

Urban Climate Monitoring System with IoT Data Analytics

G Rajasekhara Naidu^{1*}, N. Venkat ram²

¹ Department of ECM, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, AP, India – 522502

² Department of ECM, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, AP, India – 522502

*Corresponding author E-mail : rajasekhar226@gmail.com, venkatram@kluniversity.in

Abstract

Climate monitoring was one of the important thing that should be monitored thoroughly and it plays an important role in every person's life and his surroundings. Due to the increase of factories, vehicles there are so many drastically changes in the climate like increasing of temperature, humidity and the quality of air. In this paper we are designing a climate monitoring system that which detects temperature, humidity, and monitoring the air-quality. Coming to air quality we are mainly concentrating on detecting carbon-monoxide and some pollutants. The information can be checked with gadgets like PC, versatile, tablet through Thingspeak information examination.

Keywords: ESP-01, Internet of Things (IoT), Tiva TM4C Launchpad.

1. Introduction

In paper [1] the authors have explained that attention is on practical and comprehensive advancement with the assistance of the IT furthermore, hardware advancement. The rising idea of IoT assumes an imperative part to help in achieving this mission. Approach choices can be made in view of genuine information. And the sky is the limit from there critically, their effect can be observed nearly continuously. IoT idea was advanced in 1999 by an individual from the Radio Frequency Identification (RFID) advancement group. The expanding development of the cell phones and advancement in the territory of correspondence, distributed computing, implanted frameworks has made the IoT idea more applicable. In paper [2] the author has explained that IoT is a uniting innovation to make the shrewd condition and the incorporated biological community.

Analysts envision that new IoT things and organizations will grow exponentially in next couple of years. IoT will help the financial improvement while upgrading our local's life. The general plan of the IoT is mind boggling to portray in light of the way that it incorporates the arrangement of devices and various association layer headways. The structure helps in giving the open access to the particular arrangement of data. The nationals and furthermore the administrative will get the idea in regards to the city condition at any remote place with the help of web.

This framework generally envelopes the urban natural information from the substantial level and moreover incorporates the arranging, data organization and directions the continuous data. In paper [3] the author stated that the system can help in the impressive change in the city organization and improve the life of the citizens. This idea will brings the awareness for the citizens how the atmosphere is changing in the city due to pollution.

Climate monitoring was one of the important thing that should be monitored thoroughly and it plays an important role in every person's life and his surroundings. Due to the increase of factories, vehicles there are so many drastically changes in the climate like increasing of temperature, humidity and the quality of air.

In this project we are using Tiva C series Launchpad which is based on ARM Cortex-M4F MCUs. For sending the data to cloud, we are interfacing ESP-01 Wi-Fi-chip to Tiva C series Launchpad and publishing the data in Thingspeak. This system can help in transformation of managing the city and improve the awareness in public on climate changes. ESP-01 Wi-Fi chip cost is very less. ESP-01 Wi-Fi chip acts as a compelling server and gives great availability to the web. ESP-01 Wi-Fi chip acts as an effective server and provides good connectivity to the internet. Basically climate can be monitored by satellite observations and ground-based data model. In this paper we are doing a ground-based climate data model system that detects temperature, Humidity, Carbon monoxide, and air quality.

2. Literature Review

Numerous investigates are going ahead in the general public name purpose of web of things that every one of the machines or gadgets associated together brought together and controlling each one of those apparatuses. Different authors penned their different ideologies in their research work.

In paper [4] the authors has explained that air pollution is a problem for both environment and society. They also stated that there will be also unfriendly impacts on human wellbeing, biological systems, and atmosphere. To detect climate parameters in certain area they interfaced GPS module to the system to know about the climate parameters of that location. They also stated that wearable sensors can be used for observing air quality, and that information can be sent through Bluetooth to the cell phone. In paper [5] the authors has proposed a Low-power Climate observing system that is used for the research of mosquitos and pathogens. In this system they proposed that they can predict the habitat of mosquitoes that which cause critical health issues to humans like malaria, yellow fever, dengue fever. They can track their living spaces by utilizing the natural information like basing on temperature, humidity, wind speed and direction. The observed data was processed by 2.4 GHz wireless module and sent through an operating system application.

