Prashanna Nakarmi

Student Number: 22085551

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Mini Weather Station

Abstract

This essay looks at an IoT project which covers the complete information on this system. A weather station is a device which provides us with the information of weather with the details of our surroundings. What the temperature is outside or the humidity, the weather station provides us with this information real time. There are many different sensors used in this station but this IoT project covers the basics of the weather station. It measures the temperature and humidity using the DHT11 sensor.

The DHT11 sensor uses the moisture holding layer and NTC (Negative Temperature Coefficient) to collect the data from the surroundings. Using the I2C protocol, the data is smoothly transmitted to Arduino in digital form. The I2C utilizes two lines SCL for clock signals and SDA for data transmission. Arduino is the master here initiating communication while DHT11 sensor responds to the commands. As the clock signal triggers, the information is sent bit by bit until it forms a sequence of 7- or 8-bit address. The sensor detects humidity and temperature through resistance change and process it into digital form which arrives at Arduino. The Arduino processes and manages the incoming data using a software Arduino IDE. The codes written in IDE processes or gives command to process the device which operates and displays the real time data to LCD display. Several details of data acquisition, data transmission, data processing and management and data analysis and visualization is discussed.

A weather station can be defined as an instrument or a device which measures the condition of atmosphere which provides the information of weather and climate of a location it is placed in *[Oswald, 2022, What is a Weather Station].* And in today's time when the use of internet is high, the use of IOT device also known as Internet of Things connect human beings and electronic devices which makes it easier to communicate and also get information faster and easier. The basic concept of Internet of Things is to communicate or connect various electronic devices over a network or a connection and then collect data from these devices and sensors that may be transmitted in any way or manner that suits. In spite of that, the IOT device or technology may have their own flaws and challenges *[Kodali and Mandal, 2016, IOT based weather station].* The Mini Weather Station is an example to the convenience of use and utility that smart devices with sensors may achieve in the field of Internet of Things (IOT) applications. In early days when there was not much use of smart devices, people who had to stay indoors or were busy with office works or household works had a difficult time and no awareness about the environmental factors outside of the building they were in. They did not know of the temperature or humidity outdoor. People had no sense if the temperature outside is high or low, or even if it's raining or not or what the value of humidity in the environment, they are in. Hence, they would not know whether they should carry an umbrella or make plans accordingly *[Kodali and Mandal, 2016, IOT based weather station].* But now since the use of technology is high, such IOT device can be very useful. It will display the temperature and humidity in LCD using Arduino and sensors. The key components of this project are: DHT11 sensor, LCD display, I2C module and Arduino Uno. Different parts of the weather station and their functions works together to create a functional IOT device.

Data Acquisition

The mini weather station's main component is DHT11 sensor. It is a digital sensor which is widely used for measuring or sensing temperature and humidity which comes with NTC (Negative Temperature Coefficient) and 8-bit microcontroller *[EL-PRO-CUS, NA, NA].* It uses thermistor and a capacitive humidity sensor to measure the surrounding air it is kept in. This sensor can measure the temperature between the range of 0 to 50 degree Celsius with a 2-degree accuracy. The humidity measuring range of this sensor is from 20% to 80% RHwith 5% accuracy and provides one reading for every second *[crazytonics, 2023, All About DHT11 sensor].* DHT11 has a functional voltage range of 3 to 5 volts and the highest current used for measurement is 2.5mA. DHT11 sensor has three pins. The first pin is VCC in which 5v is supplied. The next pin is the output pin which gives us the value of temperature and humidity. The third pin is ground pin (GND) which is connected with the ground pin of Arduino.

DHT11 consists of a moisture holding layer which is placed between two electrode and below the lower electrode, it has a glass substrate. The moisture holding layer senses the humidity and based on this moisture, the resistance of both electrodes gets changed. By this change of resistance in the electrodes, the value of humidity gets determined. For the calculation of temperature, it uses NTC (Negative Temperature Coefficient) thermistor which changes the value of resistance according to the temperature. If the temperature increases, the value of resistance decreases and similarly, if the temperature decreases, the value of resistance increases. This sensor frequently makes use of semiconductor ceramics or polymers too get a higher resistance value even with slight temperature changes *[EL-PRO-CUS, NA, NA]*.

Data Transmission

Data transmission happens from the sensor DHT11 to the Arduino Uno and other components on the breadboard. The I2C module, an essential part which allows for proper or smooth interaction between the sensor and the microcontroller, enables or supports this connection. While the I2C module is a valuable component, it's specific involvement in the data transmission between DHT11 and Arduino may not be necessary but it is necessary for LCD display. DHT11 uses one-wire communication protocol. It communicates with microcontroller which is Arduino through a single-wire interface. One device act as the master and initiates or controls the communication with other one wired devices or slaves. This protocol does not use a clock signal because the slave devices are internally clocked and synchronized with a signal from Arduino *[Agnihotri, NA, what is 1 – wire protocol]*. In this IOT project of Mini Weather Station, the sensor DHT11, the change of resistance from moisture holding layer or the resistance measurement gets read by the IC which processes the changed resistance values into digital form. The digital form is the humidity value which gets transmitted to Arduino. As for the temperature, the readings from the DHT11 comes from NTC temperature sensor which used one signal wire or pin to transmit the data of temperature to Arduino in digital form.

