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Smart City System - Based on Internet of Things Technology

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Abstract The population of many cities in the world is increasing over time, which leads to urban sprawl and an increase in energy consumption and polluting gases, especially in urban areas. Indeed, energy consumption and pollutant gases threaten human life. On the other hand, technology has affected every aspect of our life. To prevent such threats, cities must be smart so that they can be managed in a smart way. In this sense, the main objective of this paper is to realize a prototype of an Internet of Things (IoT) system to save human life while preserving the environment. This system is called I-CITY and incorporates Smart Parking, Intelligent fire detection system with automatic fire extinguisher and quality monitoring system around the city environment. This invented device is made up of web access that gathers, sends, and processes data from their environment using embedded systems including processors, sensors, and communication gear. Finally, I-CITY solves parking problems in cities with high populations. It also contains a flame detection system that can identify local fires by processing signals receives from flames. However, this system contains a fire extinguisher to automatically extinguish the fire. Finally, an air quality monitoring system collects information from their surroundings. The information from this work could be used by decision market for better city planning.

Keywords Smart City, Smart Parking, Air Quality Monitoring, Fire Detection, Sensor, IoT

1. Introduction

Today's living conditions, such as the increase in earth's population and the need for energy, require cities to optimise the use of their energy, environmental and safety resources [1]. Hence the growing interest in reducing and controlling the costs is associated with their consumption and inventing more sustainable and ecological operating models [2]. The aim is to optimise urban mobility (transport, energy consumption, information flows, etc.) in order to facilitate the activities of stakeholders while reducing energy expenditure as much as possible [3]. Consequently, the smart city is not defined by its solutions, but by the objectives it seeks to achieve through its design. The concept of "smart city" is the integration of ICT (Information and Communications Technology). Thus, in this project, our objective is to include systems applicable to the smart city, realizing a prototype of a "small city" [4]. The systems included in this project are based on IoT [5], [6]. An IoT ecology system comprises web-enabled components that send and process data from their surroundings using embedded systems including CPUs, sensors, and communication gear [7]. IoT devices connect to IoT gateways or other edge devices to share the sensor data they gather, which is then transferred to the cloud for analysis.

The modules that make up the prototype of this project are:

- Smart parking [8]
- Intelligent flame detection system [9]
- Air quality monitoring systems [10]

2. Problem and Proposed Solution

Smart Parking

Nowadays, it can be very challenging to find parking spots in congested places, and there is no mechanism in place to check the availability of parking online. Imagine not having to go anyplace to verify the availability of parking spaces since you could get the information on your phone or over the internet. The IoT-based smart parking system can provide a solution to this issue [11]. You may quickly check the online availability of parking spaces by utilizing the IoT-based parking system. The parking system can be fully automated by this technique. The entire process, from your admittance through your payment and exit, can be automated. This considerably reduces time and effort [2].

Air Quality Monitoring

The level of air pollution is rising quickly day by day as a result of a growth in factories, industries, and automobile use that is harmful to human health. As a result, we created a system that can measure the air quality nearby, keep an eye on the levels of air pollution, and alert us when the quality of the air goes over a specific threshold. This method can identify gases that are dangerous to human health, including CO_2, NH_3, Nox, alcohol, benzene, and smoking. The air quality number in ppm (parts per million) is displayed on a small display on the device [12]. It is a compact, portable gadget that may be utilized at home, at work, in a school, or in a manufacturing facility. It can protect us from dangerous gases [13].

Fire Detection

These days, fire detection and warning systems are widely used in workplaces, homes, and other buildings. They typically hear fires and sound a siren to warn people, but what occurs if no one is around to hear the alarm. For instance, when no one is home or at work. Therefore, it's necessary to automatically extinguish fires and notify the appropriate authorities of fire events. Using the NodeMCU project, we connected this fire detector to the Internet of Things and a fire extinguisher. This project can be improved by automatically alerting the fire control department [14].

This IoT based project uses an infrared flame sensor to detect a nearby flame, and then NodeMCU triggers the relay to extinguish the fire automatically. It also notifies the authority via the Blynk IoT application.

