Design and Implementation of a Smart Weather Station Based on Internet of Things

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Abstract.

Real-time monitoring has become a crucial thing in light of a huge growing in the number of plants and cars in Iraqi cities including the city of Babylon which leading to increase the air pollution that leads to growing the number of people suffering from cancer and other diseases. Therefore, The Weather Station is proposed to monitor specific environmental elements in the Babylon city. A number of Internet of Things (IoT) technologies have been used to form the proposed system. Wireless Sensor Network (WSN) and Ethernet are the main technologies that are utilized with the proposed station. The design of the Weather Station consists of three parts: Hardware, Software and Web application. The Web APP is designed using JavaScript, AJAX, PHP, HTML, CSS, and MYSQL. This Web app has been shared on the public server to be accessed by authorized persons from anywhere around the world.

Keywords: Internet of Things, IoT, Ethernet, WSN, HTML, CSS, PHP, JavaScript, AJAX and MYSQL.

الخلاصة

قد اصبحت المراقبة في الوقت الحقيقي امرا حاسما في ضوء النمو الكبير لعدد المصانع والسيارات في المدن العراقيه ومن ضمنها مدينه بابل، مما ادى الى زيادة نسبة تلوث الهواء الذي أدى الى زيادة عدد الناس الذين يعانون من الامراض السرطانية وغيرها من الامراض. لذلك، تم تصميم محطة الطقس المقترحه لمراقبة بعض العناصر البيئية في مدينة بابل. وقد تم استخدام عدد من تقنيات انترنتت الاشياء كشبكة الاستشعار اللاسلكية و الايثرنت لتشكيل النظام المقترح.

يتألف تصميم محطة الطقس المقترحه من ثلاث أجزاء: الجزء المادي، الجزء البرمجي وتطبيق الويب. تم تصميم تطبيق الويب بأستخدام: (MYSQL،JavaScript, AJAX, PHP, HTML and CSS). وقد تم رفع تطبيق الويب على الخادم العام لكي يمكن الوصول إليه من قبل الاشخاص الموثوقين من اي مكان حول العالم.

الكلمات المفتاحية: انترنتت الاشياء، الايثرنت، شبكة الاستشعار اللاسلكية، HTML، PHP CSS، JavaScript، AJAX ، قاعدة بيانات (MYSQL).

1. Introduction.

The significance of environmental monitoring has become very critical in several fields of life. The environmental elements must be monitored to guarantee the safe working climate in industrial factories, to keep the healthy growth of crops and other aspects. The measuring process of the weather conditions has become easier compared to previous decades due to technological growth. The sensors are mini electronic devices that are utilized to measure the environmental and physical elements (Kondamudi and Gupta, 2016).

The proposed weather station has been designed to monitor several environmental elements in Babylon city such as: CO2, CO and CH4 concentrations, humidity, temperature and light level. These elements are measured, processed and then sent to web application to be observed by the authorized users around the world.

2. Problem definition.

In the last years of present century, ecological problems pose a mortal danger for millions of living creatures around the world (Bulipe and Ome, 2016). Increasing the flammable and toxic gases concentration and Global Warming phenomena are one of these problems. Therefore, the smart weather station became an important and urgent issue in both the indoor and outdoor areas to save the lives of millions of living creatures.

3. Proposed Weather Station.

The weather station is become very crucial element in the residential cities in light of the fast development in all life fields. There are a lot of studies that address several issues in Babylon city, but the smart weather station is the least discussed between them. So, the proposed weather station has been designed to be one of the leading studies in the city. The proposed weather station uses one sensing node to collect specific weather parameters of a specific region and then sends these parameters to the database of the web app by gateway node to be noticed by the employees of the Monitoring-Center-Station (MCS). The authenticated person can activate the buzzer of alarm node that is installed inside the Civil Defense building, if he observes any dangerous change in the environmental elements.

In addition to measure and display specific environmental elements, the proposed weather station activates the city's illumination system in case of low lighting level (wirelessly).

4. System Design.

The design of the weather station comprises of four main parts as shown in figure (1), namely: Sensing Node, Gateway Node, Alarm Node and Database & Web Application.

