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Recruitment Internet Of Things For Medical Condition Assessment: Electrocardiogram Signal Surveillance

Reclutamiento Internet De Cosas Para La Evaluación De La Condición Médica: Vigilancia De La Señal De Electrocardiograma

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ABSTRACT/ Recently, the world has witnessed a significant increase in attention to healthcare sensing and surveillance. For surveillance purpose of cardiac patient, the physiological information acquisition is very significant as many chronic patients can interest from continuous surveillance as a part of a diagnostic procedure. The internet of things is becoming a promising future for various applications. One of its operations is to monitor the physiological signals of patients with cardiac diseases, which can be measured by wearable wireless sensor networks. In this paper, a complete real-time surveillance Electrocardiogram system that monitors patients in various environments is presented. This system is consists of Arduino LIKE system with wireless sensor networks connect directly on the patient body by many electrodes which connect directly with PC to implement a complete connection to the internet. To guarantee a stored Electrocardiogram signal safely and quickly without any distortion through transmission, and to guarantee the compatibility of these signals through the processing, the authenticated Blynk server was used with its software app. Keywords: Internet of Things; Electrocardiogram; Wireless Body Sensor Network; Arduino LIKE. **RESUMEN** / **Recientemente, el mundo ha sido testigo de un aumento significativo en la atención a la detección y vigilancia de la atención médica. Para fines de vigilancia del paciente cardíaco, la adquisición de información fisiológica es muy significativa ya que muchos pacientes crónicos pueden interesarse por la vigilancia continua como parte de un procedimiento de diagnóstico. El internet de las cosas se está convirtiendo en un futuro prometedor para diversas aplicaciones. Una de sus operaciones es monitorear las señales fisiológicas de los pacientes con enfermedades cardíacas, que pueden medirse mediante redes inalámbricas de sensores portátiles. En este documento, se presenta un sistema completo de electrocardiograma de vigilancia en tiempo real que monitorea a los pacientes en diversos entornos. Este sistema consiste en un sistema Arduino LIKE con redes de sensores inalámbricos que se conectan directamente en el cuerpo del paciente mediante muchos electrodos que se conectan directamente con la PC para implementar una conexión completa a Internet. Para garantizar una señal de electrocardiograma almacenada de forma segura y rápida sin ninguna distorsión a través de la transmisión, y para garantizar la compatibilidad de estas señales a través del procesamiento, se utilizó el servidor Blynk autenticado con su aplicación de software.**
Palabras clave: Internet de las cosas; Electrocardiograma; Red inalámbrica de sensores corporales; Arduino como.

I. INTRODUCTION

According to the institution of the World Health Organization, recently, cardiac disease has become a serious and fatal disease that causes death to people. Therefore, the disease cannot be seen as a minor disease. Consequently, most health surveillance systems are designed to track the disease [1].

With the development of technology and electronic industry, medical data collection has become much easier. Electrocardiogram devices are smaller, have lower weights and also have lower power consumption, making them one of the most basic medical diagnostic systems in any health care center or hospital. The heart attack is the most common cardiac disease that causes sudden death, which is the

public cardiac disease. For purposes of monitoring and constantly monitoring the state of the heart, Electrocardiogram is the most common and direct method. The heart patient needs periodic and continuous surveillance and is maintained sometimes in an insensitive care unit (ICU) that needs more facilities and manpower that ultimately increases the cost and demand for qualified medical staff such as caregiver [2].

Recently, medical information systems have become inexpensive and affordable, especially as there are ongoing attempts to develop them to make them accessible to everyone. These systems have become very widespread, especially with the development of Internet of Things-based technology as well as bandwidth and PC. These factors have provided connecting data in the environment information through large medical equipment, such as an Electrocardiogram device.