3. Specification of Requirements

3.1. Material Specifications

Smart Parking

The components required to implement the Smart Parking system:

Nodemcu Card [15]

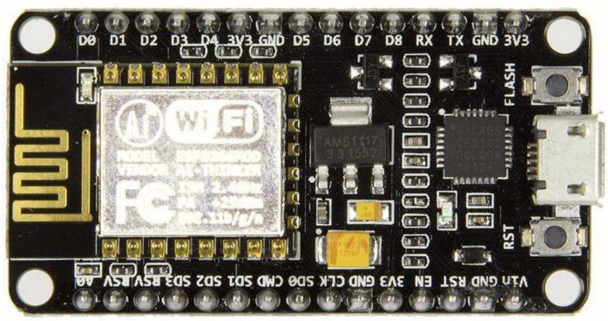

Figure 1. NODEMCU ESP8266 board

The LUA-based development card firmware named NodeMCU (Fig.1) was created especially for IoT applications. It is based in a module called ESP-12 and it works on the nodeESP8266 Wi-Fi SoC by a company called Espressif Technologies.

The following table 1 represents the configuration of the development board NodeMCU.

Table 1. Pinout configuration of the NodeMCU development board

Pin category	Pin name	Function
Power	Micro usb 3.3 V, Ground V (in)	3.3V: our development card is supplied from this specified pin GND refers to Ground Vin: refers to the Power Supply
Control Pins	EN RST	It is one pin and a button that resets the microcontroller
Analog Pin	A0	Used to measure analog voltage from 0.5 to 4.3V
GPIO Pins	GPIO1 to GPIO16	NodeMCUESP8266 has sixteen purpose in-put and out-put pins
SPI Pines	SD1; CMD; SD0; CLK	NodeMCUESP8266 use 4 pins for the SPI communication.
UART Pins	TXD0, RXD0, TXD2, RXD2	NodeMCU has two UART interfaces, uploading the firmware/program.
I2C Pines		NodeMCU ESP8266 with I2C functionality support

Infrared Obstacle Sensor

This sensor uses infrared light to detect obstacles. When the emitted infrared light hits an obstacle, it is reflected and detected by the photodiode. The distance to be reached for detection can be set with the two controllers [3].

An infrared transmitter (Figure 2) sends an infrared signal which, in the case of a reflective surface, bounces off in certain directions, including the direction of the infrared receiver which receives the signal from the detected object.

When the surface is absorbent (e.g. black), the IR signal is not reflected and the object cannot be detected by the sensor. This result would occur even if the object is not present (Figure 3).

