Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF AN AUTOMATIC IOT-BASED SEPSIS INFECTION DETECTION SYSTEM FOR AFTER-SURGERY PATIENTS

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DEVELOPMENT OF AN AUTOMATIC IOT-BASED SEPSIS INFECTION DETECTION SYSTEM FOR AFTER-SURGERY PATIENTS

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DEDICATION

I dedicate this report to my beloved,
father, KHOH KOK CHING, and mother, NG HOW LOON,
whose always support and encourage me to reach this destination.

And along with all hard working and respected,
Supervisor, IZADORA BINTI MUSTAFFA.

ABSTRACT

Sepsis is a reaction of the body to an infection at its most severe. It is a medical emergency that might put patients' life at risk. Sepsis occurs when an existing infection sets off a chain reaction that spreads throughout the body. Sepsis can cause tissue damage, organ failure, and death if it is not treated quickly. People who have weakened immune system such as the elderly folks, chronic medical conditions or people who have recently been hospitalized have higher risk to sepsis infection. Therefore, it is critical to continue to monitor their vital signs. The objective of this project is to develop a sepsis infection detection system using Arduino Uno. To detect a sepsis infection, the heart rate as well as the temperature of the patient must be monitored. And so, a non-contact infrared temperature sensor and pulse sensor were used. The signals acquired from the sensors are then sent to a smartphone by the Arduino Uno through NodeMCU ESP8266 to the Blynk application on the smartphone. When the system detects the onset of probable sepsis, it sets off the sound and light alarm, and sends a notification to the closest relative or doctor. In conclusion, this project can reduce the number of medical emergency caused by sepsis with the help of IoT.

ABSTRAK

Sepsis adalah tindak balas badan kepada jangkitan yang paling teruk. Ia adalah kecemasan perubatan yang mungkin membahayakan nyawa pesakit. Sepsis berlaku apabila jangkitan sedia ada mencetuskan tindak balas berantai yang merebak ke seluruh badan. Sepsis boleh menyebabkan kerosakan tisu, kegagalan organ, dan kematian jika ia tidak dirawat dengan cepat. Orang yang mempunyai sistem imun yang lemah seperti orang tua, keadaan perubatan kronik atau orang yang baru dimasukkan ke hospital mempunyai risiko yang lebih tinggi untuk jangkitan sepsis. Oleh itu, adalah penting untuk terus memantau tanda-tanda vital mereka. Objektif projek ini adalah untuk membangunkan sistem pengesanan jangkitan sepsis menggunakan Arduino Uno. Untuk mengesan jangkitan sepsis, kadar denyutan jantung serta suhu pesakit mesti dipantau. Oleh itu, penderia suhu inframerah bukan sentuhan dan penderia nadi telah digunakan. Isyarat yang diperoleh daripada sensor kemudian dihantar ke telefon pintar oleh Arduino Uno melalui NodeMCU ESP8266 ke aplikasi Blynk pada telefon pintar. Apabila sistem mengesan permulaan kemungkinan sepsis, ia mematikan bunyi dan penggera cahaya, dan menghantar notifikasi kepada saudara terdekat atau doktor. Kesimpulannya, projek ini dapat mengurangkan bilangan kecemasan perubatan yang disebabkan oleh sepsis dengan bantuan IoT.

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LIST OF SYMBOLS

ºC	-	Celsius
ºF	-	Fahrenheit
%	-	Percentage
k	-	Kilo
M	-	Mega
Hz	-	Hertz
B	-	Byte
Ω	-	Ohm
V	-	Voltage

LIST OF ABBREVIATIONS

bpm	-	Beats per minute
IoT	-	Internet of Things
COVID-19	-	Coronavirus disease
WiFi	-	Wireless Fidelity
LED	-	Light-emitting Diode
IR	-	Infrared
USB	-	Universal Serial Bus
ICSP	-	In Circuit Serial Programming
CPU	-	Central Processing Unit
RISC	-	Reduced Instruction Set Computer
RTOS	-	Real-time Operating System
RAM	-	Random Access Memory
IOS	-	Iphone Operating System
GND	-	Ground
RXD	-	Receive Data
TXD	-	Transmit Data
SCL	-	Serial Clock
SDA	-	Serial Data
VCC	-	Voltage Common Collector
VLSI	-	Very Large-scale Integration
GSM	-	Global System for Mobile Communication
LCD	-	Liquid Crystal Display
ADC	-	Analog to Digital Converter
RF	-	Radio Frequency
ECG	-	Electrocardiogram
EEG	-	Electroencephalogram
PC	-	Personal Computer
SMS	-	Short Message Service
TTL	-	Transistor-Transistor Logic