A wireless network called wireless biomedical sensor networks is wirelessly connected to the PC in order to provide essential information about the physical phenomenon to be studied. It is a collection of sensors used for specific physical phenomenon transmission (such as temperature, humidity, Electrocardiogram signal, etc.) and then transmits phenomenon information wirelessly to the data processing center (server) to benefit without the need the patient's presence. These networks represent a potential solution to the problem of transmitting vital signals from the patient to specialists in remote areas for medical diagnosis purposes which represents a solution for monitoring long-term(24/7) and ongoing healthcare [3].

The designing of this surveillance scheme is for homecare conditions and is usually classified into three elements, which is the data acquisition part, the data terminal part and the data processing part that will be demonstrated in the next parts. This article will additionally explain the HW and SW improvement and integral.

The proposed surveillance system for a cardiac disease patient-care environment in various settings are usually divided into three basic parts as shown embedded in Figure 1, as follows:

1. Data acquisition part (patient side, Wireless Body Sensor Network),
2. Data Processing Part (Arduino LIKE Part), and
3. Diagnosis or Decision part (Physician Part)

This work is organized as follow: Related work Electrocardiogram signal surveillance is discussed in Section3. The system method and materials presented in Section 4. Section 5, presented a proposed system architecture. The proposed procedure, introduced in section 6. Experiments results & discussion are shown in section 7. And in section 8, show the concludes the work [4].

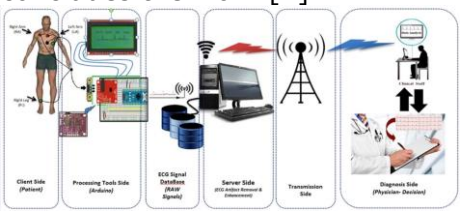

Figure 1. The Overall Proposed System

II. SYSTEM OBJECTIVE

Whatever portable devices were embedded with the patient's body (by clothing or a portable device or others), the optimum objective of wearable technology is easy to patient information access directly and rapidly.

III. RELATED WORKS

There are many heart rate monitoring systems used by health professionals in most hospitals. Most of these systems are manual methods to measure the Electrocardiogram signal.

For the purposes of the examination, the Electrocardiogram chart is read on a device installed beside the bed or through special screens for this purpose. The long distances here are not supported by these wired and optical devices.

There are many problems in these systems related to the high cost of hospital stay, which is financially burdensome for the patient if it is a long time and is one of the requirements for treatment completion for patients and needs to be fixed in addition to the monitoring of experts [5][6].

There are novel methods have been designed in order to measure the heart rate and surveillance the patient's case, including the heart rate's automation and measurements of Electrocardiogram utilizing modern approaches. Many authors have made an assessment of the available systems available for the purpose of controlling various vital body features such as temperature, Electrocardiogram, heart rate, pulse rate, etc. [8][7].

Many researchers utilized many techniques for different heart signals data gathering in order to detect a heart attack or emergency related to cardiac disease[12]. The authors proposed

a detection system for heart attack by using a ZigBee heart rate surveillance system and an alarm. Researchers conducted an extensive study on healthcare and medical practices based on mobile phones. This method highlights the use of inbuilt applications such as services on site for smartphones such as the Global Positioning System which is used to monitor the location of older cardiac patients with instability [9][10].

There are many researchers who have suggested their different methods using smartphones and are able to detect, store and analyze collected medical records in order to monitor the health of heart patients[11]. Based on a healthcare surveillance system in different settings (hospitals, homes, etc.) that use a wireless sensor network, cardiac patients can be closely monitored to give a proper diagnosis and save their lives[13]. Hence, these systems have made great progress as they became more accurate, reliable and cost-effective and facilitated wear using biological sensors. These systems have achieved different goals such as low cost and reduced long hospital stay as well as continuous and long-term monitoring of heart patients without expert attendance[14] [15].

IV. METHOD AND MATERIALS

Each heartbeat can be captured through an Electrocardiogram sensor with electrodes that can be directly attached to the patient's chest. These heartbeats turn into an electrical signal by the Electrocardiogram electrodes connected directly to the chest of the patient through the medical test. Electrocardiogram sensors are very light and lightweight sensors, which measure the accuracy of the continuous heartbeat and give heart rate data. The doctor and medical assistant using this device continuously.