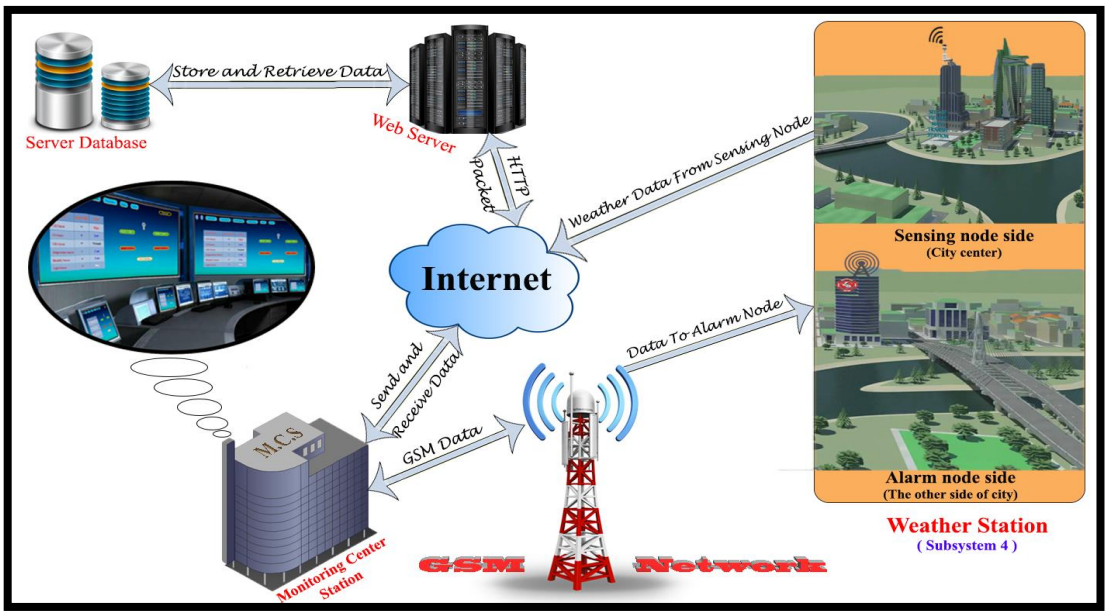


Figure (1) Architecture of Weather Station.

4.1. Sensing Node.

The sensing node comprises of two parts: Hardware and Software.

4.1.1. Hardware.

As illustrated in figure (2), the implemented sensing node comprises of microcontroller (mega-2560), sensors, LEDs and W5100 Ethernet Shield as a connection unit.