Figure 2. Infrared obstacle sensor

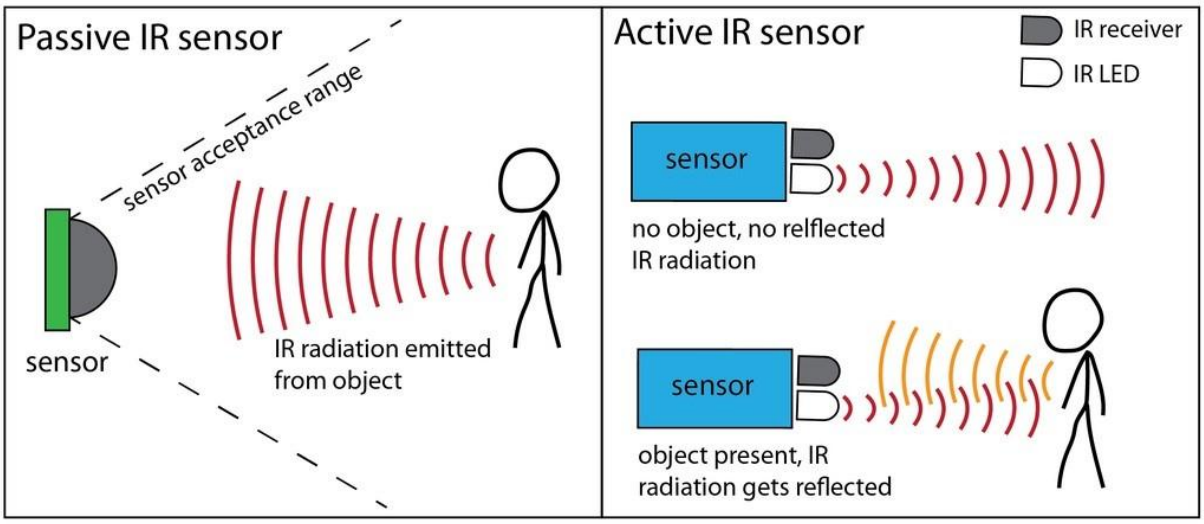

Figure 3. Operating principle of an infrared sensor

Air Quality Monitoring

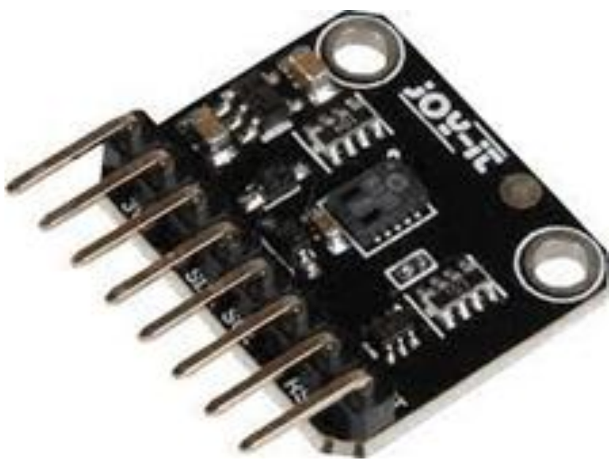

Figure 4. CCS811 Pollutant gas sensor [17]

The CCS811 [18] (Fig.4) is an extremely low powered and high performance digital gas sensor which combines an analogue-digital converter (ADC) and an I2C interface with a metallic oxide (MOX) sensor that have the ability to detect a variety of volatile organic compounds (VOCs) for the surveillance of indoor air quality.

In order to calculate the total volatile organic compounds or equivalent CO_2 levels from the measurements, the CCS811 supports clever algorithms;

Figure 5. OLED display screen

The OLED (Organic Light-Emitting Diode) (Fig.5) is an alternative to the LCD screen. OLED is extra light, thin as paper, and produces a brighter, sharper and high quality image.

LCD is the abbreviation of the English term "Liquid Crystal Display". The LCD display is in particular a visual interface between a system (project) and the human being (user). Its role is to transmit useful information from a system to a user. It will therefore display data that can be used by the user of a system [19].

Fire Detection

Sensor structure:

Flame sensors (Fig.6) are constructed with an electronic circuit that picks up EM radiation.

An insulated metal rod serves as the sensor's focal point, sending an alternating current signal into the flame.

This alternating current is received by the flame, which then injects the burner with its DC component.

The burner is then told to use a stranded wire to transmit the received DC signal first to the burner support and subsequently to the control.

The gas valve is then locked onto by the control after detecting the current loop to complete the stroke. The signal is likely to deteriorate when this modest amperage/voltage signal is return

The flame detector uses an infrared flame flash technique, which enables it to penetrate a layer of dust, oil, water vapor, and occasionally ice [20].

Figure 6. Infrared flame sensor

3.2. Software Requirement

In addition to a script editor for typing codes, a message area, a tool bar with buttons for frequently used operations, and a number of menus, the Arduino Development Software Integrated Environment, sometimes known as the Arduino Software (IDE), is also available. To download software and communicate with the Arduino hardware, it establishes a connection.

Figure 7. Fritzing simulator

Fritzing (Figure 7) is a software suite for electronics. Developed by the University of Applied Science Potsdam, it is mainly known for editing electrical diagrams. In addition, the software also allows for the simulation of schematics.

Electrical circuits designed with this software can be used in documentation as the software controls most of the graphical appearance of the circuits.