CMOS	-	Complementary Metal-Oxide-Semiconductor
IC	-	Integrated Circuit
SIM card	-	Subscriber Identity Module card
MQTT	-	MQ Telemetry Transport
NTC	-	Negative Temperature Coefficient
LDR	-	Photoresistor

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CHAPTER 1

INTRODUCTION

1.1 Background

The immune system of the patient defends them from diseases and infections, but it can also go into overdrive in reaction to an infection. Sepsis occurs when the immune system's chemicals sent into the bloodstream to combat an infection instead create widespread inflammation throughout the body. Septic shock, a medical emergency, can result from the sepsis infection. Sepsis can occur when a patient is recuperating from a procedure in the hospital, although this is not always the case. If the patient experiences the sepsis infection symptoms which are a fever above 38ºC (101ºF) or a temperature below 36ºC (96.8ºF) and heartbeat rate higher than 90 beats per minute (bpm), it is critical that they get medical help right away. The sooner a patient seeks care, the better his or her chances of survival [1], [2].

In the medical technology field, the rising usage of mobile technology and smart gadgets has had a significant influence on the globe. Health professionals are increasingly taking benefit of the advantages that these technologies provide, resulting in major improvements in healthcare clinical treatment. Similarly, countless regular users benefit from the advantages of M-Health (Mobile Health) applications and E-Health (healthcare assisted by ICT) to enhance, help, and aid their health [3]. The normal body temperature is 37°C (98.6°F). This is an average number that might be somewhat higher or lower. A body temperature value that is higher or lower than the norm does not always indicate that a person

is ill. Age, gender, time of day, and activity level are the factors that might affect a person's body temperature. The average body temperature of babies and children is between 36.6℃ (97.9°F) and 37.2°C (99°F). The mean of the body temperature in adults is between 36.1℃ (97°F) and 37.2°C (99°F). The average body temperature in elderly persons is lower than 37°C (98.6°F) [4]. Adults have a resting heartbeat rate of 60bpm to 100bpm. In general, a lower resting heart rate indicates greater cardiac function and cardiovascular fitness. A well-trained athlete, for example, would have a resting heart rate closer to 40bpm [5].

Patient monitoring system through Internet of Things (IoT) is a technology that allows patients to be monitored outside of traditional clinical settings (for example, at home), potentially increasing access to care and lowering healthcare expenditures. This has the potential to greatly improve a person's quality of life. It helps patients to preserve their freedom while avoiding problems and lowering their own expenditures. This system causes these goals possible by delivering care to the patient's home. Furthermore, patients and their families are relieved to know that they are being watched over and will be helped if any health issues occur [3]. This technology allows us to keep track of patients even if they are not at the clinic or hospital. It has the potential to enhance the access to health services and facilities while lowering costs. Remote patient monitoring saves time for both the patient and the doctor, resulting in improved health service efficiency and dependability [6].

1.2 Problem Statement

Sepsis is a life-threatening disease caused by the body's reaction to an infection, such as a kidney or bloodstream infection. Infection can affect anyone, and practically any illness, including COVID-19 can cause sepsis. In the United States, sepsis affects at least 1.7 million individuals and kills around 270,000 people each year. Sepsis affects one out of every three hospital patients who dies. In approximately 87% of instances, sepsis or the infection that causes sepsis begins outside of the hospital [7]. Despite the fact that sepsis can be fatal, the sickness might be mild or severe. Mild instances have a better chance of recovery. It is impossible to overemphasize the importance of monitoring a sepsis patient's vital signs including heartbeat rate and body temperature. After the patient returns home from the hospital, sepsis infection might develop. As a result, even after the patient has gone home, it is critical to continue to monitor them. The doctor has no ideas of knowing whether any of the patient's vital signs change. In order to solve these problems, an automatic IoT-based sepsis infection detection system is to notify the patient and doctor through a real-time system.

1.3 Project Objective

The main aim of this project is to propose a low cost, portable and functional IoT-based sepsis infection detection system. The following are the specific objectives:

a) To develop a sepsis infection detection system using Arduino Uno.

b) To detect patient's body temperature and heartbeat rate using MLX90614 non-contact infrared (IR) temperature sensor and pulse sensor.

c) To implement an effective sepsis infection detection system towards the patient using IoT.

