ESP8266 ASYNCHRONOUS WEB SERVER BASED REAL TIME TEMPERATURE MONITORING BY CONTACTLESS IR THERMOMETER FOR SOCIAL DISTANCING

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Abstract

The commercial hand-held contactless thermometers are used to measure the body temperature to detect the virus-infected persons within a distance of about 3 feet. It is not a sufficient distance for virus protection without personal protective equipment (PPE) suit. The web server based on the contactless infra-red (IR) thermometer can measure the body temperature and display it on the PC monitor or mobile phone at the distance of 150 feet indoor and 300 feet outdoor from the sensor module. Since ESP8266 MCU is the Wi-Fi chip with microcontroller capability, it is suitable to use in the hardware interfacing and software development of a web server based contactless IR thermometer. Web server-client communication takes place by using the Hypertext Transfer Protocol (HTTP). Web server home page is created by using Hypertext Markup Language (HTML) and Cascading Style Sheet (CSS). Since asynchronous Javascript and XML (AJAX) are used in a web server system, the real time-temperature readings are automatically updated without the requirement to refresh the web server home page.

Keywords: ESP 8266 MCU, contactless, web server, HTTP, HTML, CSS, AJAX.

Introduction

Physician, nurse, and medical aid monitor the body temperature with a hand-held contactless IR thermometer to detect the virus-infected person within 3 feet distance without PPE suit. If the distance is too close, the virus can infect another. To avoid virus infection, the contactless IR thermometer is upgraded by using a web server. The contactless IR temperature sensor, microcontroller, WiFi module are mainly required. MLX90614 is used as a contactless IR temperature sensor. The Microcontroller is functioned as the data processing and these processed data are transmitted to a web server via WiFi. Since ESP8266 NODE MCU is, generally, the combination of microcontroller and WiFi module, it is used to implement the contactless IR thermometer system.

ESP8266 can be used as the control device that can connect to the WiFi network using HTTP and creates a web server with HTML and CSS. When the connected device accesses under the same web server, ESP 8266 reads the temperature from the MLX90614 sensor and sends it to the web browser of which device works under the same WiFi. Data is displayed once on the monitor of a PC or Android phone only if a web server is refreshed. In practice, its delay time is considered to measure the body temperature of many people. It can be solved by using the asynchronous Javascript and Xml (AJAX) that call the function repeatedly.

Experimental Procedure

Hardware, Software Equipments

The main components are ESP8266 NODE MCU and the contactless IR temperature sensor MLX 90614. ESP 8266 board, ESP8266 library and MLX 90614 library are required to be included in Arduino IDE. Web server home page is created by using HTML and CSS. Server to client or client to server is communicated on the HTTP platform.

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ESP 8266 NODE MCU

ESP8266NODE MCU is the microcontroller with integrated WiFi. NODE MCU is the combination of node and MCU (microcontroller unit). It composes of ESP-12E module containing ESP8266 chip 32-bit reduced instruction set controller (RISC) processor which supports real-time operating system (RTOS) and operates with adjustable frequency 80Hz to 160Hz. For program and data storage, 128KB RAM and 4MB flash memory have already added inboard. These memories are enough to make up the webpage, AJAX data which have large strings. Since ESP8266 is attached to WiFi, it can connect to WiFi network or can interact with the internet. Moreover, it can set up its own network as a server. CP 2102 USB- to-UART controller chip which included in ESP8266 board converts USB signal to serial data for communication with the computer [Abhijit Mukherjee, 2020].

There are 17 general purpose input-output (GPIO) pins in ESP8266 NODE MCU as shown in Figure 1. These pins are assigned to some peripheral capabilities including an analog-to- digital converter (ADC), universal synchronous receiver and transmitter (UART), pulse width modulation (PWM), serial peripheral interface (SPI), inter- integrated circuit (I2C), and inter- integrated sound(I2S). These pins are multiplexing features, that is; a single GPIO pin can multiplex as PWM / SPI / I2C [Vowstar, 2020].

Contactless IR Temperature sensor MLX 90614

MLX 90614 is an infrared sensor which is used to measure the temperature without contact. It consists of an infrared-sensitive thermopile detector MLX 81101 and the signal conditioning MLX 90302. An optical filter that cuts off the visible and near-infrared radiation is attached to the module to protect sunlight and ambient diffuse light. The high accuracy and high resolution of that thermometer are obtained due to the consisting of low noise amplifier, high-resolution 17-bit ADC, and the digital signal processing system of MLX90302 in MLX 90614 module.