4. Circuit Diagrams by Fritzing

Smart Parking

Our smart parking electrical diagram (Figure 8)

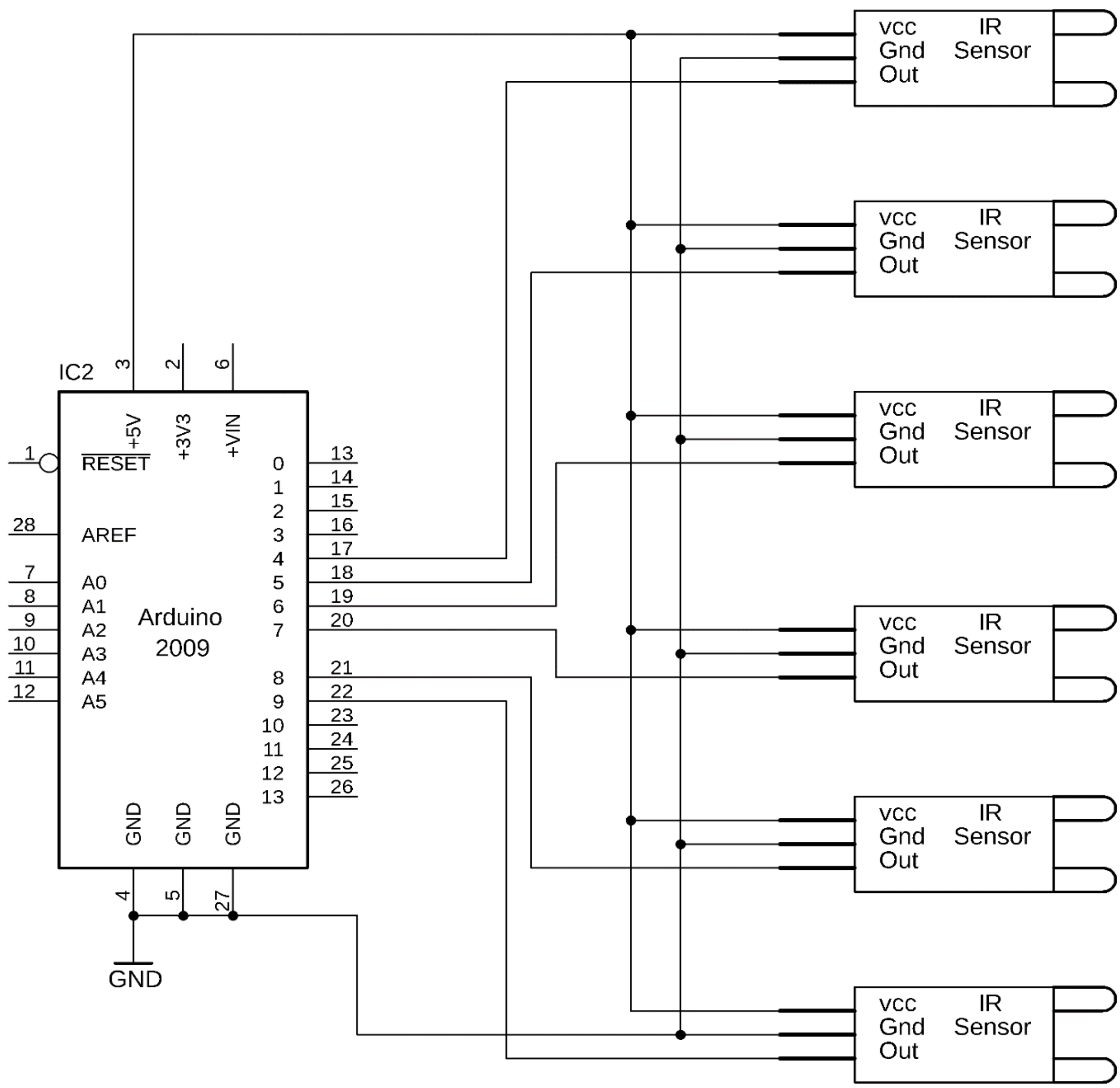

Figure 8. Smart parking diagram

Air Quality Monitoring

Air quality monitoring system electrical diagram (Figure 9)