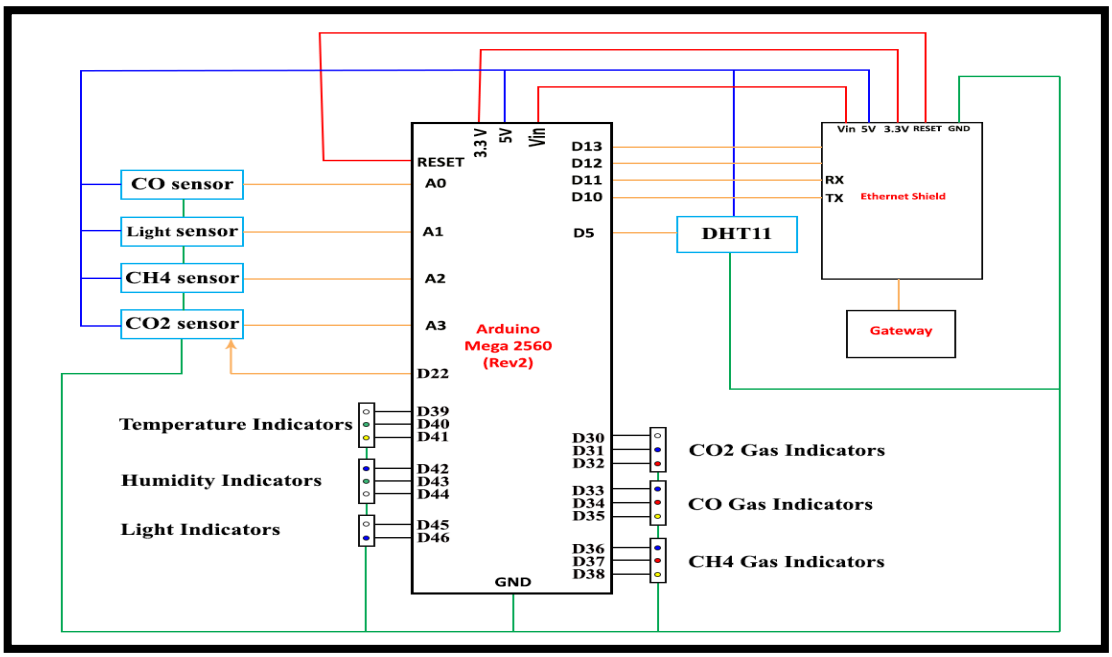


Figure (2) The structure of the Sensing Node.

Microcontroller.

Atmega2560 microcontroller is utilized as a processing unit in the sensing node. There are several characteristics of Atmega2560 that make it more suitable for the presented system, include: flexibility in programming, energy consumption, durability, inexpensive and open source hardware and software (Ala'a Imran M., 2013).

Sensors.

The sensing node collects the environmental elements by six types of sensors, namely: Carbon Monoxide gas, Carbon Dioxide gas, Methane gas, Temperature, Humidity and light. All these types give their output as analog voltage, this voltage is feed to the microcontroller to be processed and then sent.

LEDs.

LEDs are optional elements with sensing node. They are utilized as sensors' indicators. As shown in figure (2), three LEDs are used with each sensor except the LDR sensor which has two LEDs .

W5100 Ethernet Shield.

To provide the communication between the Gateway Node and the Sensing Node, the W5100 Ethernet Shield is utilized with sensing node. The W5100 Ethernet Shield comes with Micro SD card slot as depicted in figure (3) to save files or other data for serving through the network.

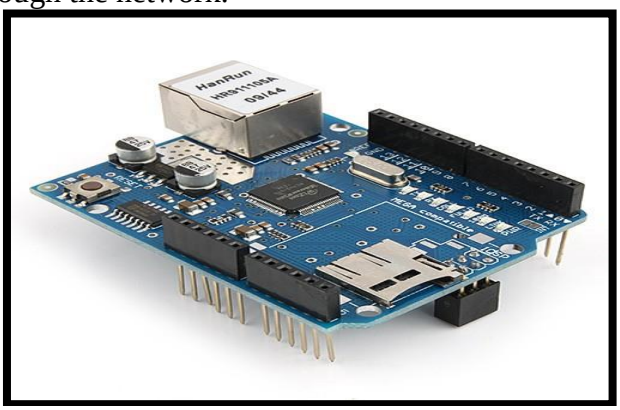


Figure (3) W5100 Ethernet Shield.

This shield can connect with Arduino Uno, Mega 2560&1280 and Duemianove. The W5100 and SD card can connect with arduino by utilizing the SPI bus. The SPI bus is D50, D51 and D52 pins on the Mega module while on the Duemilanove module is D11, D12 and D13 pins. On both modules, D4&D10 pins are used for the SD card and to choose the W5100 respectively. D4&D10 cannot be utilized as general I/O pins (datasheet of W5100 Ethernet Shield).

4.1.2. Software.

The software part of the sensing node follows several steps as illustrated in figure (4).

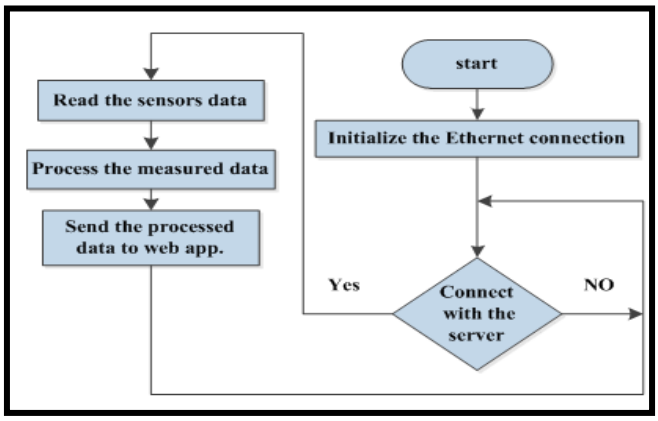


Figure (4) Steps of the sensing node software implementation.

