR AZMI BIN AWANG MD ISA

Date :

DEDICATION

For the sake of Allah, my Creator and my Master,

My great messenger, Muhammad S.A.W who taught us the purposes of life,

My beloved parents Halim Bin Karim and Rosnani Binti Om,

ABSTRACT

Coverage and energy efficiency metrics are two fundamental issues for almost all types of application in wireless sensor network (WSNs). Coverage reflects how well an area is monitored by sensor nodes and in energy efficient networks where less energy is consumed to provide the same level of services. These twin specifics are presented to evaluate the performance of a wireless sensor network. Due to its simplicity and ease of analysis, full coverage is widely implemented in many theoretical studies. However, sometimes full coverage is not the best way to represent some real-world application due to its strong restrictions and its deterministic characteristics. In this thesis, Modified Harmony Search algorithm (MHS) is proposed to achieve a sensor node deployment such that the covered area is optimal and data transfer has low energy consumption. Through computer simulations, experimental results verified that the proposed method improved the coverage of area in compare to some related methods. Based on the result obtain from every experiments, coverage area percentage performance is affected by the number of hotspots. This is shown by Harmony Search (HS) based method where the coverage area percentage increases as the number of hotspot increase. However, the sink node position and size of data transmitted will not affect the performance of coverage area. This is because the coverage area value is fluctuated as the parameters value increases. Throughout the experiment conducted, sensor nodes deployed using Modified Harmony Search algorithm (MHS) gives better coverage area compared to other existing methods. The average coverage area percentage obtained by Modified Harmony Search is 63 %. The average coverage area percentage obtained by Modified Random is 48 % and the average coverage area percentage obtained by Harmony Search is 46 %. The highest coverage area recorded for Modified Harmony Search is 70 %. To enhance the energy efficiency, shortest path distance finder is added to each method. Throughout the research, Modified Harmony Search with shortest path distance finder gives optimum results.

ABSTRAK

Litupan dan kecekapan tenaga adalah dua isu utama bagi hampir ke semua aplikasi Rangkaian Pengesanan Tanpa Wayar (WSN). Litupan mencerminkan sebaik mana sesebuah kawasan itu dipantau oleh nod pengesan dan berada dalam rangkaian kecekapan tenaga dimana kurang tenaga digunakan bagi menyediakan tahap servis yang sama. Kedua-dua spesifik ini dipersembahkan bagi menilai perlaksanaan Rangkaian Pengesan Tanpa Wayar. Disebabkan oleh faktor ringkas dan kemudahan untuk menganalisis, litupan penuh banyak digunapakai dalam kajian teori. Walaubagaimanapun, litupan penuh tidak sesuai untuk digunakan dalam beberapa aplikasi dunia sebenar berikutan beberapa sekatan dan ciri-ciri tertentu. Dalam tesis ini, algoritma Modified Harmony Search (MHS) diperkenalkan bagi mendapatkan satu atur kedudukan nod pengesan yang mampu memberikan liputan yang optimum disampaing penggunaan tenaga yang rendah bagi proses pemindahan data. Berdasarkan simulasi komputer, keputusan eksperimen mengesahkan bahawa kaedah yang diperkenalkan menambah baik liputan kawasan berbanding liputan kawasan bagi beberapa kaedah yang berkaitan. Berdasarkan keputusan diperoleh dari kesemua eksperimen, peratus liputan kawasan dipengaruhi oleh bilangan titik-titik panas. Hal ini dibuktikan oleh kaedah berdasarkan Harmony Search (HS) di mana peratusan litupan kawasan bertambah apabila bilangan titik-titik nod bertambah. Walaubagaimanapun, kedudukan nod tumpuan dan saiz data yang dipindahkan tidak mempengaruhi peratus litupan kawasan. Hal ini kerana nilai litupan kawasan turun naik apabila nilai parameter meningkat. Sepanjang eksperimen dijalankan, nod pengesan yang diatur menggunakan algoritma Modified Harmony Search memberikan litupan kawasan yang lebih baik berbanding kaedah yang sedia ada. Purata peratus litupan kawasan yang diperoleh kaedah Modified Harmony Search ialah 63%, 48% bagi kaedah Modified Random dan 46% untuk kaedah Harmony Search. Peratus tertinggi yang dicatatkan oleh kaedah Modified Harmony search ialah 70%. Bagi meningkatkan kecekapan tenaga, pencari jarak laluan terdekat ditambah pada setiap kaedah.Kaedah Modified Harmony Search dengan pencari jarak laluan terdekat memberikan keputusan yang optimum sepanjang penyelidikan.

ACKNOWLEDGEMENTS

First and foremost, I would like to give my highest gratitude to the Allah S.W.T for His blessings that I have now completed my Master of Science in Electronic Engineering. Special thanks also dedicated to my supervisors Associate Professor Dr. Azmi Bin Awang Md Isa, Dr. Afifah Maheran Binti Abdul Hamid and Mrs. Ida Syafiza Binti Isa for their supervisions during the duration of my research. They have helped and guided me very well regarding useful information and research techniques in order for me to complete this research project. Special dedications also to the authority of Universiti Teknikal Malaysia Melaka, especially to the Faculty of Electronic and Computer Engineering for the university research grant. The faculty had also provided useful and conductive facilities for me to conduct my research works. At last, I would like to extend my gratitude to my parents; Mr. Halim Bin Karim and Mrs Rosnani Binti Om, my siblings, and my friends for their encouragement, love and motivations throughout my whole journey. Once again, thank you so much.