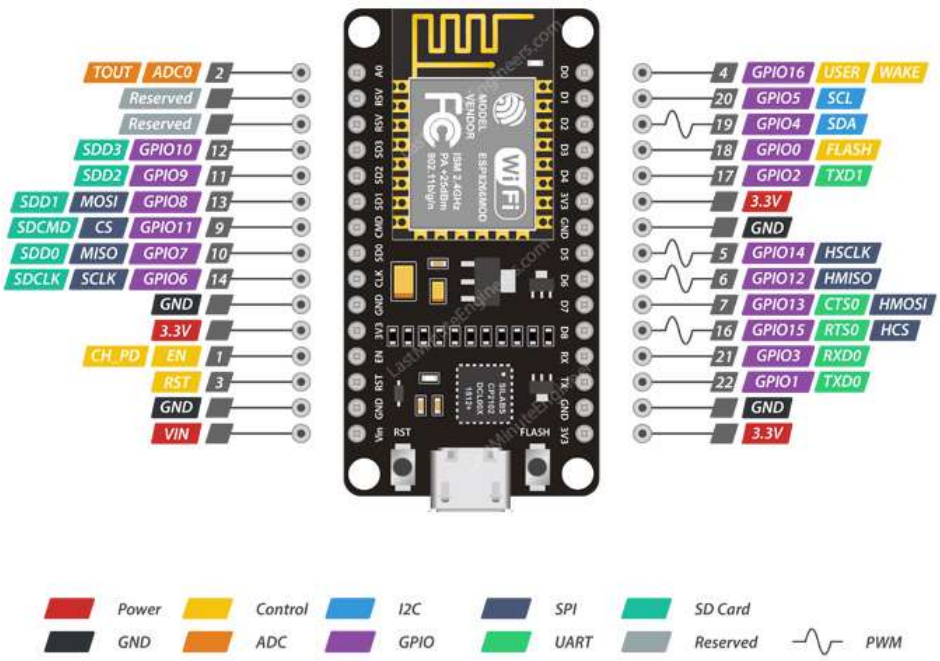

Figure 1 Pin assignment of ESP8266 NODE MCU

According to Stefan-Boltzmann law, the thermal (IR) energy emitted from any object that isn't below absolute zero (0K) is directly proportional to the fourth power of its absolute temperature. The infrared thermopile inside the MLX90614 detects how much IR energy is being emitted by materials in its field of view (FOV), it produces an electrical signal proportional to that. The MLX90614 produces both object temperature and ambient temperature. The object temperature is the non-contact measurement from the sensor, while the ambient temperature measures the temperature on the cover of the sensor. The object temperature measurements can vary from -70 to 382.2 °C (-94 to 719.96 °F), while the ambient temperature reading varies from -40 to 125 °C. The resolution of both the ambient temperature and object temperatures is ±0.5 °C.

The MLX90614 (as shown in Figure 2) used in this research is rated for a 3V operating voltage with a single infrared sensor and an internal filter. This sensor has both digital pulse width modulation (PWM) and System Management Bus (SMBus) output. SMBus is a 2 wires interface based on the I2C principle. SMBus can be regarded as an I2C connection. A default I2C address of 0x5A is in MLX90614. By reconfiguring the address of an MLX90614, the multiple devices (up to 127) can be added to the same bus to get a larger temperature map [Melexis, 2020].

Figure 2 MLX 90614 IR sensor

Web Server and Client

Web server is one that stores, processes, and transfers the web pages to the client which is the web browser on a smartphone, tablet, and personal computer (PC). The request and response between the web server and client takes place using a hypertext transfer protocol (HTTP) capability. A client initiates to request the server for a web page using HTTP. The server also responses with the content of that web page or error if it cannot be able to process. Web server home pages are mostly made of HTML documents.

ESP8266 NODE MCU can connect to the WiFi network and act as a web server. Moreover, it can set up its own network to connect other devices. It can operate in three different modes: station (STA) mode, soft access point (AP) mode, and both at the same time. In this research, the system is implemented in the station (STA) mode.

System Operation

ESP8266 NODE MCU detects the digital signal from the MLX 90614 sensor and processes to convert the temperature. And then, it acts as web server in station mode. ESP8266 gets the internet protocol (IP) from the wireless router or WiFi hot spot and delivers the web pages to the devices that are requested under the same WiFi network. The operation of a web server based temperature monitoring system is categorized into two sections; hardware interface and software development.

Hardware Interface

Since the MLX 90614 IR sensor is inter-integrated circuit (I2C), it composes only two serial communication pins of serial clock (SCL) and serial data (SDA). From the data sheet of ESP8266 GPIO 5(D1) and GPIO 4 (D2) are SCL and SDA of ESP8266 respectively. So, SCL pin and SDA pin of MLX 90614 is connected to D1 and D2 of ESP8266, respectively as shown in Figure 3. The block diagram of the working principle of a web server based temperature monitoring system is shown in Figure 4.

