BLACK COMBUSTION

- PCB BOARD
- CCS-811
- CLIMATE CHANGE
- IoT SYSTEM

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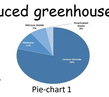
Abstract

Our country is on the verge of facing the most dangerous environmental problems and the most severe impact on the sustainability of life on Earth. The greenhouse effect is the primary cause of climate change. Some gases in the Earth's atmosphere mimic the effect of greenhouse glass by trapping solar heat and preventing it from escaping back into space, which would otherwise contribute to global warming. After conducting extensive research on the impacts of heat on many continents, we discovered that carbon dioxide contributes most to global warming. When examining Egyptian industries, we discovered that burning coal to produce power results in significant emissions of carbon dioxide and several hazardous pollutants. We completed a project based on an IOT system that can monitor, using sensors, the quantities of gases created by burning coal as CO2, PM, and NOx as a result of the previously mentioned circumstances. Its primary objective is to establish a link between the abundance of eCO2 and the rise in temperature. The information gathered will make it possible to forecast the anticipated temperature concerning a specific eCO2 value. We've concluded that our project satisfies the design criteria.

Introduction

The biggest threat to humanity's future is climate change. Petroleum derivatives - coal, oil, and gas - are the largest supporter of global environmental change and global warming, accounting for about 75% of worldwide emissions of ozone-damaging substances and about 80% of all outflows of carbon dioxide. According to Global Monitoring Lab (GML) observations, in 2021, carbon dioxide alone was responsible for about two-thirds of the total global warming effect of all human-produced greenhouse gases (as shown in Pie-chart 1). Looking at the other solutions proposed by the countries, we found that Forecast Forest Fire Prediction using IoT is one of the most effective solutions to face the problems of fires. The main idea of the project is to use IoT and deep learning to predict the occurrence of fires by reading indicators of temperature, humidity, the percentage of carbon dioxide in the region, and other sensors. It has many advantages as it helps to prevent fires at early stages, but despite that, it is difficult to implement. The system consists of diverse sensors and devices, so the cost of these devices is very high (as shown in fig 1). Also, the accuracy at the beginning isn't accurate, until the deep learning starts forming a pattern. Its implementation lies in the fact that it is difficult to draw conclusions from it and deal with it. For our project, we have identified several design requirements, and the most important of them is accuracy, which prompted us to take into account every step during the implementation of the project. We decided to work on electricity generated from coal based on the proportions of gases resulting from the burning operations and their contribution to raising the temperature of the earth. In the end, our project achieved the requirements of dynamic range, accuracy, and stating a relation between eCO2 and temperature.



Pie-chart 1

Fig(1)

Method

Each IoT system integrates four distinct components: sensors and/or devices, connectivity, data processing, and the user interface. We divided the basic steps to prepare our project into three main steps as follows: connecting the circuit, creating the PCB, writing the code, and displaying the data.

1. After determining the sensors required for our project, we started by checking if all the sensors work by using the example codes. Afterward, we started connecting each sensor to a simulating application.
2. 2. We used the circuit connection data to create a Printed Circuit Board the circuit using a free-use application as shown in fig (2). We took a printout of the PCB layout. Then we cut a copper plate for the circuit board according to the size of the layout. We used a width of 5.5±1 cm and a height of 6.2±1 cm. Consequently, we rubbed the copper side of the PCB using steel wool or abrasive spongy scrubs. This removes the top oxide layer of copper as well as the photo resists layer. Afterward, we put the printed layout on the copper surface of the board and iron the image side down to the copper side. Then we needed to heat the Electric iron to the maximum temperature. After that, we dipped the PCB into the Etching solution (Ferric chloride solution, FeCl3) for approximately 30 mins. The FeCl3 reacts with the unmasked copper and removes the unwanted copper from the PCB. Thenceforth, we used pliers to take out the PCB after it has been printed on the copper. We placed the sensors in the holes we made on the PCB that represents the pins as shown in fig (3).
3. After finishing the connection, we started writing our code. We followed a simple criterion that uses the example codes we used at the beginning to make sure all of the sensors work and collected it in one code. We created an account on a site called IoT Analytics: Thing Speak Internet of Things, and then created a channel with the name of our project. We used the channel ID to connect the readings of our sensor with the channel using the code.

fig (2)

fig (3)

Test plan

In order to demonstrate that our project meets its intended requirements, the prototype has to be tested more than once to ensure that it works properly. The testing procedure was done as follows:

1. We started by burning some coal and putting them into a heat-resistant glass box.
2. The glass box has a hole from the top; to simulate the industries that use burn coal, for instance, electricity production
3. We put our IoT part beside the hole to get the most accurate results.
4. We calculated the rates every 17 seconds, and we conclude that when the temperature from burning increases, the CO2 rapidly increases.