4.2. Gateway Node.

To send sensors' readings to the database through a global network WAN, The TL-WR940N router from TP-Link Company is used by the Sensing Node. This gateway is connected with W5100 Ethernet Shield through the pin No.1 and with internet through the WAN input slot by Ethernet cables.

4.3. Alarm Node.

The alarm node is the other side of the weather station. It is designed to inform the Civil Defense Directorate of the city about the serious changes in environmental parameters. The alarm node comprises of two parts: Hardware and Software.

4.3.1. Hardware.

As illustrated in figure (5), the implemented alarm node comprises of microcontroller (mega-2560), buzzer, LED and Arduino GSM Shield as a connection unit.

Microcontroller.

Microcontroller of the alarm node is the same as microcontroller of the sensing node.

Buzzer.

This unit is used to notify the staff within the building of the Civil Defense about alarming when any of the measured value exceed the irregular limit.

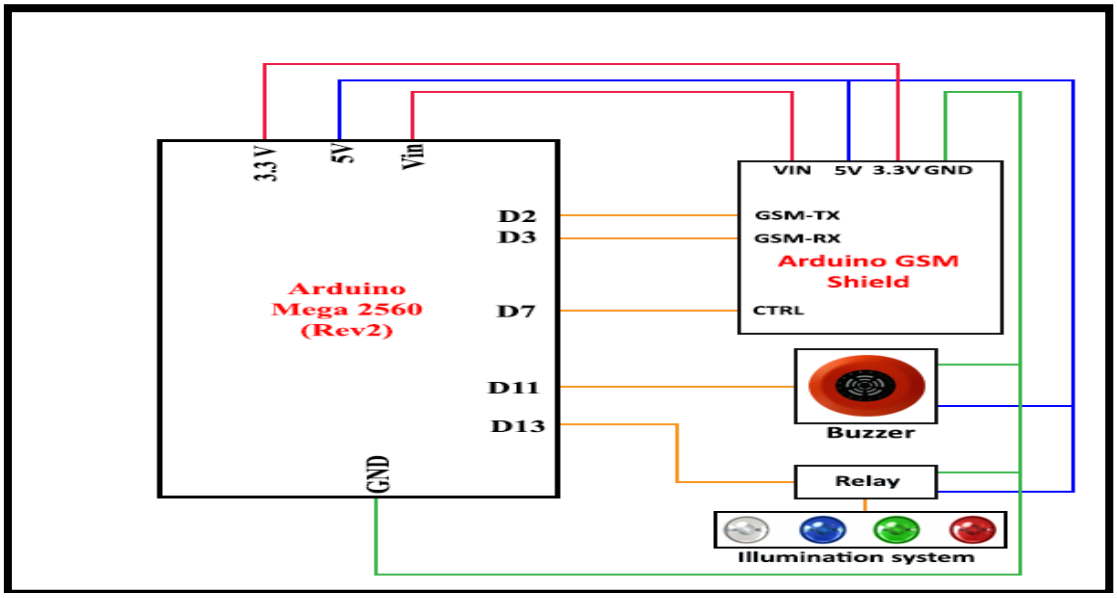


Figure (5) The structure of the Alarm Node.

Relay.

This unit is considered the activation node of the illumination system. It is utilized to activate the illumination system of the city.

Arduino GSM Shield.

To activate and deactivate the systems of illumination and alarm, the Arduino GSM Shield is utilized to receive the commands by SMS. As depicted in figure (6), the arduino GSM Shield is dependent on M10 Module for communication tasks. This module is controlled by AT command. GSM850 MHz, GSM900 MHz, DCS1800 MHz and PCS1900 MHz are the basis frequencies that can operate with this module.

This shield will be ready for communication with GSM network by connecting it with arduino and inserting the unlock SIM cad (Mahmoud and Ali, 2016).