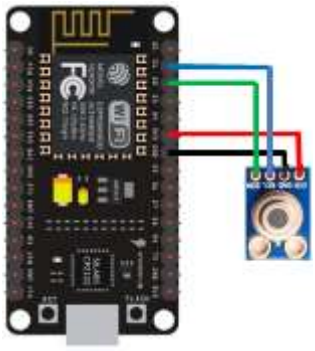

Figure 3 Circuit connection of ESP8266 and MLX90614 sensor

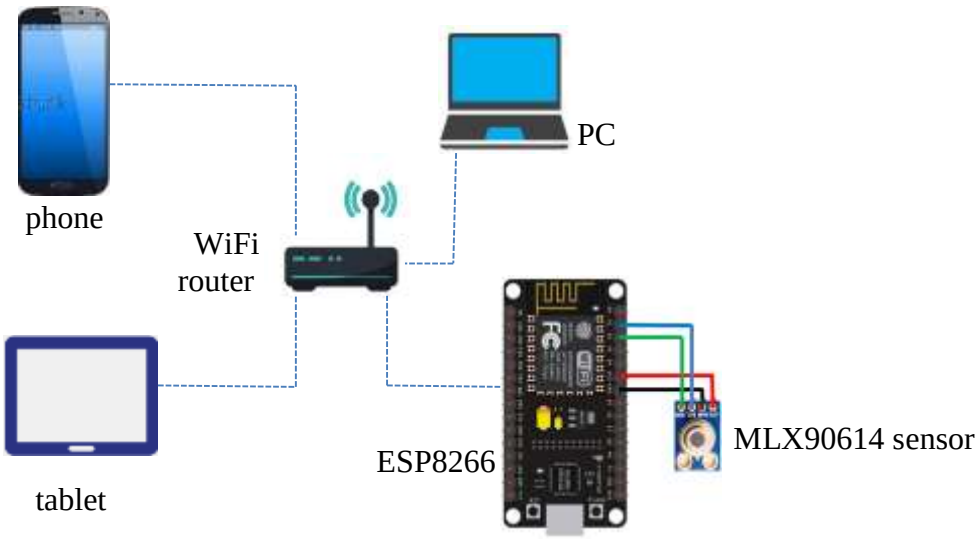

Figure 4 Block diagram of web server based communication

Software Development

ESP8266 is compatible with Arduino IDE. ESP8266 board and library are not included in the default Arduino IDE so that they are required to install in Arduino IDE. http://arduino.esp8266.com/stable/package_esp8266com_index.json is pasted into the "Additional Board Manager URLs" Field of preference in the IDE window as shown in Figure 5. After the URL path is defined, ESP8266 board can be installed using the board manager, as in Figure 6 [Santos R, 2020].

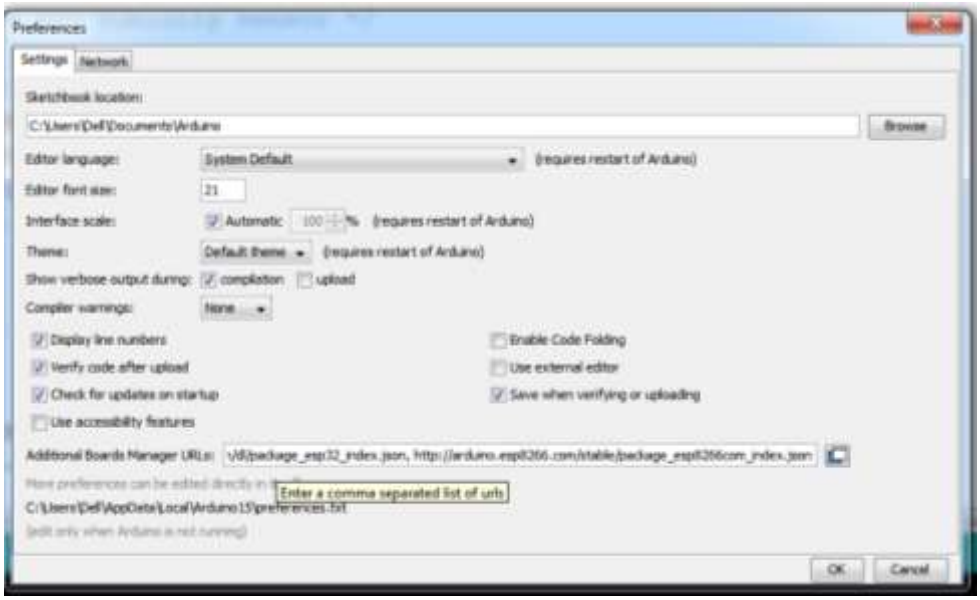

Figure 5 Including ESP8266 board

Figure 6 Installing ESP8266 library

As ESP8266NODE MCU is configured as station (STA) mode, it will communicate the local WiFi network. It needs to define the network credentials of service set identifier (SSID) and password.