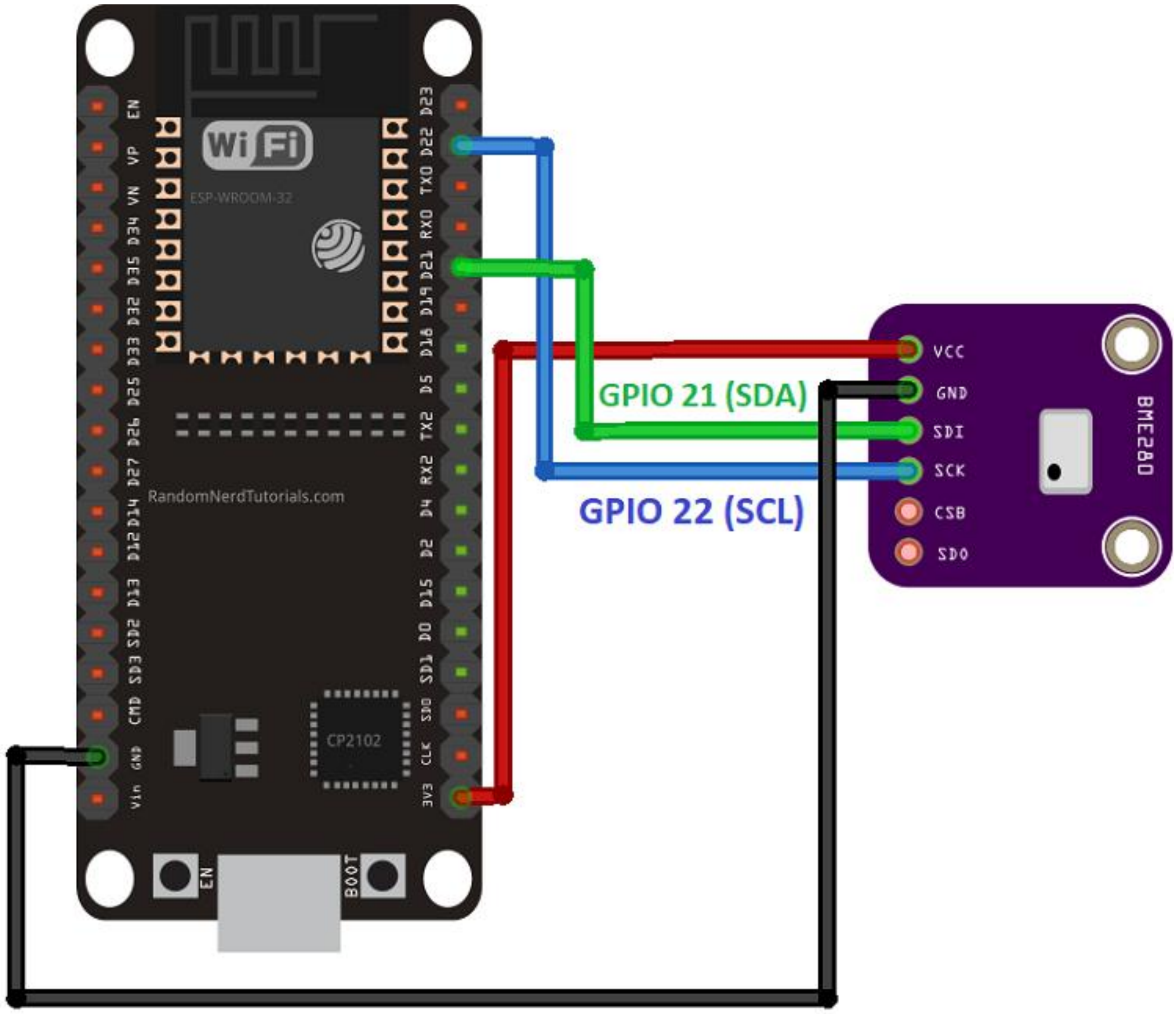

Figure 9. Diagram of the air quality monitoring system

Flame Detection

Flame detection diagram (Figure 10)