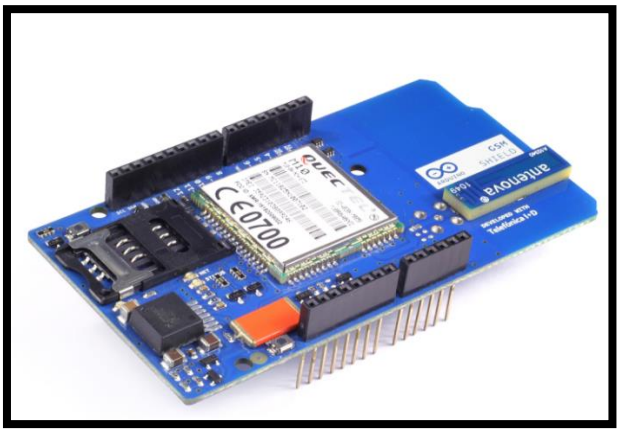


Figure (6) Arduino GSM Shield.

4.3.2. Software.

The software part of the alarm node follows several steps to be ready for connecting as illustrated in figure (7).

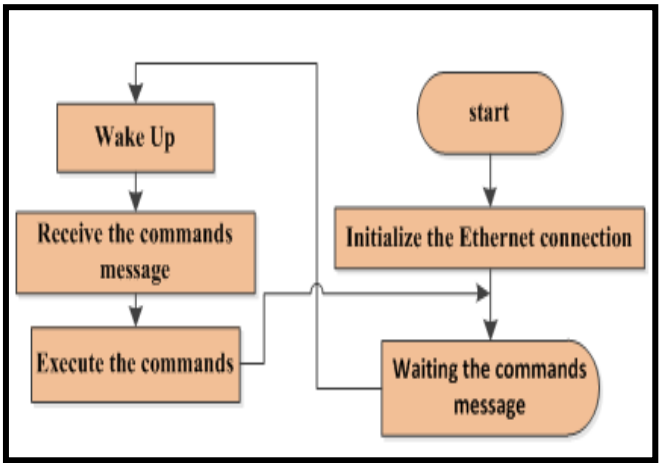


Figure (7) Flow chart of the alarm node software.

4.4. Database and Web Application.

The web application is the end-user app. The web-app of the proposed weather station is designed by using: HTML, CSS, PHP, Java-Script, JSON and MYSQL database. MYSQL database is utilized to store the sensors data in the desired form.

The main page of the web application is illustrated in figure (8).

5. System Features.

The following point represents the main characteristics of the proposed weather system.

- Real-time monitoring system.
- At anytime and anywhere, the Web app can be accessed by authenticated persons.
- High reliability system.
- High time-response system.
- Offers flexibility in use in addition to ease of monitoring.

6. Results & Discussions.

The web application can display the sensors data as numeric data or graphic charts as shown in figure (8) & (9).

Figure (8) shows the main page of the weather station (in the main system, we have proposed more than one application based on IoT); the weather station is a part of that system (in other papers, the other parts of the system will be presented successively). In such figure, the measured parameters (CO2, CO, CH4, Temperature, Humidity, and Light) are displayed as numeric values with the indicated level (High, Moderate, Low,…) for each sensor according to the international standard.

Also, via the main page of the web application, the alarm node buzzer and the illumination system can be activated wirelessly.

While the other way to display the sensors' readings for long-term measurements, it’s the graphic charts. Each sensor's level (excluding the light sensor) is displayed with the light's level as shown in figure (9) due to the fact that the gases concentration, temperature and humidity change from morning to the night gradually, in other words they are related to each other.

According to tests’ results, the proposed system offers high accuracy and great flexibility. In addition, the system‘s Web app can be accessed from anywhere in the world due to the use of IoT technology.

7. Conclusions.

The proposed station has been implemented to monitor the environmental elements of a specific region by using IoT principle. This proposal offers a low-power solution to establish a weather station. This station can be installed in an outdoor and

indoor areas and the sensor data is successfully uploaded to web app in both cases. It's reliable and low-cost system as compared with other systems.

