MEDICAL EQUIPMENT TRACKING SYSTEM USING HYBRID QR CODE, WI-FI AND ULTRA-WIDEBAND

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ABSTRACT

Tracking technology is getting widely used in hospitals and is expected to assist in tracing the location of medical equipment and preventing medical equipment from loss or misplacement. However, the current tracking devices have some drawbacks such as low accuracy, low coverage area and high power consumption. The objective of this study is to develop a new hybrid tracking system to overcome these drawbacks. A new tracker device that uses Ultra-Wide Band (UWB) as the main module which has a high level of accuracy was developed and tested in this study. This study also presented several methods for improving the coverage area of the new tracker system, such as mapping the Received Signal Strength (RSS) of DWM1001-UWB anchors, combining it with an ESP8266-Wi-Fi module for a wider range of coverage area and using QR Code as a backup solution when the UWB and Wi-Fi modules are not working optimally. Additionally, this study has also optimized the battery life of the new tracker by removing the responsive mode of the UWB module. The new tracker was tested in a simulation-lab environment. The data of the movement of the tracker was collected in the JavaScript Object Notation (JSON) form and has been visualized by using Message Queuing Telemetry Transport (MQTT) method to the web-application. It was discovered that the new tracker has an accuracy of 74.6 mm-113.6 mm. It was also discovered that combining UWB with Wi-Fi and QR-Code as a hybrid system with one web-application can improve the tracker's coverage area. The battery lifetime of the new tracker was also estimated based on the type of usage and this can assist in ensuring that the tracker is constantly operating and does not lose signal due to running out of power. Results showed that with the typical active usage of 8 hours/day, the new tracker is capable of operating for 14.7 months. This study has succeeded in realizing a new hybrid tracker system with higher accuracy, higher coverage area and lower power consumption, consisting of UWB as the main module, with Wi-Fi module and QR-Code as a backup solution. The new tracker can become a single unit board and integrated in a single web-application.

ABSTRAK

Teknologi peranti pengesan telah digunakan secara meluas di hospital dan ia dijangka dapat membantu dalam mengenalpasti lokasi peranti perubatan, bagi mencegah kehilangan peranti perubatan atau kecuaian penyimpanan. Walau bagaimanapun, peranti pengesan yang ada pada hari ini mempunyai beberapa kelemahan seperti ketepatan yang rendah, kawasan liputan yang terhad dan penggunaan tenaga yang tinggi. Objektif kajian ini adalah untuk membina sistem pengesan peranti perubatan hibrid baharu untuk mengatasi kelemahan ini. Peranti pengesan baharu yang menggunakan Ultra-Wide Band (UWB) sebagai modul utama dan mempunyai tahap ketepatan yang tinggi telah dibina dan diuji di dalam kajian ini. Kajian ini juga membentangkan beberapa kaedah untuk meningkatkan kawasan liputan pengesan baharu, seperti memetakan kekuatan isyarat terimaan (RSS) bagi Anchor DWM1001-UWB, menggabungkannya dengan modul ESP8266-Wi-Fi untuk memperoleh kawasan liputan yang lebih luas, dan menggunakan QR-Code sebagai penyelesaian alternatif apabila modul UWB dan Wi Fi tidak berfungsi secara optimum. Selain itu, kajian ini juga memanjangkan hayat bateri peranti pengesan baharu dengan mengalih keluar mod responsif modul UWB. Peranti pengesan baharu ini telah diuji dalam persekitaran makmal simulasi. Data pergerakan peranti pengesan ini telah dikumpulkan dalam bentuk JavaScript Object Notation (JSON) dan telah divisualisasikan menggunakan kaedah Message Queuing Telemetry Transport (MQTT) ke aplikasi sesawang. Berdasarkan data yang telah dikumpul, ia dapat dilihat bahawa peranti pengesan baharu ini mempunyai ketepatan sebanyak 74.6 mm-113.6 mm. Ia juga mendapati bahawa menggabungkan UWB dengan Wi-Fi dan QR-Code sebagai sistem hibrid dengan satu aplikasi sesawang dapat meningkatkan kawasan liputan pengesan. Jangka hayat bateri peranti pengesan baharu juga telah berjaya dianggarkan berdasarkan tren penggunaan aktif selama 8 jam sehari dan ini mampu memastikan peranti pengesan sentiasa beroperasi dan tiada kehilangan isyarat berlaku akibat kehabisan tenaga. Keputusan menunjukkan bateri peranti pengesan ini boleh berfungsi selama 14.7 bulan. Kajian ini telah berjaya merealisasikan sistem peranti pengesan hibrid baharu dengan ketepatan yang lebih tinggi, kawasan liputan yang lebih jauh dan penggunaan tenaga yang lebih efisyen yang terdiri daripada UWB sebagai modul utama, dengan modul Wi-Fi dan QR-Code sebagai penyelesaian alternatif. Peranti pengesan baharu ini mampu menjadi papan unit tunggal serta dikombinasikan denganWeb-application tunggal.