There are three pins in the Electrocardiogram sensor electrodes connected by a 30-inch cable. The Electrocardiogram sensor is easily connected to the control unit, can be carried easily, and placed on the patient's waist or in the pocket. The Electrocardiogram sensor is placed on the arm and leg of the patient to easily pick up the pulse as all sensor poles have ways to assemble into the body. So, the patient can select the kind of electrode to measure heartbeat. The following figure 2, shows the overall methodology of the proposed system.

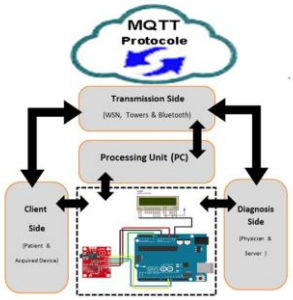

Figure 2. The Methodology of Electrocardiogram Signal System

The proposed surveillance system is consists of three main parts, firstly, the patient tier (the client, as an input to the system as Electrocardiogram signals); secondly, is the system tier (based on Arduino LIKE as a processing unit); and finally is the specialist's tier (Diagnosis or Decision level). The proposed system halts any part of these three parts mentioned above causes the system stops completely. Every part of these parts is the system is directly connected wirelessly with Wireless Body Sensor Network that used for patient healthcare monitoring.

V. PROPOSED SYSTEM ARCHITECTURE

The architecture of the proposed system can be described as the following:

A. H/W and S/W System Requirements:

All healthcare tracking devices for cardiac diseases consist of two basic parts: hardware and software. A patient's heart health monitor consists of both hardware and software requirements. Hardware requirements consists of, Arduino LIKE -Microcontroller Type (model WEMOS D1-ESP 8266), Operating Voltage 3.3 V, Digital I/O Pins 11, Analogue Input Pins 1(Max Input:3.2 V), Clock Speed 80MHz/160MHz, Flash 4 MByte, Module of Electrocardiogram Sensor (Electrocardiogram AD8232), Pieces of Electrocardiogram Electrodes Connector (RA, LA, and RL: RA-Input, LA - Input, and RL- Input with size 3.5 mm, and finally Power Supply. On the other hand, software requirements include, IDE Arduino LIKE with C language built-in, Processing IDE, Blynk Cloud Server, Cloud Server App, to implement the proposed model.

1) Message Queuing Telemetry Transport (MQTT) Protocol

The MQTT protocol is one of the most widespread and dependable Internet protocols. The simplified design and lightness of these protocols make it an appropriate solution for embedded devices with limited

and unlimited resources in processing and storage capacity. The protocol offers benefits that reduce power consumption and bandwidth, and these are two very important factors in Internet objects. MQTT is a message-transfer protocol between a server and a client/publisher/publish/subscribe client. Is a light, open, and easily designed. protocol. This is according to the official definition and is designed specifically for the context of Internet applications[18][19][20]

B. Electrocardiogram Data Acquisition

The acquisition of data is a part of the surveillance system concerns with the Electrocardiogram sensor panel development consisting of amplified signal circuits and Electrocardiogram electrodes. The function is to collect data (heart signal) of the human body and amplify and filter the signal before sending it to its destination. Another part of the enterprise is a data terminal consisting of microcontroller circuits to process the acquired data and then send it to the data processing part[21][22][23]. It receives a heart signal in analog format and then transforms it to an 8-bit resolution of the digital signal and 500Hz sampling rate before sending these signals to the PC. For the purpose of enabling multi-hop connections, a simple routing mechanism is implemented, thus ensuring that the data reaches its destination via intermediate sensor points regardless of the patient's distance from the base station. The Electrocardiogram sensor node is designed in Figure 3 for continuous transmission to signal wirelessly to the base station. The sensor collects helpful Electrocardiogram data for the patient. These collected cardiac signals are filtered and amplified in order to prepare them for transmission purposes, that can be obtained directly from the patient's body through continuous observation. These signals range in value from 0.5 mV to 5.0 mV.