This data was available for both pc, mobile and web based applications. In paper [6] the authors has designed a climate monitoring system based on sensor network, that which stores the sensor data and generates real-time alerts in the event of an emergency. In paper [7] the authors has developed a monitoring system for industries which detects temperature and humidity of indoor rooms. The RF transmitter and receiver are used for transmitting and receiving the sensor data. In paper [8] the authors has presented their views on a smart phone based sensor framework for body territory atmosphere and air quality checking and observing. Poor air quality is one of the highest general dangers. Be that as it may, many people can't tell whether the air quality is great or awful. Mostly these devices are most expensive, so they proposed an advanced mobile phone based sensor framework, which is utilized for individual body region miniaturized scale atmosphere observing. They had used arduino board and Bluetooth modules, with various ease small scale sensors for detecting temperature, relative humidity, Co2. This system is very low cost and effective. In paper [9] the authors has proposed an Air quality monitoring system using MQTT. While increasing in large scale-industrialization and urbanization there is a requirement of monitoring air quality. The primary contributor of air pollution is particulate matter (PM2.5) which causes human health issues. They had used GPY1010AU0F a sharp dust sensor for measuring smoke and dust particles in the environment and the data is send through ESP8266 based NodeMCU-12E. The MQTT uses publish, subscriber, and broker services. The MQ7 sensor is used for sensing carbon-monoxide level in air, which is mainly released from vehicles. In paper [10] the authors stated about the challenges of detecting small changes in climate and how to calibrate the sensors for readings and how to maintain their calibrations in challenging environments like space,oceans,mountains,tropics,polar regions, and deserts. In paper [11] the authors has presented his views on a novel sensor design for implementing for advanced urban micro-climate monitoring and environment mode for future adaption of urban infrastructure with a framework for storing the data for modelling. In paper [12] the authors has stated about the idea of developing an automated system for climate monitoring and management. They developed the system on the using modern components that are having Ethernet-Interface. The device is versatile, and was very easy to rebuild for specific applications. In paper [13] the authors has proposed a framework for wireless sensor networks (WSNs) designed for observing the effects of climate changed in crop fields. They additionally planned a model which comprises of two base stations and a few hubs that are controlled by solar powered cell. The climatic parameters are sent through WSN to the base station, while the base station speaks with remote information server through GPRS network. Using multiple methods of communication, it enables monitoring areas where GPRS is not in coverage area.

3. Proposed System

In this proposed system we are monitoring some urban climate parameters such as temperature, humidity, carbon-monoxide, and air quality in real time with data analytics. The data is transferred to thingspeak.com through HTTP protocol using ESP-01 Wi-Fi chip. In the proposed system we are using Tiva Launchpad which was based on TM4C123GH6PM microcontroller. The various sensors we are using in the proposed system are LM35 (temperature), HR202 (humidity), BMP180 (Pressure), MQ7 (Carbon-Monoxide), MQ135 (Air Quality). ESP8266 Wi-Fi chip is low cost and act as both access point and station point in the designed system. The data analytics is used to examine the data and process them in the form of graphs and bars. Thingspeak API provides IoT data analytics for the designed system.

4. Methodology

The methodology, hardware, software, required for climate monitoring system as follows. Hardware components required are TM4C123GH6PM Launchpad, esp8266 Wi-Fi chip, lm35 temperature sensor, hr202 humidity sensor, MQ135, MQ7 for gas sensing. The IDE used ARM keil u vision 5. The brief note on each of the components required is discussed in the coming sections.

Tiva C series Launchpad is a development board that was developed by Texas Instruments. The Launchpad consists of TM4C123GH6PM Microcontroller architecture was based on ARM Cortex M4F processor and gives a performance of 80-Mhz operation. It consists of flash of 256 kb single cycle flash memory, 32KB SRAM and 2kb of EEPROM. Coming to communication interfaces it has 8 uart's, four SSI modules, four I2C modules, Two CAN 2.0, USB 2.0. It also had 2 watchdog timers, and 6 physical gpio blocks, and has two 12 bit ADC modules. Now coming to the Launchpad it has 43 I/O pins, On-board USB ICDI (In-circuit Debug Interface), Micro AB USB port, 2 user push buttons, and 3 user led which is a tricolor led, 16 MHZ Main Oscillator crystal and a 32 kHz real time clock crystal. C and C++ languages are flexible to utilize for this board.