All the safety procedures were considered while constructing, and testing the prototype. We made sure to place the soldering iron in the holder when not in use and to wear safety glasses and gloves. Also, wearing face masks during the test plan.

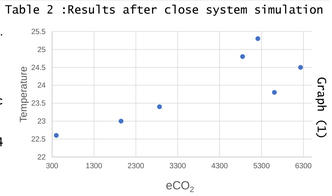
Results

During the test plan, the following data has been collected:

Trial	1	2	3	4	5	6	7
CO_2	400	1946	2864	5607	6232	4847	5211
Temperature	22.6	23.0	23.4	23.8	24.5	24.8	25.3

Table 2 :Results after close system simulation

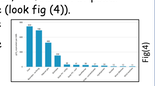
Based on the data gathered in table (2), we set out to fulfil our third design need, which called for establishing a relationship between eCO2 and temperature in order to forecast future values for the temperature. We plotted the data on a graph, designating the eCO2 (the independent) on the x-axis and the temperature on the y-axis(depended), and concluded that CO2 and the increase in temperature are directly related. The correlation (r) has been calculated to be 0.8352995789. From this value, we started forming the equation of the line of regression. The equation of the line of regression will meet our design requirement as it provides a scientific calculation for identifying and predicting future outcomes. Using the outcomes, the line of the regression equation is: 22.434X+3.8235391×10-4 We will be explaining the results and laws used in the analysis section.



Graph (1)

Analysis

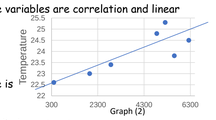
Climate change is one of the most serious problems facing the planet. By looking at the outputs of the industries, we found that power generation from burning coal is the most contributing to carbon dioxide emissions and an impact on the climate (look fig (4)). Therefore, using the Internet of Things, we have decided to develop a solution as follows: we created a device that measures the relationship between carbon dioxide produced by factories, and the amount of temperature change. After testing and analyzing the results of our system, we found that the solution achieves the design requirements which are:



Fig(4)

- Accuracy: We chose DHT 11 (Temp And humidity sensor module) with an accuracy of ±2 degrees Celsius accuracy to meet our requirements which were ± 5 degree Celsius accuracy.
- Dynamic range: We chose CCS-811 sensor with range of measuring eCO_2 from 400ppm to 8192ppm which met our design requirement range which was range of 400ppm to 4000 ppm.
- Constructing prototype testable, and based on IoT system.
- Building a relationship between one independent variable and a dependent variable that causes climate change: the main goal of our project is to study the changes in CO2 and temperature concerning time in a simulated environment to predict a relation between them.

The most commonly used techniques for investigating the relationship between two quantitative variables are correlation and linear regression. Correlation quantifies the strength of the linear relationship between a pair of variables. The data can be represented by the ordered pairs (x, y) where x is the independent variable, and y is the dependent variable. The independent variable is the cause, whereas, the dependent variable is the effect, its value depends on changes in the independent variable.



Graph (2)

In our study, we represented the change in CO2 as the independent variable -i.e. the cause-, while in contrast, the temperature is the dependent variable. We started by representing the data of the testing phase on a scatter plot (as shown in graph (2)) which can be used to determine whether a linear (straight line) correlation exists between two variables.

After representing the x and y variables, we began calculating the correlation coefficient. The correlation coefficient (r) is a measure of the strength and the direction of a linear relationship between two variables. The symbol r represents the sample correlation coefficient. The range of the correlation coefficient is -1 to 1. A relation is called significant if is between the range of [0,5:1] or [-1:0,5]

The formula for r is: $r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}}$

Where:
r=correlation coefficient,
x=values of the x-variable in a sample,
y=values of the y-variable in a sample,
n=number of pairs of data

X	Y	XY	X^2	Y^2
400	22.6	9040	160000	510.76
1946	23.0	44758	3786916	529.0
2864	23.4	67017.6	8202496	547.56
5607	23.8	133446.6	31438449	566.44
6232	24.5	152684	38837824	600.25
4847	24.8	120205.6	23493409	615.04
5211	25.3	131838.3	27154521	640.09
∑X =27107	∑Y =167.4	∑XY =658990.1	$\sum X^2$ =133073615	$\sum Y^2$ =4009.14

Table 3

Consequently, with table (3), we got the value of r, which has been found to be: 0.8352995789

The value indicates that is directly strong, also called significant, between the eCO2 and temperature. Hence, after verifying that the linear correlation is significant, we determined the equation of the line that can be used to predict the temperature for a given value percent of eCO2.

The equation formula of a regression line is: $\hat{y} = ax + b$

where $\hat{y}$ is the predicted y-value for a given x-value, a is the slope, and b is the y-intersect.