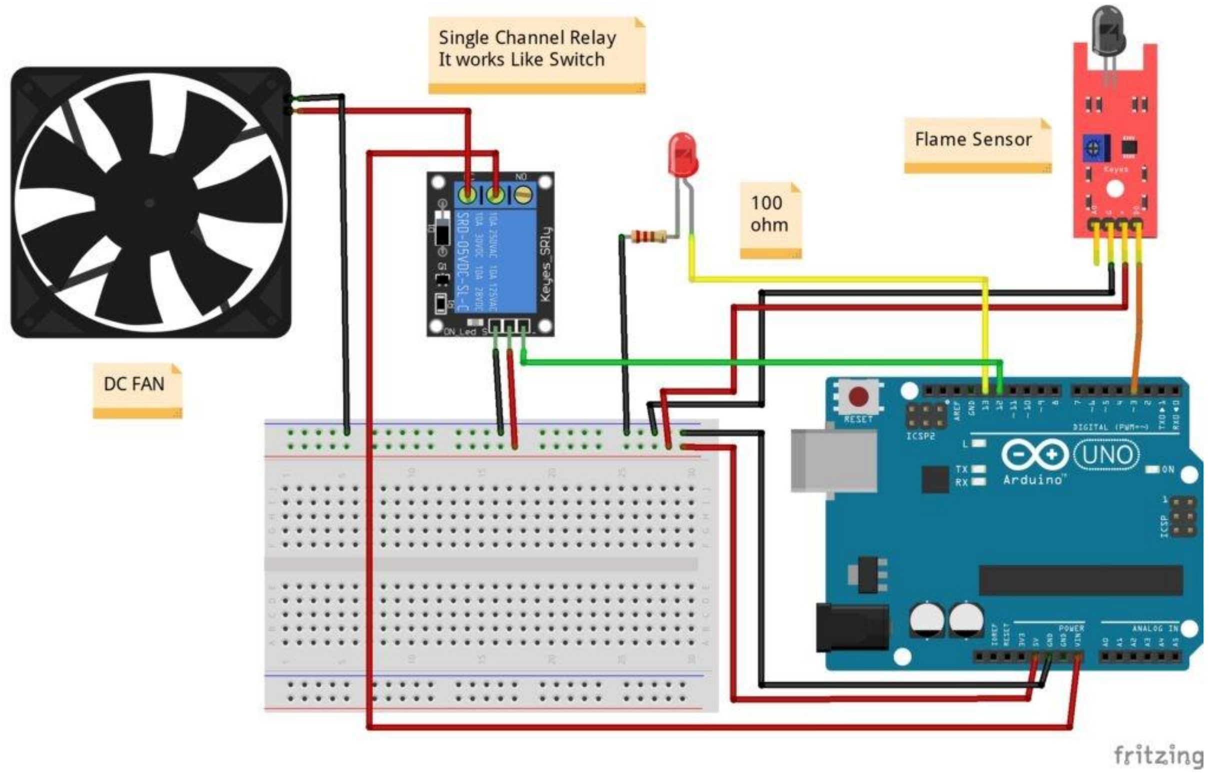

Figure 10. Diagram of the intelligent fire detection system

5. Code Developed by Ardouino

The code developed for this paper is cited in the appendix.

