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Low Cost IoT based Remote Health Monitoring System

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***Abstract*:** Nowadays in Hospitals and healthcare sectors have low cost IOT (Internet of Thing) based remote health monitoring system and labs, to collect a subject or patients' real-time data is vital to save life and it is also helpful for early detection of a disease. A prototype of a system which can be set for remote supervising of Pulse oximetry, heart rate, and body temperature have been discussed in this paper. The system is developed with the help of Wemos Mega development board along with MAX30105 particle sensor and MLX90614 contactless temperature sensor. The Wemos Mega development board is been programmed to transmit the data efficiently to a remote server station using a wireless network that interconnects in limited area following IEEE 802.11 protocol then the patient data can be monitored using an android based satellite phone or through any internet browser which are connected to that network. The cost of this system is reduced by using open source electronic hardware and free software. Then system was tested on 20 volunteers and the data were compared with commercially available device.

Index Terms: Internet of Things in Medicine, Android, remote patient monitoring, heart rate sensing, temperature sensing, pulse oximetry

I. INTRODUCTION

In India, (IOMT)which stands for' Internet of medical things' is providing new ways for providers and their patients to readily access and use health information, it also as the capability to upgrade the quality, safety, and productivity of health care. In general, IOMT helps health-care providers to store, collect, retrieve, and to convey information electronically. In home health, the use of technology that allows patients to supervise their own vital signs from their home and communicate results to a hospital professional wirelessly could increase the ability to address a problem before a patient requires acute care. Improvements in sensors which used wireless technologies and the size of their associated hardware have several potential applications in the medical health system. The capability to remotely monitor vital signs in real-time is a burgeoning interesting areas [1]. Portability, ease of deployment/scalability, real-time/always-on capability, reconfiguration and self-organization are some of the advantages of using a wireless sensor network in a healthcare system. Wireless devices using some of the existing communication technologies have some limitations. Some of them are expensive and not power efficient. Others like Bluetooth limit the number of nodes and low transfer speed that can interact with each other at anytime [2]. Therefore, wireless area network using Wi-Fi has low latency, high transfer rates and high bandwidth.

ESP8266 chip with wife is a good alternative to other wireless technologies. It works with low power and it is able to connect an enormous number of devices into a single network. It uses 2.4GHz frequency bandwidth. It facilitates wireless applications to use a standard communication protocols totally built on IEEE 802.15.4 technology. for personal wireless area networks which means related to limited areas. [3]. It also offers low- latency communication between devices without requiring synchronizing the network delays. Compact systems with a minimum training time that are low-cost, simple and affordable are highly desirable for the applications in human health care. This paper is based on a wifi based system and describes in details heart rate ,pulse oximetry, and body temperature sensing. The system is developed using Wemos Mega development board which a combination of an Arduino mega micro-controller and ESP8266 WIFI chip. An experiment on a group of 20 volunteers was conducted to measure their heart rate, skin body temperature and pulse oximetry. Burton's equation [4] was applied to obtain the mean body temperature based on their core and skin body temperature and it was concluded that the equation gave a good estimation of mean body temperature.

II. SYSTEM DESCRIPTION

A visionary view of the system is represented in Fig. 1. The core of the system consists of an Arduino Mega micro-controller hardware and software, MLX90614 infrared based temperature sensor, MAX301005 particle sensor basically for heart rate and pulse oximeter sensor, an ESP8266 network IC integrated with Arduino mega in Wemos Mega development board.

The sensor which is used is placed on patient finger with a clip like arrangement for reducing any disturbance in readings due to movement of fingers. The readings from the sensors are sent to local area network via router on a given server through esp8266 chip and the readings can be retrieved using a PC or an android system using a Virtuino App which is connected to that network. Figure 1: visionary view of the system A.

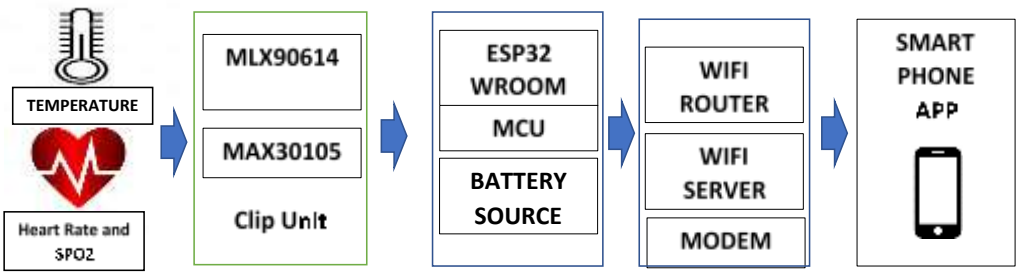

Figure 1: Conceptual view of the system

A. Wemos Mega Development Board

The Wemos Mega Development Board consist of Arduino Mega is a single-board micro-controller with Espressif Esp8266 network chip integrated thus enables IOMT based electronics process in multidisciplinary projects to be more accessible [5]. The hardware compromises of a elementary Arduino board with a 10-bit ATmega2560 processor and with 54 digital input/output pins support. The other component of the board is ESP8266 WROOM chip with ESP-WROOM-02 mcu which is has built in 32-bit Wi-Fi module which support IP/TCP 10-bit ADC, network stacks, and HSPI/PWM/UART/I2C/I2S interfaces which are embedded in this module.ESP-WROOM-S2 uses a 32 MB SPI flash working as SPI/SDIO slave, with 8 Mbps SPI speed.