1.4 Scope of Project

The scope of this project are as bellow:

a) Study various literature regarding the technology and development related to this project to have a clear idea of what the current trend is, and which context is suitable in developing this project to ensure its success.

b) Acquire physiological inputs namely the body temperature and heart rate using the MLX90614 non-contact IR temperature sensor and pulse sensor by using Arduino Uno.

c) Develop an algorithm to classify the inputs as sepsis infection indicators.

d) Transmit the output data through a NodeMCU ESP8266 to the patient's and doctor's mobile device with a mobile application called Blynk.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter investigates and examines earlier research, projects, articles, and journals that are relevant to this project. This chapter contains theoretical principles as well as some practical suggestions for this project. Furthermore, these associated tasks were carefully examined to increase the project's quality and dependability. As a result, this chapter is included to ensure that a solid strategy for implementing this project is in place.

2.2 Microcontroller in Patient Monitoring System

2.2.1 PIC Microcontroller

A patient monitoring system developed by Islam et al. [8], used a PIC16F877A microcontroller which regulates the function of switches, LCD display, GSM modem interface. The microcontroller also samples the input waveform. The microcontroller counts pulses for 15 seconds before displaying heart rate on the LCD. The GSM module simultaneously sends the report to the doctor.

Kale et al. [9] has proposed a system which monitor patients with heart illness and physical disorders using also the PIC16F877A microcontroller. Besides heart rate, the system also detects the body temperature. An ADC is implemented into the PIC16F877A microcontroller, which will convert analogue data to digital.

The development of a wireless temperature and heartbeat monitoring system for a patient using the PIC16F72 microcontroller was described by Das, Alam and Hoque [10]. This device was made up of two PIC16F72 microcontrollers, one for measuring and transmission and the another one for receiving. The algorithm counts the heartbeat for a certain interval of time and yields the heart rate in beats per minute. The PIC16F72 microcontroller then sends the heart rate and temperature to be transmitted. The authors continue to explain that the acquired signal needs to be amplified as the photodiode signal was too weak for the microcontroller to detect it directly. The amplified pulses were counted by the microcontroller after the signal was amplified to the appropriate voltage level. The signals were filters and was transmitted using an RF transmitterto the second microcontroller on the receiving end, which then displays the signal on an LCD. Temperature and heartbeat signals were processed in the PIC16F72 and wirelessly delivered to and received at the remote end through RF transmitter and RF receiver. The signals received was processed in the PIC16F72, and the measured data was successfully presented on the remote end via the LCD.

2.2.2 Raspberry Pi Microcontroller

The Raspberry Pi is a low-cost, small sized computer that connects to a computer display or television and operates with a standard keyboard and mouse. Early work by Biswas et al. [11] and Petkar et al. [12] explained how to design a wireless body temperature and blood pressure monitoring device that show the outputs on a monitor by using Raspberry Pi. An ADC converts the analogue data into digital data, allowing the data to be updated continually. The Raspberry Pi method of coding and flexibility allows easy future modifications.

In [13], a wireless system was described utilising the WiFi, Bluetooth, and USB boot all available on the Raspberry Pi. To construct a communication link between the GSM interface and the Raspberry Pi, a switching circuit was used.

A similar health monitoring system proposed by Amru, Mahesh and Ramesh [14] If each of these parameters exceeds the set value, the system sends a pre-programmed notification to the doctor across the IoT. At the end of the day, the doctor may monitor the patient continuously. The patient may also seek immediate attention if needed through the system.

2.2.3 Arduino Uno Microcontroller

Miah et al. [15] demonstrated a health monitoring system includes an Arduino Uno board, transmission system, and Android app. Due to the usage of readily accessible Arduino Uno and a smart phone as an Android device, the built system is cheap at a lower price than previous produced system. The Arduino Uno board is designed to count pulses and detect body temperature, then transfer the data to the built "Heartmate" android app through Bluetooth module. Arduino Uno development board was utilised, which features an ATmega328 microcontroller, to determine the number of cardiac bpm. It also takes your body temperature and delivers the results to your Android app through the Bluetooth module. A thread continually collects analogue signals of heart rate and body temperature and feeds the data to an Android application. The signal is then rendered computable by the Arduino Uno board using a high pass filter, low pass filter, and amplifier circuit.

Early work by Ahmed et al. [16] was completed with first gathering data from the patient, such as patient's body temperature, pulse rate, and ECG then transferring it to a