Data processing and Management

In the IOT project Mini Weather Station, the Arduino Uno plays the role of processing and managing the data received from the DHT11 sensor. The Arduino is based on microcontrollers which are integrated circuits where instructions can be stored. Programming language is used in Arduino IDE which created a program to interact with the devices or circuits. Mostly C++ programing language is used. Arduino has communication ports, input and output ports which connects to different components on the circuit *[CircuitSchool Staff, 2023, What is Arduino]*. DHT11 sensor includes NTC thermistor and 8-bit microcontroller IC. The functions of these are already discussed above. The data or information from sensors connected to the circuit transferred to Arduino will be processed with the help of a software Arduino IDE. Some code snippets are:

void loop(): The loop function runs continuously after the setup.

DHT.read11(dht_apin);: Reads the humidity and temperature from the DHT11 sensor.

lcd.clear();: Clears the LCD to display fresh data.

lcd.setCursor(0, 0);: Sets the cursor to the first row, first column.

lcd.print("Humidity: ");: Prints the text "Humidity: " on the LCD.

lcd.print(DHT.humidity);: Prints the humidity value from the sensor.

Similar steps for displaying temperature.

delay(5000);: Delays the program for 5000 milliseconds (5 seconds) before the next iteration.

These code snippets are how Arduino can understand and execute the program and the project can function *[electronics simplified, 2021, Mini Weather Station using DHT11 and LCD]*.

Data analysis and visualization

The IOT project mini weather station relies on data analyzing and converting it into useful or working information. The DHT11 sensor captures the data like temperature and humidity from the environment and sends the information to Arduino. With the help of programing from Arduino IDE, the Arduino Uno analyses the data and executes them. After the data is processed and managed, the information or data which is temperature and humidity gets displayed in LCD using I2C protocol. I2C protocol uses serial connection using two lines to send and receive data. The two connections are a Serial Clock pin (SCL) in which the Arduino Controller board signals at frequent intervals. The second connection is a Serial Data pin (SDA) over which the data is transmitted between the two devices. In I2C communication, one device acts as the master (Arduino in this case), the one who initiates and controls the communication. And the other device like the LCD display in this case, acts as slaves, the one who responds to the request. When the clock line changes or moves from low to high, a single bit of data is transmitted to I2C device through SDA line. The data keeps being transmitted until a sequence of a 7- or 8-bit address and a command is formed *[Dejan, 2023, How I2C Communication Works?]*. When the information is sent by the master, one bit after bit, the device which is slave sends the message or data and if the device has something to return back or execute, it does through the same data like (SDA) or Serial Data Pin using the clock signal (SCL) for timing *[Zambetti, Soderby, Hylen, 2023, Inter-Integrated Circuit (I2C Protocol)]*. The Arduino gives data to LiquidCrystal_I2C library to communicate with the LCD.

The LCD shows the real time data of temperature and humidity. This is a simple project of weather monitoring so it does not keep the previous data of temperature and humidity but it only shows the real time data of the environment it is kept in. While this project may not