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LIST OF ABBREVIATIONS

NKRA	-	National Key Result Areas
HS	-	Harmony Search
WSN	-	Wireless Sensor Network
MHS	-	Modified Harmony Search
MR	-	Modified Random
IR	-	Intersection Rate
PAR	-	Pitch Adjustment Rate
HMCR	-	Harmony Memory Consideration Rate
RR	-	Random Rate
QoS	-	Quality of Service
ADC	-	Analog Digital Converter
MANET	-	Mobile Ad Hoc Networking
NBC	-	Nuclear, Biological and Chemical
DSN	-	Distributed Sensor Network
CH	-	Cluster Head
VAP-E	-	Virtual Area Partition Enhancement
WVD	-	Weighted Voronoi Diagram
SRA	-	Sensing Radius Adaptation
MTC	-	Multiple Target Coverage
APTEEN	-	Adaptive Periodic Threshold-sensitive Energy Efficient Sensor Network
TDMA	-	Time-division Multiple Access

FSK	-	Frequency Shift Keying
PPM	-	Pulse Position Modulation
NLOS	-	Non-Line of Sight
LOS	-	Line of Sight
AOA	-	Angle of Arrival
ANN	-	Artificial Neural Network
HM	-	Harmony Memory
PSO	-	Particle Swam Optimization

LIST OF SYMBOLS

d	-	Distance
R	-	Radius
θ	-	Angle
h	-	height
B	-	number of backbone node
N	-	Total number of nodes
n	-	Number of transmit
NI	-	Number of Iteration
*r*1	-	Random number 1
*r*2	-	Random number 2
a	-	Intersection rate
b	-	Pitch Adjustment Rate value
x_i, y_i	-	Node position selected from HM
x_{iN}, y_{iN}	-	Neighbour of selected node from HM
$x_{newlocate}, y_{newlocate}$	-	New node position
x_{HMSi}, y_{HMSi}	-	Node position in HM

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   ISSN : 2289-8131, Vol. 9, No. 2-13

CHAPTER 1

INTRODUCTION

1.1 Background

Quite recently, due to the increase in the number of crimes throughout the nation, the government has taken the issue of crime prevention seriously and placed a priority in crime rate reduction as one of the NKRA (National Key Result Areas) under the Ministry of Home Affairs (Shahrudin, 2016). Wireless Sensor Network (WSN) application can be implemented to overcome this problem. However, using a big amounts of wireless sensor node may incur high cost (G.Thirumalaimuthu, Lawrence and S.Meenakshi, 2016). Hence, battery-powered wireless sensor nodes in a mesh network to provide extended coverage area for the system was deployed. In a mesh network, connectivity is an important issue for communication purpose between the nodes. Thus, this research focuses on exploring the performance of battery-powered wireless sensor nodes using Modified Harmony Search algorithm (MHS) for localization of the nodes with the possibility of achieving higher throughput and longer network lifetime. Therefore the objectives of this research are to study, deploy and analyse the WSN implementation with MHS in order to provide extended coverage area. The parameters that are being considered are node optimisation for localization and remaining battery level. Node optimization is important to achieve an excellent link quality between the nodes while remaining battery level prolongs network lifetime. This fundamental study can lead to an efficient security system using WSN with better performance of throughput and energy efficient of the nodes besides enhancing the coverage and network lifetime. This research is essential to support the government's

initiative to reduce the crime rate in Malaysia. Moreover, this is a potential collaborative community project between the researchers and the industrial partners in order to transfer the knowledge to nearby communities.

Most of the residential areas are provided with a guard system. However, the system is inefficient because the guard cannot monitor the whole residential area at one time. Therefore, an alert wireless system to guard the houses is needed so that actions can be taken quickly if houses be robbed. WSN limitations include radio range, battery lifetime, and geographical area. Thus, a multi-hop transmission of data between sensor nodes is needed. An optimisation method for node localisation can be used as a solution.

1.2 Problem Statement

Recent advances in wireless communications and electronics have enabled the development of low-cost and low-power, yet multifunctional sensor nodes that are small in size and able to communicate untethered in short distances. These tiny sensor nodes, which consist of sensing, data processing, and communicating components, leverage the idea of sensor networks (Akyildiz, and Cayirci, 2002). WSN is a wireless network that usually consists of a great number of far distributed devices that are equipped with sensors that measure quantities in our environment to monitor physical or environmental phenomenon.

Coverage problem reflect how well an area is monitored by the sensors. Coverage is one of the elements in sensor network which determine the effectiveness of the sensor application. Previous researchers had come out with different techniques and methods in order to ensure higher coverage area performance. However, there are limitations for each method.