Figure 3. Heart Rate Measuring Sensor Type (Electrocardiogram AD8232)

A. The Core Terminal

Vital Electrocardiogram data is transferred from the patient to the server as well as the PC using the AODV multi-hop routing system. The function of the PC is a data processor, where it is utilized for Electrocardiogram signals reconstruction from the digitized signals.

As a serial interface, the receiver module can be connected directly as shown in Figure 3, is connected as a serial communication interface to the PC via RS22. It receives data sent by a wireless controller and sends these data sequentially to a PC that will be processed and displayed in the form of analog Electrocardiogram signals that were built using the built-in graphical user interface built-in.

Graphical user interfaces is easy to use, it has been programmed by applying Visual Studio version 6.0 programming and able to get an information packet in real time. Then decoded the stream raw data package, and plot it upon the screen[16].

Showing the heartbeat visually and on the computer screens helped to detect the abnormalities and abnormalities in the heart, for example, bradycardia sinus or tachycardia sinus. Figure 4, explains the core terminal of the suggested system:

Figure 4. WEMOS D1 Arduino Like

A. Wearable Wireless Sensor Network

Signals measurement will be transmitted directly to the local PC located in the patient to be able to constantly sense Electrocardiogram signals of any patient, a wearable wireless network sensor that is built on the patient's body is utilized. wireless sensor networks has main electrodes, sensor chest, communication, transmitter, and a signal processing circuit. The electrodes connected to the patient's chest capture heart signals from the heart. Captured Electrocardiogram signals will be filtered and amplified utilizing the interfacing and signal processing circuit home, and then transfer these signals to the internet and to the mobile device that supports the software sending measured data to the Internet.

In case a patient outside the boundaries of the hospital, Electrocardiogram data will be captured and transferred to the internet directly, and then to the hospital control room for any emergency procedures should be

taken. The physician will communicate with the hospital server directly for any action[17].

B. Environment Local Server (ELS)

ELS has all indispensable databases for all patients and doctors that connected to these databases. It contains all necessary patients information since they have been connected to this server. This server is the general signals used by physicians for the proper diagnosis of their patients and the therapy speed.

C. Alarm System (AS)

In case of an emergency, the AS will be activated. Therefore, a warning and light warning procedure will be taken. A small, high-volume warning device is connected to the Arduino LIKE system. In the future, the warning system will be integrated into the mobile phone, as well as the local server, and the PC in the patient's environment.

VI. THE PROPOSED PROCEDURE

In this article, a broad real-time monitoring Electrocardiogram system that monitors the patient through various environments (home, office, hospital, and others) was introduced. In this scheme, a wireless sensor networks Network on the body of a patient with a cluster head sensor which connects with the deployed Wireless Home Network, Wireless Office Network or Wireless Hospital Network is connected. All data recorded utilizing the wireless sensor networks network are transmitted via Wireless Hospital Network. For any urgent emergency action, the hospital sends the data to the doctor immediately.

For Electrocardiogram signal surveillance, the Arduino LIKE board to perform the functions of communications and data processing were utilized. The patient assessment suggested procedure is described below:

1) Connect Arduino LIKE Circuit with PC directly.
2) An Electrocardiogram signal acquisition from the patient body by using 3 main electrodes (LA, RA, and RL)
3) Send the Electrocardiogram signal through the amplification circuit.
4) Using the amplification circuit for Electrocardiogram signal amplification.
5) Using the board of Arduino LIKE for signal amplification reading.
6) Measuring the voltage and time interval for all Electrocardiogram signal.
7) Utilizing a home wireless network or Bluetooth for Electrocardiogram data transmission.
8) Comparing an Electrocardiogram data with an Electrocardiogram Value rated on PC.
9) If found an Electrocardiogram irregular signal, the alarm message is sending.

The following part describes the practical side of the proposed system applied on the real patient through the testing phase.

Figure 5. Overall System Connections

The above figure shows the method of components connections of the proposed system and the method of connecting to the patient's body.