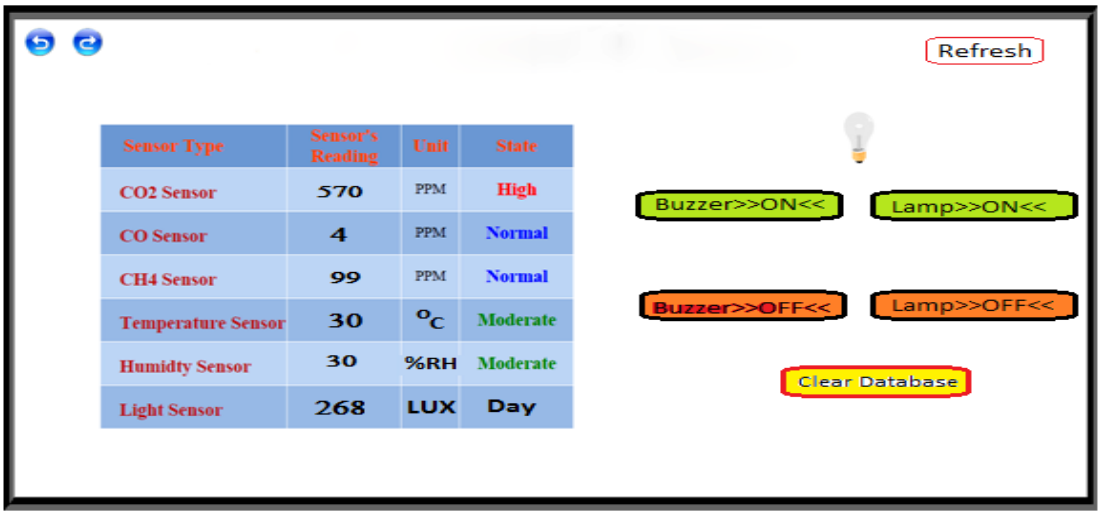
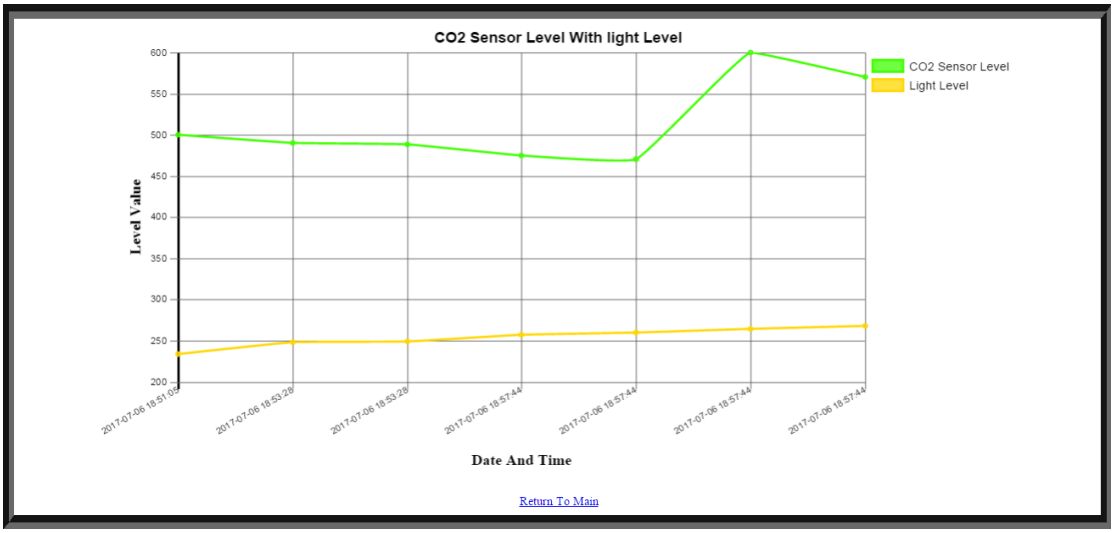
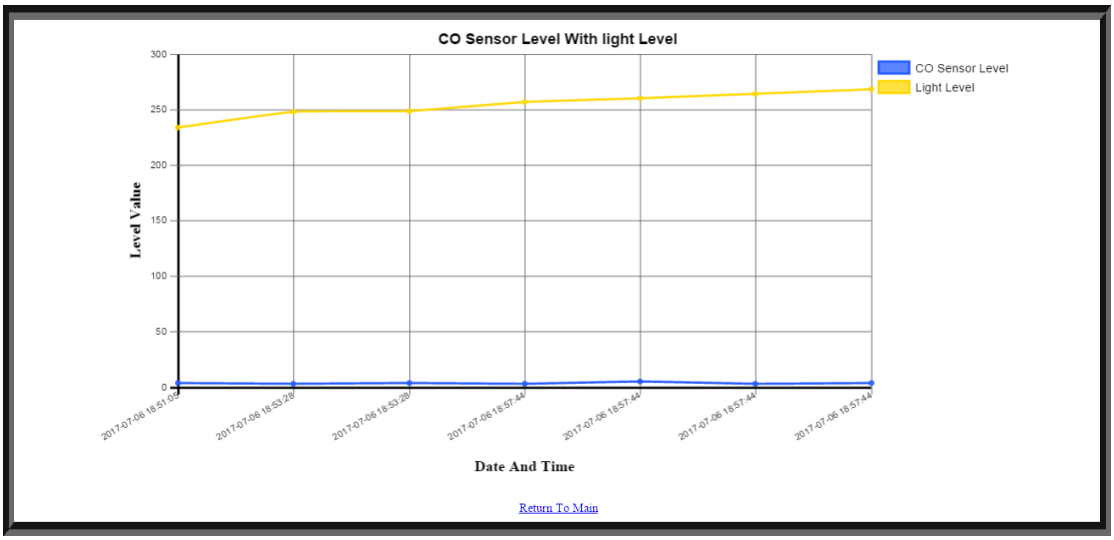