const char ssid = "xxxxxxxxxxx";*

const char password = "xxxxxxxxxxx";*

WiFiServer server(80);

Web server is at Port 80 which has assigned to use internet communication with HTTP. While ESP8266 is connecting the network, connectivity status is examined with Wifi.status( ) function. If it is connected, the IP address is obtained by using Wifi.localIP ( ) function. When the server receives a request on the root path, it will trigger the function. When the ESP8266 web server receives a request from the client, Send.HTML( ) function generates the web page. Server.send( ) function takes temperature data as the parameters of HTML content. CSS is used to design the web page style such as font family, display, margin, and text alignment. The icon used to display temperature reading is a scalable vector graphics (SVG) defined in <svg> tag.

The temperature is displayed once when the webserver is refreshed. The asynchronous Javascript and Xml (AJAX) is used to automatically upload temperature. Java script setInterval( )

function is used to call the function repeatedly. AJAX script process to 1) request data from the server, 2) receive data from the server and 3) send data to the server.

Results and Discussions

Cerebration

Web server-based contactless IR thermometer is designed and constructed by using ESP8266 and MLX 90614 temperature sensor as shown in Figure 7. While the program is uploading to ESP8266, it connected to the local WiFi network. If it is connected to a WiFi network, an IP address can be obtained on the serial monitor by pressing the RST (reset) button fixed on the ESP8266 board. An IP address is found that http://192.168.1.6 as shown in Figure 8. If this IP address is inserted in the web browser of PC, tablet, or phone, the data can be visualized on the PC monitor, smartphone, and serial monitor as illustrated in Figure 9 to Figure 10, respectively. One set of data consists of ambient temperature and object temperature in degree Fahrenheit (°F) and in degree Celsius (°C) each.