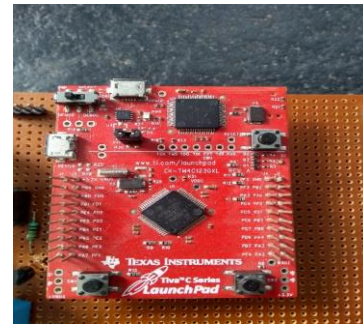


Figure.1.TM4C Launchpad

Esp8266 Wi-Fi chip is interfaced to the board, for transferring the sensors data to Thingspeak cloud. ESP8266 is low cost Wi-Fi chip with full TCP stack. It has 16 GPIO pins. It uses various interfaces like SPI, I2C, and UART. We are using UART communication for interfacing it with the Launchpad.

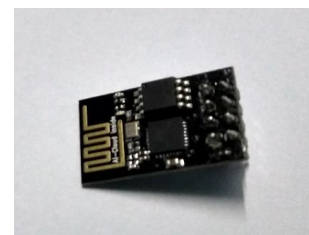


Figure.2. ESP-01

LM35 is a series of IC temperature devices. The LM35 has 3 pins power supply, output voltage, and ground. The output voltage of the LM35 varies linearly proportional to the temperature observed by the IC. The LM35 can measure temperature from -55 to 150 degree centigrade. The LM35 is low-cost because of trimming it to the Wafer-Level. The LM35 voltage value is converted to digital by using ADC converter and later using the ADC value the temperature is calculated.

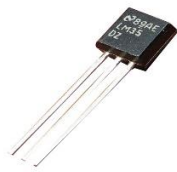


Figure.3. LM35

For recording the humidity, we are using SY-HS-220 analog sensor, these sensor convert's the relative humidity to the output voltage. SY-HS-220 has 2 pins, in which one pins gives the voltage out and one pin to the ground. Its operating temperature is between 0-60 degrees centigrade and humidity is 30-90% RH. The output voltage of the sensor varies linearly proportional to the humidity observed by the IC.



Figure.4. SY-HS-220

For detecting CO₂ (Carbon dioxide) and CO (Carbon Monoxide) we are using MQ135 and MQ7. We are using MQ7 for carbon monoxide. MQ7 is highly sensitive to carbon monoxide. MQ7 is also sensitive to some combustible gases like H₂, LPG, CH₄, and alcohol. The values of carbon monoxide is calculated in ppm.



Figure.5. MQ135 Gas Sensor

Carbon Monoxide is mainly released by vehicles and factories. The MQ7 gas sensor is composed of AL₂O₃ ceramic tube, Tin Dioxide (SnO₂) sensitive layer, measuring electrode and a heater are fixed in a stainless steel net. We are using MQ135 sensor for measuring CO₂ (Carbon Dioxide). MQ135 is used for detecting hazardous gases like NH₃, NO_x, alcohol, Benzene, smoke, CO₂. MQ135 also works similarly as MQ7.



Figure.6. MQ7 Gas Sensor

5. Working of Proposed Approach

When the system is powered on the esp8266 Wi-Fi chip turns on and reset itself. After resetting it scans for the available access point and connects to it. If there is no availability of access point or no proper signal for access point the red led will be glow. After connecting to the access point it starts communicating with the cloud using HTTP protocol. The values of temperature, humidity, carbon dioxide, carbon monoxide are read continuously for every interval of time as defined. During the transferring of the data the led will glow as green, indicating that the transmission is going on.

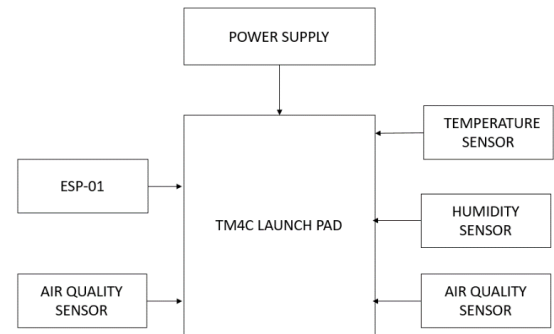


Figure.7. Block Diagram

6. AT commands

AT commands are used to provide the communication between the device and cloud. We can observe the data transmission using AT commands from the terminal. By using AT commands we can change some parameters of esp8266, which provides the communication. When the device is powered on the ESP-01 resets and scans for the available access points. If the access point is available it connects to it and starts communication with cloud. If there is no availability of the access point which is allotted to the system, then it again scans for the available access point until it connects to it. After it connects to the access point, then it connects to the cloud using HTTP protocol and transfers the data to Thingspeak.