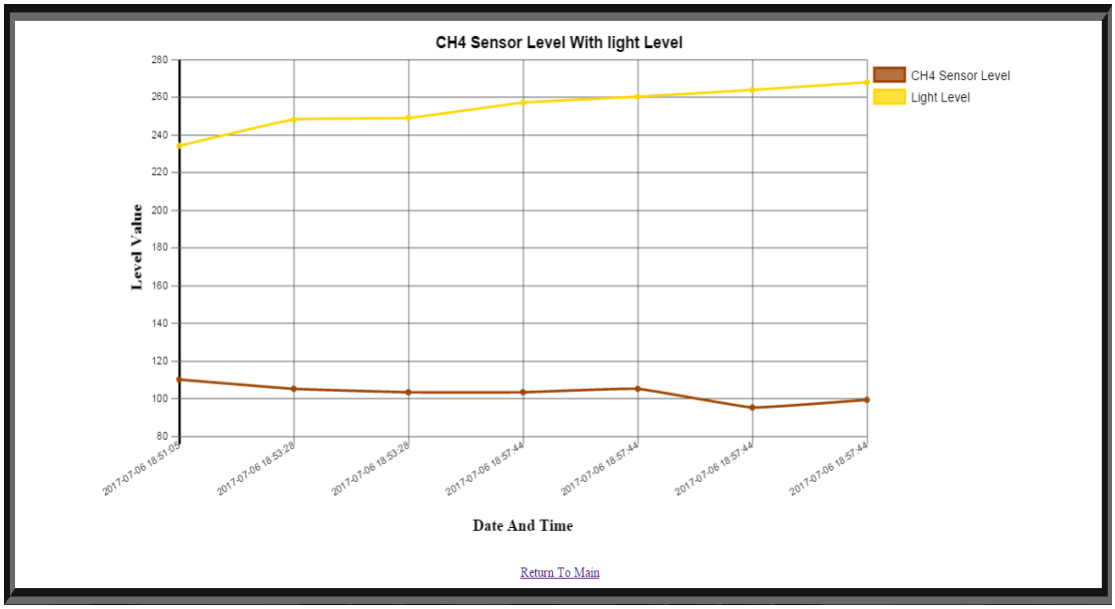
Figure (8) Main page of the web application.