To get a and b, we used the following formulas: $m = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{n(\Sigma x^2) - (\Sigma x)^2}$ $b = \frac{\Sigma y - m(\Sigma x)}{n}$

According to our outcomes, we calculated a and be to be: a= 22.43364751, b=3.823539088×10^{-4}

In the end, the equation of the regression line is: **22.434X+3.8235391×10^{-4}**

Code:

We started the code by including the required libraries, defining our variables, and the pins. We also connected the ID of ThingSpeak with the code to collect the readings of the sensors. We set the receiving time to every 17 seconds as shown in fig 5. The Void loop will check for the time to keep reading as long as the program is running as shown in fig 6. The read sensor function gives the variable t for temperature, co2 for eCO2, readings as shown in fig 7.

In fig 8, we represent the ThingSpeak code. It first starts getting the readings on the right field of the chart. Then, it prints it on the graph.

Fig (6)

Fig (5)

Fig (7)

Fig (8)

Connection:

After determining the sensors required for our project, we will start connecting each sensor as follows: - DHT11 module: it has three pins. The GND connects to the ground of the circuit, and the VCC which is considered the power supply connects to 5V power. Sometimes 3.3V power isn't enough so, it is better to use 5V power, lastly, the Signal or Data pin which outputs both temperature and humidity through serial data connects to 11 in the Arduino.

- 1psc CCS811 HDC1080 CO2 Sensor Module Board: it has 8 pins. The VCC (the power pin) uses 3.3V to power the board. We used 3.3V. The second pin is the GND. Then SCL and SDA pins are connected respectively to the SCL and SDA on Arduino. The other pins remain without wiring.

Learning outcomes

Table 4

CH3.01	**According to the basic steps of the scientific method, we can learn the steps we take to solve our challenge concepts of uncertainty and precision, Helping calculate values accurately. A comparison of quantitative analysis and qualitative analysis helped to define the loneliness and loneliness parameters.**
PH.3.04	The basic elements of communication help to understand communication in the system. For example, an antenna can act as a transmitter and receiver Like a mobile app. The types of wave propagation (earth, sky, space) were most useful in it Determine the transmitted signal.
PH.3.05	In Digital comparison with analog, the digital number is a specific value but the digital number is a range Value. Study Wi-Fi and how it works. Sampling and quantity coding process.
EN3.01	We learned how to write native essays that help us to write the poster and the portfolio
ST 3.02	We have studied regression analysis. The benefit of regression analysis is that it can be used to understand all kinds of patterns that occur in the data. That helped us understand what could make a difference to our results.

Materials

Item	Cost	Item	Cost	Item	Cost
Glass box	50	Arduino Uno	330	1psc CCS811 HDC1080 CO2 Sensor Module Board	300
Coal	10	WiFi ESP8266-12-F Serial TTL Module	65	DHT11 Temp & Humidity Sensor Module	35

Table 1 : Materials that were used in Capstone total price:790 pounds

Conclusion

We concluded by doing the test plan and collecting data that the temperature increases by 2.09 degrees when there is a percentage of 16.727 carbon dioxide in the air. A potential increase of at least 2.7°F over two years is projected for all countries except for a scenario involving the mitigation of greenhouse gas emissions. That will result in the melting of the polar ice, which will lead to the sinking of most coastal cities. For that we suggest to capture of carbon, by separating the carbon dioxide from emissions sources, the carbon dioxide can then be injected underground for permanent storage. Reuse and recycling also reduce the environmental impacts of coal production and use.

Recommendation

We suggest the following for the project's upcoming work:

- To help reduce carbon impact it is recommended that all new Terp carbon-powered sensors be supported, to reduce energy consumption and generate renewable energy on-site and perform closed-circuit measurements of carbon consumption and waste.
- Replacing certain sensors with more efficient ones. For instance: The DHT22 temperature sensor, which has a wider dynamic range, can replace the DHT11 temperature sensor.
- We recommend using PCB instead of traditional wiring. A printed circuit board can contain several parts and elements because they utilize copper tracks rather than actual wires, it allows for the same types of results without using current-carrying wires. The boards are less substantial and smaller.

- As we mentioned previously, the problem of electricity production from coal combustion produces many greenhouse gases, including carbon dioxide, PM, and NOx. In our project, we studied the carbon dioxide variable. We intend to investigate more influencing factors and build more correlations to further the research.

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Acknowledgment

First, we want to thank Allah for guiding us to complete our project. then we want to thank: Mr. Yasser Abo Donia (our school principal). Mrs. Souzan Negm (our School deputy) Mr. Haytham Makshat (Our capstone leader). Mr. Kamel Reda (The General capstone leader). Mr. Shokry George (The Fablab manger). Mr. Galal Khira (Art teacher), for their hard work and dedication while helping us.

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