Working algorithm of ESP-01:

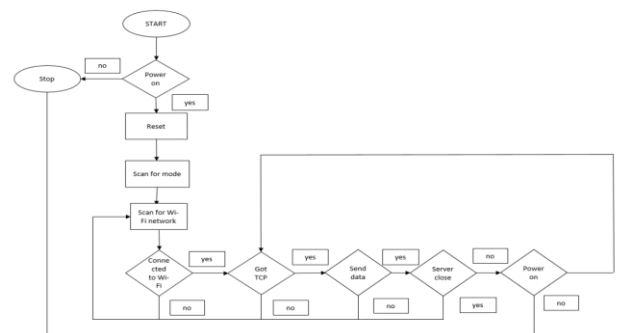


Figure.7. Flow Chart of Wi-Fi chip

7. Experimental Results

The underneath figure demonstrates the exploratory setup for the framework. The green led will indicate that the data is transferring perfectly, through access point without any disturbance. If there is indication of red led, we can conclude that the access point is not available to the system.

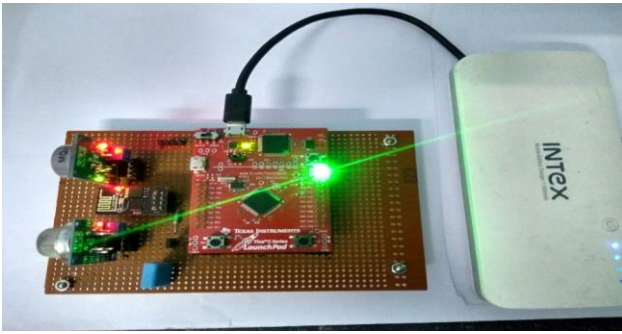


Figure.8. Experimental Setup-I

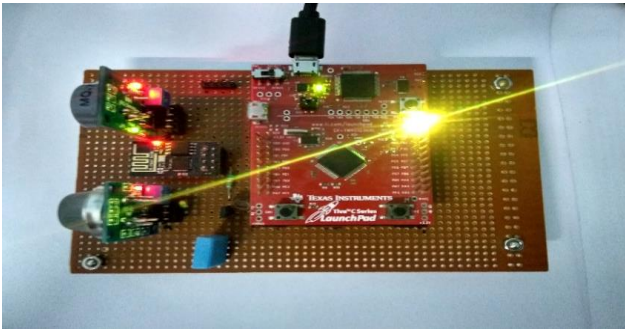


Figure.9. Experimental Setup-II

The below figures shows the data of temperature , humidity , MQ135,MQ7 gas sensors that are send to the Thingspeak cloud. The values that are sent to the Thingspeak will directly generated the graphs varying with respect to time. The Data analytics in the Thingspeak has made easy to compare the climate parameters change from time-to-time.

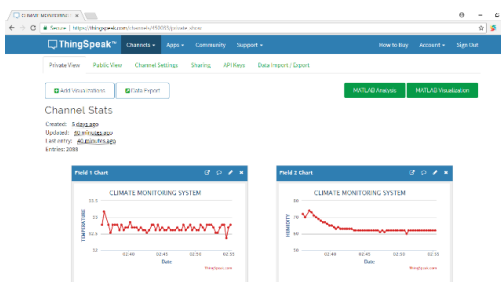


Figure.10. Output in Thingspeak

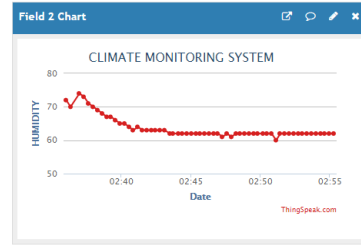
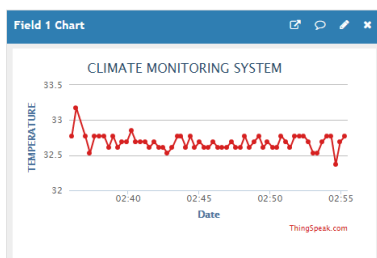