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LIST OF ABBREVIATIONS

BLE	-	Bluetooth Low Energy
GUI	-	Graphical User Interface
IoT	-	Internet of Things
JSON	-	JavaScript Object Notation
LOS	-	Line of Sight
MQTT	-	MQ Telemetry Transport
N/A	-	Non-Applicable
NAN	-	Not a Number
NLOS	-	Non-Line of Sight
QR-Code	-	Quick Response Code
RFID	-	Radio Frequency Identification
RSS	-	Received Signal Strength
RSSI	-	Received Signal Strength Indicator
RTLS	-	Real-Time Location System
TDoA	-	Time Difference of Arrival
ToA	-	Time of Arrival
ToF	-	Time of Flight
TWR	-	Two Way Ranging
UTM	-	Universiti Teknologi Malaysia
UWB	-	Ultra-Wide Band
Wi-Fi	-	Wireless Fidelity

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CHAPTER 1

INTRODUCTION

1.1 Problem Background

In recent years, hospitals have faced significant cost pressures in terms of their management system, in terms of maintaining their medical equipment, how to monitor the productivity of their medical equipment, how to monitor their services to patients (1,2). there are a lot of lost assets, not in the right place, wasted accidentally (3), nurses need a very long time to find medical equipment, which of course is very detrimental in terms of time and resource, many equipment are damaged unnoticed, many equipment are needed at the same time by other users, technicians find it difficult to identify assets and various other problems that can be caused by poor management systems for assets in hospitals (4). With the increasing burden on patients in the hospital, the need for stable management is needed, and the demand for medical supplies will always increase. Therefore, it is very important to ensure that they are used effectively (4,5).

Recognizing that poor tracking system of medical equipment will reflects ineffective use of organizational assets, Hospital assets play an important role in providing health care. The increasing number of hospital assets, however, brings important issues related to asset productivity, security, safety, and sustainability (6,7) and the current error-prone manual system makes it difficult to track the movement of medical equipment. Conventional paper-based asset management is not really effective to use for a large number of assets in the hospital (8) It is clear that hospitals must upgrade their technologies. The rapid advancement of technology allows us to overcome this problem, one solution is to use Internet-of-Things (9–11), specifically called as Realtime Localization System (RTLS), DWM1001 is one of the UWB modules that researchers can develop to be used as a RTLS Tracker. The tracker must be able to collect information about the location of the medical equipment, and condition of the medical equipment, and also can be customized for patient needs as well (9–11). This data can be used to estimate patterns to encourage asset management to achieve the optimal distribution of medical equipment available throughout the hospital.

The ability to know the location of medical equipment is not enough, with IoT-based technology, in addition to location, another features that can greatly help the management system in Hospital could also be implemented (12), such as, the ability to find out whether the object (could medical equipment or patient) is falling or not, so the hospital can find out more early on (13–15), the device can also send a signal in the form of a help button, so that officers can be notified more quickly, features like this will certainly make work at the hospital easier (16–18).

With a variety of complexities in the hospital, tracker made should also adjust to these complexities. with many medical equipment in the hospital, many rooms and barriers, many people passing by, requires that the Tracker is guaranteed to be reliable, and customizable (12,19,20).

1.2 Problem Statement

There are many smart trackers available in the market, they use either low-cost technology such as barcode (21,22) and RFID (23–26), or they use high-cost technology (chip-based tracker). However, the existing trackers have some drawbacks. They are either for special purpose with limited function only or very complex and expensive. There are some trackers that focused only for location tracker, or temperature condition only. Some trackers don’t give information real-time, such as barcode and RFID (22,27–31), some complex trackers provide real-time information, but it is costly and not accurate such as Wi-Fi and BLE. In order to overcome this problem, a new hybrid tracker for hospital management and special platform for implementation, has been explored and realized.

1.3 Research Objectives

The objectives of this thesis are:

1. To develop a new hybrid QR Code, Wi-Fi and Ultra-Wideband tracking system
2. To test and evaluate the new hybrid tracking system.

1.4 Research Scope

The scope for this research includes:

1. Literature Study
2. Software Specification Design
3. Tracker Hardware Design
4. Design Implementation
5. Test Design
6. Data Analysis
7. Paper and Report Writing

1.5 Thesis Organization

This Thesis is generally divided into five chapters. Each chapter can be divided into one or more sections. with the presentation as follows:

- Chapter I INTRODUCTION

  This chapter discusses the background of the thesis, problem formulation, objectives, problem boundaries, research methodology and writing systematics.

- Chapter II LITERATURE REVIEW

  This chapter contains the basics of theory, information and alternative designs needed by the author to meet the specifications of the technology and module to design and implement this thesis.

- Chapter III RESEARCH METHODOLOGY

  This chapter describes the specifications, the process of designing algorithms localization and implementation on the Tracker.

- Chapter IV RESULTS AND ANALYSIS

  This chapter explains about results, including testing systems designed and verified with system specifications made.

  and contain the discussion about the interpretation of the results, opinion and recommendation for the next thesis.

- Chapter V CONCLUSSION AND RECOMMENDATIONS

  This chapter contains conclusions from the results obtained in this thesis, along with suggestions for future development.

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