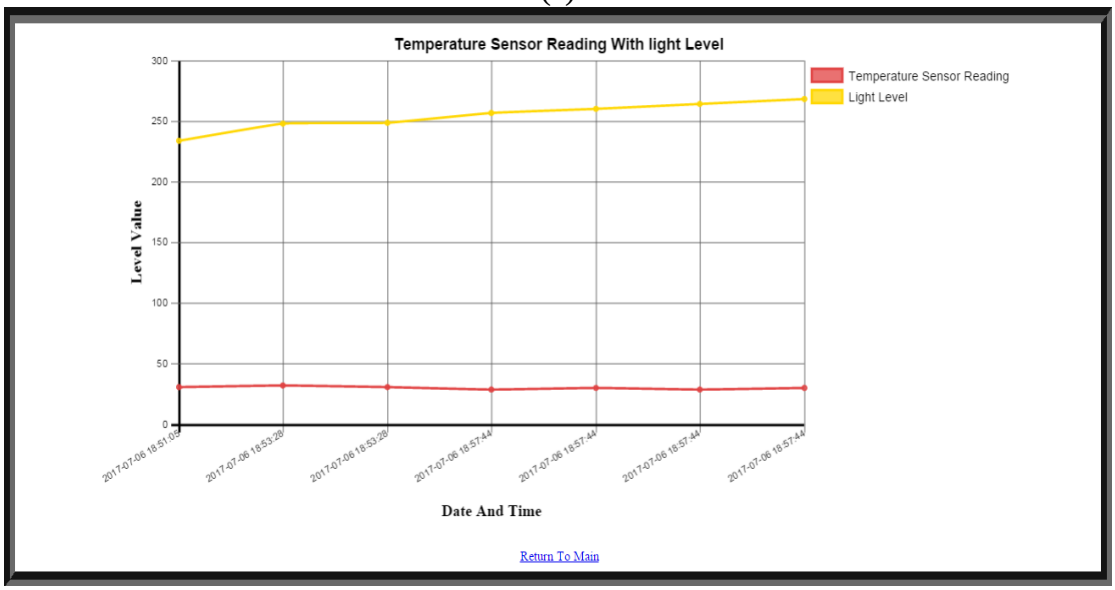
(a)



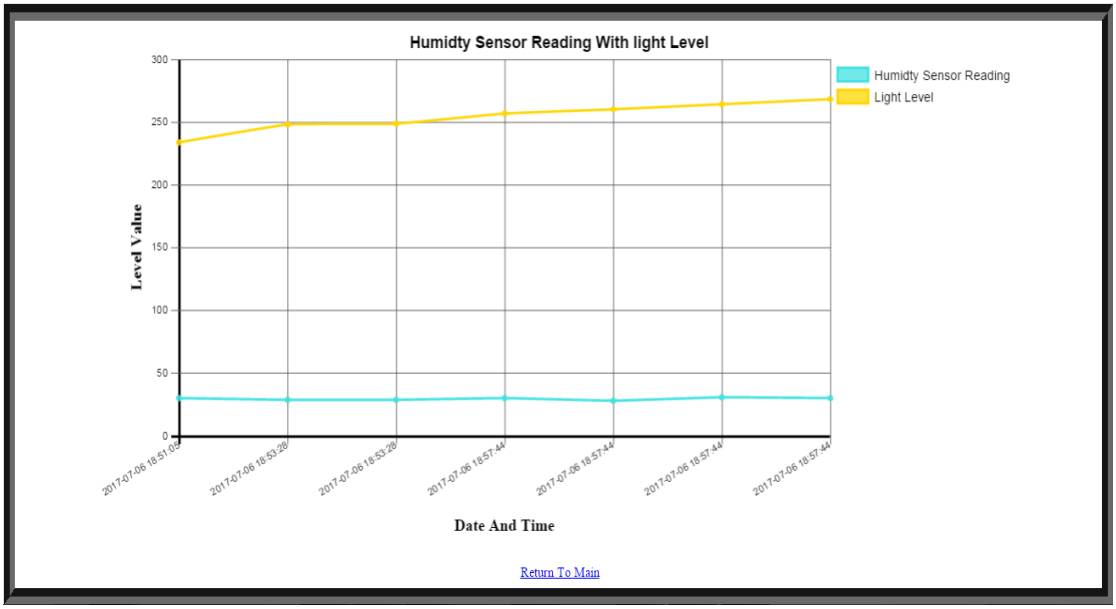
(b)


CH4 Sensor Level With light Level
CH4 Sensor Level
Light Level
Level Value
Date And Time
Return To Main

(c)


Temperature Sensor Reading With light Level
Temperature Sensor Reading
Light Level
Level Value
Date And Time
Return To Main

(d)



(e)

Figure (9) Graphic charts of CO2, CO, CH4, Temperature and Humidity Sensors reading respectively in addition to light sensor in each chart.

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