Figure.11. Output of Temperature and Humidity

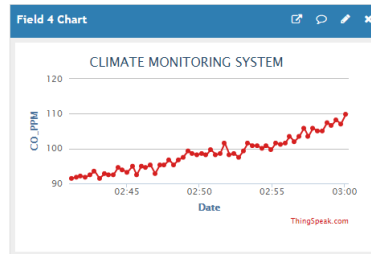
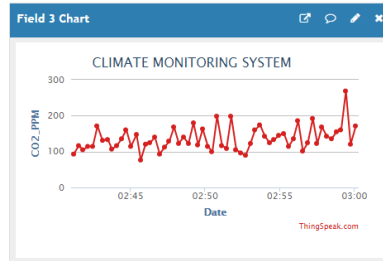


Figure.12. Output of Carbon Monoxide and Carbon Dioxide in PPM

8. Conclusion

The main objective of this project is to store the different values of climatic parameter in the cloud and to analyze the data. So with the data stored in cloud we can compare the values with respect to time. We can alert people and can create public awareness, that how the climate is changing due to pollution and how it is effecting their surroundings and their health conditions. This work will be carried forward by integrating different climate sensors as in this project we are monitoring only four parameters temperature, humidity, CO2 and CO and sending them to the cloud.

References

- [1] Rohini Shete, Sushma Agrawal, "IOT based Urban Climate monitoring using Raspberry Pi", 2016 International conference on Communication and Signal Processing (ICCSP).
- [2] Ovidiu Versman and Peter Fiess, "IOT – Converging Technologies for Smart Environments and Integrated Eco-systems".
- [3] N Pradeep Kumar, Ravi Kumar Jayoth, "Development of cloud based light intensity monitoring system using Raspberry Pi", 2015 International Conference on Industrial Instrumentation and Control (ICIC)
- [4] Marin B.Marinov, Ivan Topalov, Elista Gieva, Georgi Nikolov "Air Quality Monitoring in Urban Environments", IEEE conference, 2016 39th International Spring Seminar on Electronics Technology (ISSE).
- [5] Byul Hur and William R.Eisenstadt "Low-Power Wireless Climate Monitoring System with RFID security Access Feature for Mosquito and Pathogen Research", IEEE conference, 2015 First conference on Mobile and Secure Services (MOBISSECSERV).

- [6] Fantazi walid, Tohar Ezzedine “Design of a Climate Monitoring System Based on Sensor Network”, IEEE conference, 2017 13th International Wireless Communications and Mobile Computing Conference (IWCMC).
- [7] Pravin C.Saptue, Deepti P.Theng “Intellectual Climate System for Monitoring Industrial Environment”, IEEE conference, 2013 Third International Conference on Advanced Computing and Communication Technology (ACCT).
- [8] Jeffery P.smith, Xinrong Li “Air Sniffer: A Smart Phone-Based Sensor System for Body Area Climate and Air Quality Monitoring”, IEEE Conference, 2016 10th International Symposium on Medical Information and Communication Technology (ISMICT).
- [9] Ravi Kishore Kodali, Borade Samar Sarjerao “MQTT based Air Quality Monitoring”, 2017 IEEE Region 10 Humanitarian technology Conference (R10-HTC).
- [10] Catherine C. Cooksey, Gerald T.Fraser and Howard W.Yoon “Sensor Calibration and Characterization to meet climate Monitoring requirements”, 2014 IEEE Ninth International Conference on Intelligent Sensors, Sensor Networks and Information Processing (ISS NIP).
- [11] Mukesh Jha, Prashanth Reddy Marpu, Chi-Kin Chau, Peter Armstrong “Design of sensor network for Urban Micro-climate Monitoring”, 2015 IEEE First International Smart Cities Conference (ISC2).
- [12] Renat B.Salikhov, Vali Kh. Abdrakhmanov, Konstantin V.Vazhdaev “System of Monitoring and remote control of temperature conditions, climate and heat consumption”, 2016 13th International Scientific – Technical Conference on Actual Problems of Electronics Instrument Engineering (APEIE).
- [13] Truong-Tein VO, Tuan-Duc Nguyen, Minh-Thanh VO “Ubiquitous Sensor Network for Development of climate change Monitoring system Based on Solar Power Supply”, IEEE 2013 International Conference on Advanced Technologies for Communications (ATC 2013).