B. Arduino Micro-Controller Software

The Arduino IDE is java based cross-platform application. It is obtain from the Wiring project basically IDE and the Processing programming language . [5]. The Arduino software consists has the boot-loader and a programming language compiler within the board. The Arduino hardware can be programmed using a specific programming language which is similar to C++. It makes programming micro-controller much easier. It can transmit the data by writing them onto the serial port using a simple serial communication command with need for synchronization, initialization and/or using interrupts. The Arduino software is free and open-source. It enormously cuts down the cost of micro-controller programming.

C. Mlx90614 Temperature Sensor

The MLX90614 is an Infra Red thermometer for noncontact temperature measurements[6].Both the Infrared sensitive thermopile detector chip and the signal conditioning, it also have. low noise amplifier, 17-bit ADC and a very powerful Digital signal processing unit with high accuracy and resolution of the thermometer. The thermometer comes factory calibrated with a digital PWM and SMBus (System Management Bus) output .As in standard form, the 10-bit PWM which is configured to continuously transmiting the measured temperature ranges from -20C to 120?C, with the output resolution of 0.14.

D. MAX301005 particle sensor

The MAX30105 is an integrated particle-sensing module[7].It consists internal LEDs, low noise electronics with ambient light rejection ,optical elements, and photo dectors. It can be functioned in 1.8V power supply and an independent 5.0V power supply for the internal LEDs. It interacts through a standard I2C-compatible interface. These integrated module can be ceased with the help of software with have zero standby current, allowing the power rails to remain powered in all times. It has very High Sensitivity Optical Reflective Solution for detection of wide range particle sizes with different variety which is used to detect heartrate and pulse oximetry.

E. Virtuino mobile application

Virtuino is an Human Machine Interface(HMI) platform for IoT servers, and Arduino based module. It is used to create virtual display and controls such as on/off button,slider switches in smartphone using android or IOS. It enable us to create virtual screens on our phone or tablet to control every automation system via Bluetooth, WiFi or Web. So In our system we are using Wifi.[8].

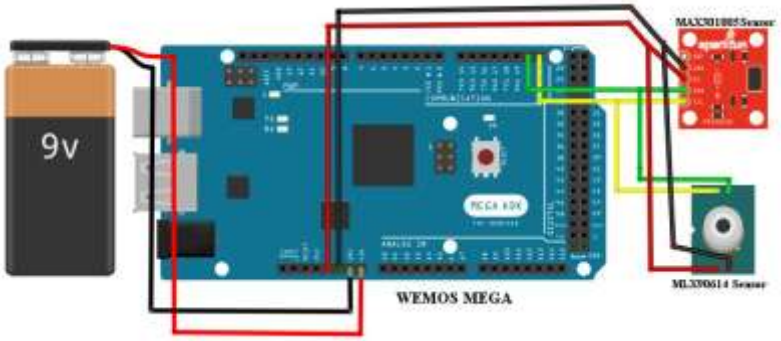

Figure 2: Circuit Diagram of the system

III. Calculations:

A. Temperature calculation

TheMLX90614 is an IR sensor consists of serial connected thermo-couples with cold junctions placed at thick chip substrate and hot junctions, placed over thin membrane. The IR radiation absorbed from the membrane heats (or cools) it.[6] The thermopile output signal is:

$$V_{ir}(Ta, To) = A \times (To^4 - Ta^4)$$

Where To is the absolute object temperature (Kelvin), Ta is the sensor die absolute (Kelvin) temperature, and A is the overall sensitivity.

An on board temperature sensor is needed to measure the chip temperature. After measurement of the output of both sensors, the corresponding ambient and object temperatures can be calculated. These calculations are done by the internal DSP, which produces digital outputs, linearly proportional to measured temperatures and can be read using microcontroller.

B. Heart Rate Calculation

MAX301005 sensor was used to measure Heart rate, which is based on Penpheral Beat Amplitude (PBA) algorithm using Arduino microcontroller. The Buffer of 100 sample was created and based on intensity chane of IR and Red light the heart rate is measured and averaged using internal DSP sensor in the sensor.[7] The heartrate is then obtained from FIFO register of the sensor using Arduino microcontroller.

C. Pulse Oximetry Calculation

The basic principle of pulse oximetry is based on the distinctive characteristics of hemoglobin which can be categories into oxygenated and deoxygenated .based on absorption of red and IR light .Based on absorption of light the Oxygenated hemoglobin absorbs more infrared light and authorizes more red lights to pass through while on the other hand deoxygenated hemoglobin absorbs more red lights and authorizes more infrared light to pass through [9].Red light ranges lies in between 600-750nm wavelength and the infrared light ranges in between 850-1000nm wavelength light band.