WEMOS D1 Arduino Like is connected directly to the Electrocardiogram sensor type EC82 AD8232, which is connected to the three electrodes that directly connect to the patient's body. The first electrode (V1) placed on the right rib of the chest, the second electrode (V2) placed on the left rib of the chest, the last electrode (V3) is located in the half distance between V1 & V2. All these components are directly connected to the WiFi ESP 8255 embedded in the WEMOS D1 Arduino Like, and directly to the access point (internet). These data sent to the cloud server (based-on MQTT protocol) to transmit directly to the physician for diagnosis purpose.

VII. RESULTS AND DISCUSSION

A prototype was developed to monitor and test an Electrocardiogram signal by the physician. System validation includes determining the correct samples for a human study indicated to evaluate the performance of the system in various real-world environments. Heart rates can be divided into three basic stages: sinus arrhythmia, sinus rhythm, and irregular heartbeat sinus. The heart rate is measured within the number of beats per minute (BPM) or the number of contractions of the heart in one minute. The following Figures 5 (a, b, and c), shows the different Electrocardiogram signal readings from various patients gained from a private clinic that has been monitored by the proposed model. These three forms were taken from three patients with myocardial infarction: Electrocardiogram arrhythmia (Electrocardiogram Irregular

heartbeat), Sinus arrhythmia, Sinus arrest, and Sinus bradycardia. These signals were captured through the proposed system.

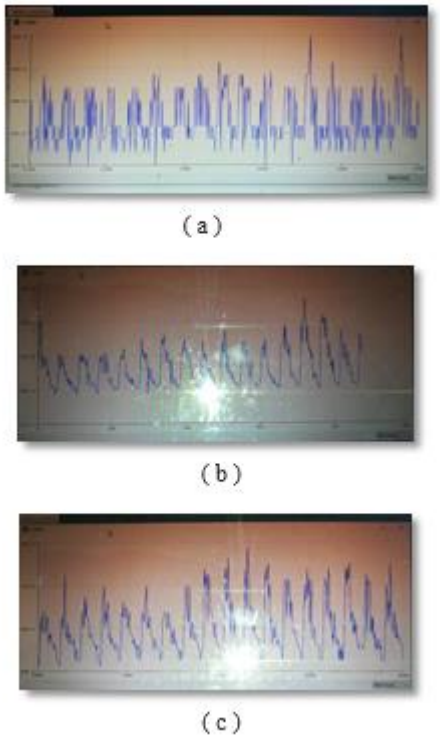

Figure 6. a,b, and c, A different Electrocardiogram signal readings for different patients

The QRS detection flag recognizes the steep slopes and high amplitudes of the QRS complex adequately to be utilized as an Electrocardiogram device for patient surveillance.

Based on the above readings, the cardiac disorders kind determined with the assist of the proposed model.

VIII. CONCLUSION

The mortality of cardiovascular disease is a surprise, and that patients with this disease need to continuously monitor the interest of their lives. Therefore, the patient must be medically monitored by observing the body's vital parameters which accurately illustrates the patient's current condition, such as heart rate, pulse rate, electrical heart (Electrocardiogram). In this paper, present the system architecture of the healthcare surveillance based on WSN and Arduino LIKE that is developed to surveillance the parameters of a certain body of the cardiac patient continuously. The Electrocardiogram signal captured by biometric sensors connected to the Arduino LIKE plate is sent to measure the heart rate and signals to the server using the wireless node. Data is provided on remote servers for doctors and caregiver based on Internet of Things. Electrocardiogram data are acquired by readings from heart rate sensor using an Arduino LIKE, and send it over Wi-Fi to the internet to transmit to the specialists for diagnosis purposes. Data is provided on remote servers for doctors and caregivers. The initial tests mention to the system accuracy is better results, this is referred to the system efficiency to provide necessary medical assistance to the cardiac patients. To ensure that cardiac signals stored safely and rapidly transmission without distortions during transmission, and to ensure the compatibility during the processing, a reliable Blynk cloud server was used with its application.

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