include many user controls, it includes basic user controls which are easy to understand. The user interaction includes changing the feature like delay (like changing in the code delay (4500)) in which the LCD shows the information of temperature and humidity based on the delay. The sensor senses the data of the current time and then again takes the data after 45000 seconds of delay and sends the data to Arduino which then processes the data and sends it to LCD for visualization. While the current project focuses on a simple LCD display, there is a potential for future plans like there could be charts or graphs for representation of data and there could also be advanced sensors for user interaction for analyzing and visualizing the data. The graphs of this project could look like the following:
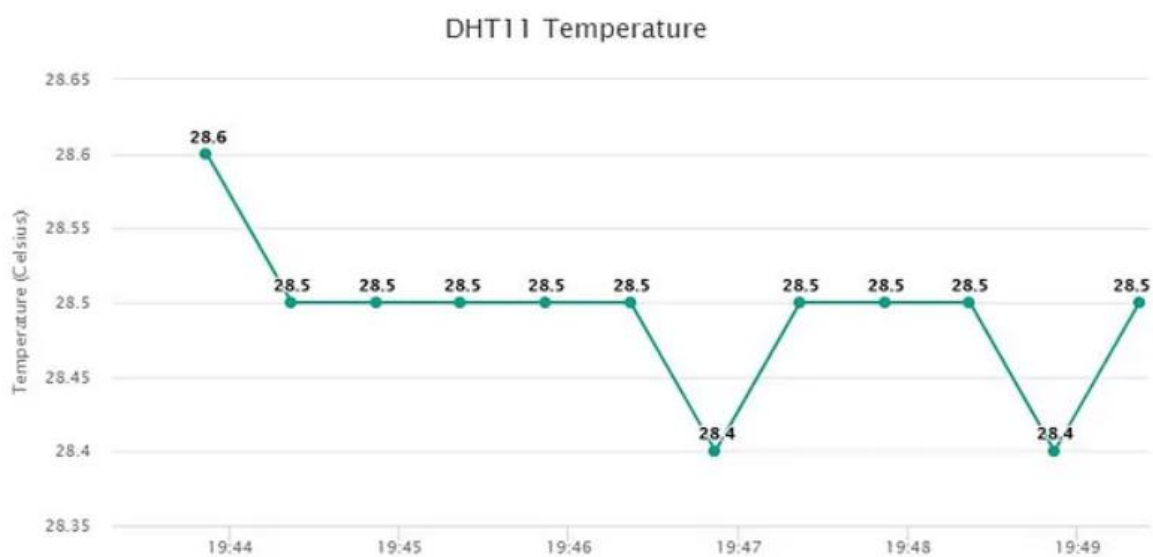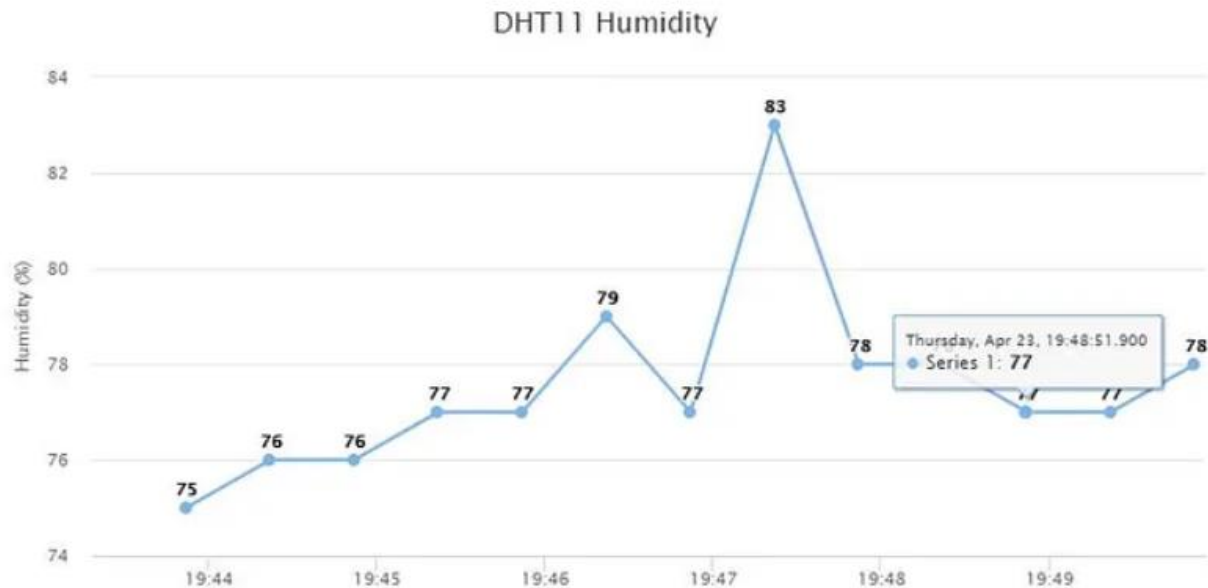

Figure: DHT11 temperature record chart

Figure: DHT11 humidity record graph

<u>Conclusion</u>

In conclusion, the IOT project Mini Weather Station is a simple project which measures temperature and humidity real time of the environment it is kept in. This project includes the sensor DHT11 which is the key component to measure the temperature and humidity, Arduino Uno, I2C module for smooth data transition and other components. The humidity measuring range of the sensor is 20% to 80% and the temperature measuring range is 0 to 50 degrees Celsius. The communication in the components of this project is done by I2C protocol which ensures smooth transmission of data. Arduino Uno which the main component of this project, manages and processes the data. Arduino can process the data by the code or the programing written in Arduino IDE and it sends the data to LCD display for data visualizing of the real time information of the weather to the people. Since the data from the sensor is taken at a certain delay, it provides efficient information. This is a simple project which measures temperature and humidity and displays it on LCD. However, there is more opportunities to make the project advanced by adding interactive features and different ways to analyze and visualize the data. This IOT project contributes to a smarter world.

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