Figure 7 Contactless thermometer

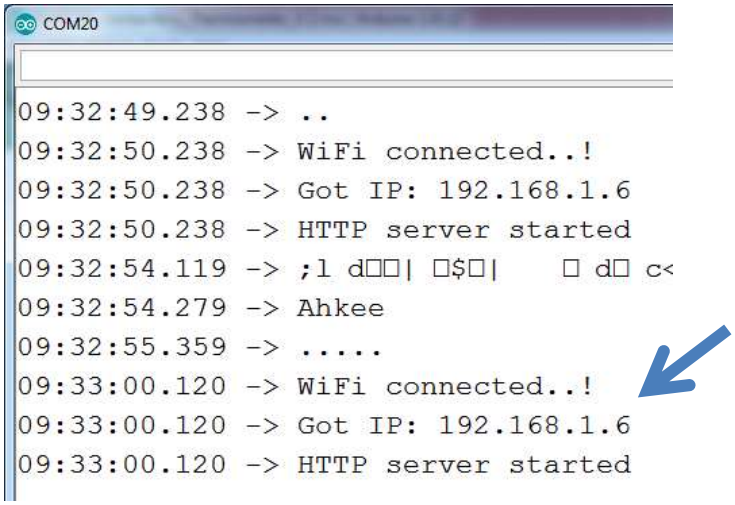

Figure 8 Obtaining IP address

Figure 9 Temperatures on PC monitor

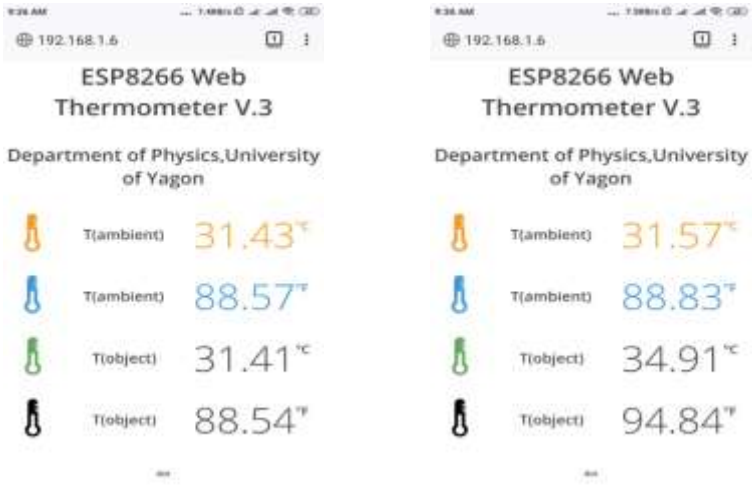

Figure 10 Temperatures on smartphone

Figure 11 Temperature on serial monitor

Discussions

Without AJAX script, the set of temperature can be monitored on the PC or phone only if the webserver is refreshed. Due to the manual refresh, it takes a delay time so that it is not convenient to measure the body temperature of many people. The program including AJAX script is uploaded and the temperature reading is automatically uploaded without a manual refresh of the webserver. It is obviously seen that there are three sets of temperature readings within one second, as shown in Figure 11.

If ESP8266 creates an own WiFi network as a soft access point (AP), the maximum number of clients that can be connected to AP is limited to five. In this research, the webserver in station (STA) mode is communicated to more than five numbers of clients such as PSs, phones, and tablets.

The set of temperature monitor on both laptop and phone at the same time is illustrated in Figure 12. It is seen that the decimal values of temperature are a little different because the clock speed in the performance of devices such as PC, phone had different.

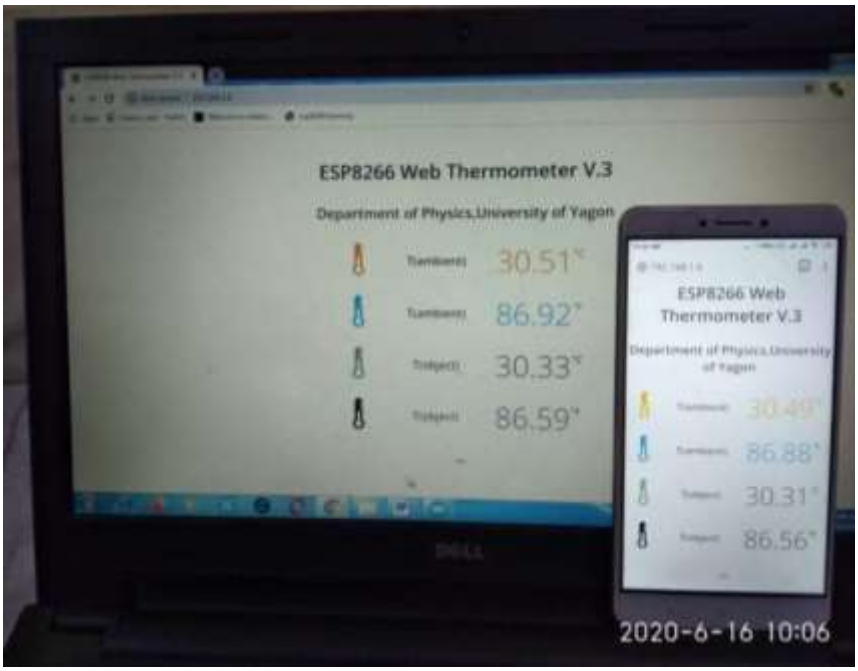

Figure 12 Temperature reading on both devices at the same time

Conclusion

Social distancing is one of the recommended preventive measures in the virus pandemic. When the body temperature is monitored by using a hand-held IR thermometer, the distance between two persons is a close distance about 3 feet. This distance is not safe for medical aid without PPE suit. This web server based contactless IR thermometer can measure the body temperature at the distance of 150 feet indoor and 300 feet outdoor. The temperature can be monitored on PC, tablet, and phone which is in the safe zone by connecting the webserver via WiFi hot spot or WiFi router. The cost of a set of web server IR thermometer plus internet charges is approximately equivalent to the cost of a PPE suit. Although it uses the electronic components and network, it is a user-easy device. The output temperature resolution is 0.14°C within the object temperature range -20°C to 120°C. As temperature uploading is reliably fast, it is useful to monitor the body temperature of many people safely and precisely.

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References

Abhijit Mukherjee, (2020) *ESP8266-based Contactless Thermometer*. Shanghai, China

Melexis, (2020) *MLX90614 Non-Contact Infrared Thermometer*. Rare components, India.

Santos Rui, (2020) *ESP8266 Web Server with Arduino IDE. Random Nerd Tutorial Lab*. No Starch Press, America.

Santos Rui, (2020) *ESP 32 troublesshooting guide. Random Nerd Tutorials Lab*. No Starch Press, America.

Santos Rui, Santos Sara. (2019) *Home Automation Using ESP8266*. No Starch Press, America.

Vowstar, (2020) *NodeMUC*. GitHup, Inc., China.