The heart rate sensor uses an infrared light emitter that shine through a translucent site with good blood flow [10]. It has an emitter which emits the IR light. Opposite the emitter is a photo-detector or a phototransistor that receives the light that passes through or bounces back from the measuring site. There are two methods of sending light through the measuring site: transmission and reflectance. In the transmission method, the emitter and detector are opposite each other with the measuring site in between and the light can then pass through the site. In the reflectance Using this method Spo2 level are calculated with the help of DSP within the ic and stored in the output register. Using 1 byte output data which is read using microcontroller.

IV. RESULT:

S.No	Age	Temperature		SpO2
		in °C	in °F	%
1	22	37.06	98.7	99
2	18	36.67	98	98
3	24	37.11	98.8	98
4	22	36.94	98.5	99
5	20	36.72	98.1	97
6	21	36.81	98.2	99
7	19	36.83	98.3	98
8	20	37.06	98.7	97
9	23	36.94	98.5	99
10	21	36.72	98.1	98
11	22	37.06	98.7	97
12	22	37.06	98.7	99
13	19	36.81	98.2	96
14	19	36.83	98.3	99
15	22	37.06	98.7	98
16	21	36.94	98.5	97
17	21	36.72	98.1	99
18	20	36.81	98.2	98
19	22	36.83	98.3	97
20	19	37.06	98.7	99

Mean (Average)	36.902
Median	36.885
Range	0.44
Mode	37.06, appeared 6 times
Geometric Mean	36.901734740187
Largest	37.11
Smallest	36.67
Sum	738.04
Count	20

Table 1: Experimental Result obtained using Patient Monitoring System

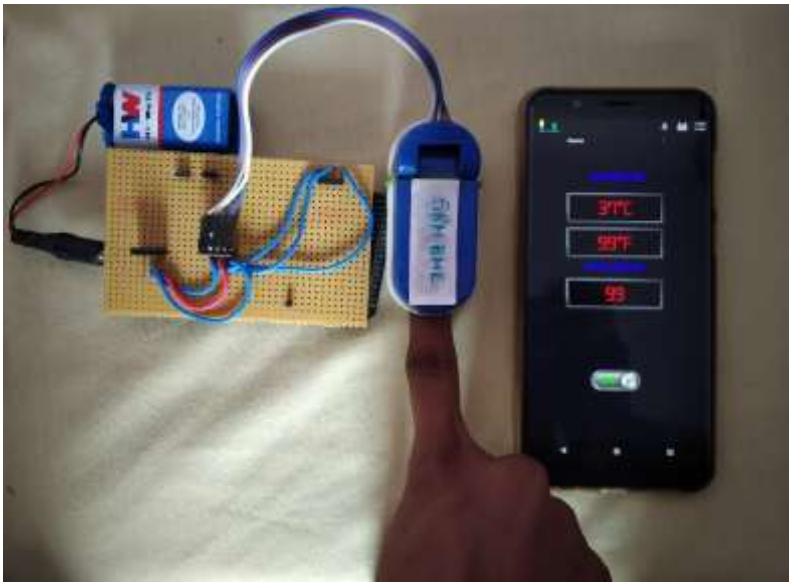

Figure 3: Experimental Setup of the System

V. FUTURE WORK

This paper shows an Arduino Mega and ESP8266 based wireless health monitoring system and temperature and heartrate sensors. An Arduino Mega micro-controller is used to process the data acquired by the sensors and transmit to a remote computer using Wifi network. Although the Arduino micro-controller is small, there is space to further reduce the size make the sensor even smaller and lighter.

Further improvement now focuses on evolving software to analyze the data transmitted from the sensors. The software aims to enable two-way communications and remotely change monitoring requirement based on the individual situation. The system will allow the micro- controller to be programmed remotely, increase the security of data using a more advanced encryption algorithm.

In terms of the micro-controller and the associated PCB boards, further study focus on making the boards smaller and cheaper to further reduce the cost, weight and size of the sensors Currently the sensors use a 5 volts input. Future improvement will look at the power supply with smaller size and lower voltage input. A long-life, light and cheap battery with maximum current input and low input voltage will be an ideal option especially if it can be charged with different power sources.

VI. CONCLUSIONS

This research was to develop a wireless health monitoring system that is capable of measuring two vital signs of health and communicating with the end device. An initial exploratory study on the system presented has been conducted on a group of 20 volunteers from 18 to 24 years old. The results of the study identified an acceptable measurement of the human mean body temperature, Spo2 level and heart rate.

The research work presented has established a base for such a healthcare monitoring environment. The developed sensors are efficient in reading human mean body temperature,Spo2 level and heart rate.. Through the wireless network, a remote computer or a smartphone is capable to obtain the real time data, perform the analysis and plot the result.

With this prototype system, more features can be added such as the functionalities to detect blood pressure and glucose level. With the further development on the reliability of sensor nodes, security and data analysis etc. the system together with the remote monitoring software will have an enormous application area not just in human health care field.

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