6. Results and Discussion

Smart Parking

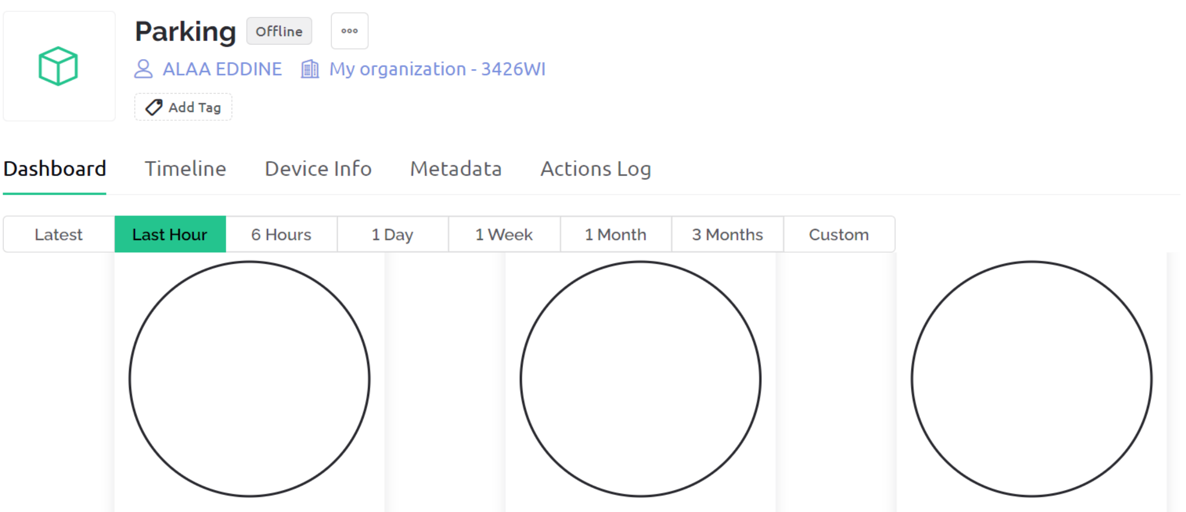

Figure 11. Interface of the parking space monitoring application

Here, we use the NodeMCU, five IR sensors, and two servo motors to develop an IoT-based parking system. Three IR sensors are used here in order to detect the presence of a parking slot, while two IR sensors are utilized to detect cars at the entrance and exit. Depending on the sensor value, the servo motors are employed to open and close the parking doors. Here, we publish the data to the cloud using the blynk IoT platform so that it can be viewed from any location.

The NodeMCU is connected to the servo motors and IR sensors. The entire process is managed by the NodeMCU, which also sends time and parking availability data to the blynk IoT platform. (Fig.11&Fig.12)

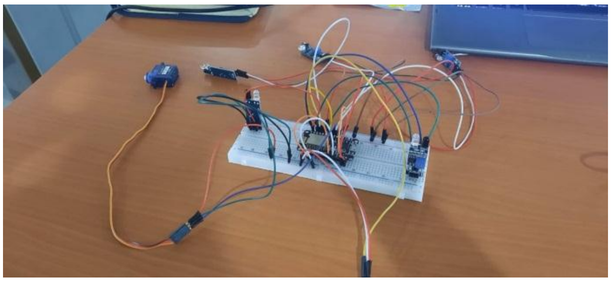

Figure 12. Nodemcu ESP8266 and infrared sensors

Air Quality Monitoring

Gas sensors are gaining interest with the development of applications in the automotive, home automation or environmental fields. To meet this demand within the smart city, we have developed an air quality monitoring system that can detect air pollution and send signals (Fig 13).

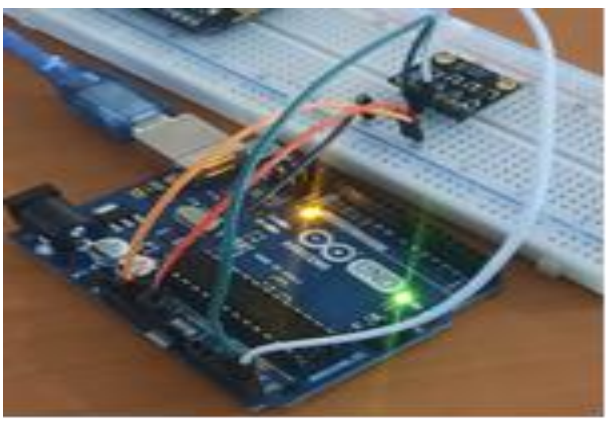

Figure 13. Our air quality monitoring model

Intelligent Flame Detection System

Our job entails creating an IoT-based fire alarm system that can detect fire accidents and send the user an alert message.

A fan has also been incorporated into this system's design to automatically put out the flames (Fig 14). The system is working properly. The message "warning / fire detected" has been issued when the flame has been discovered (Fig 15).

Figure 14. Operating circuit

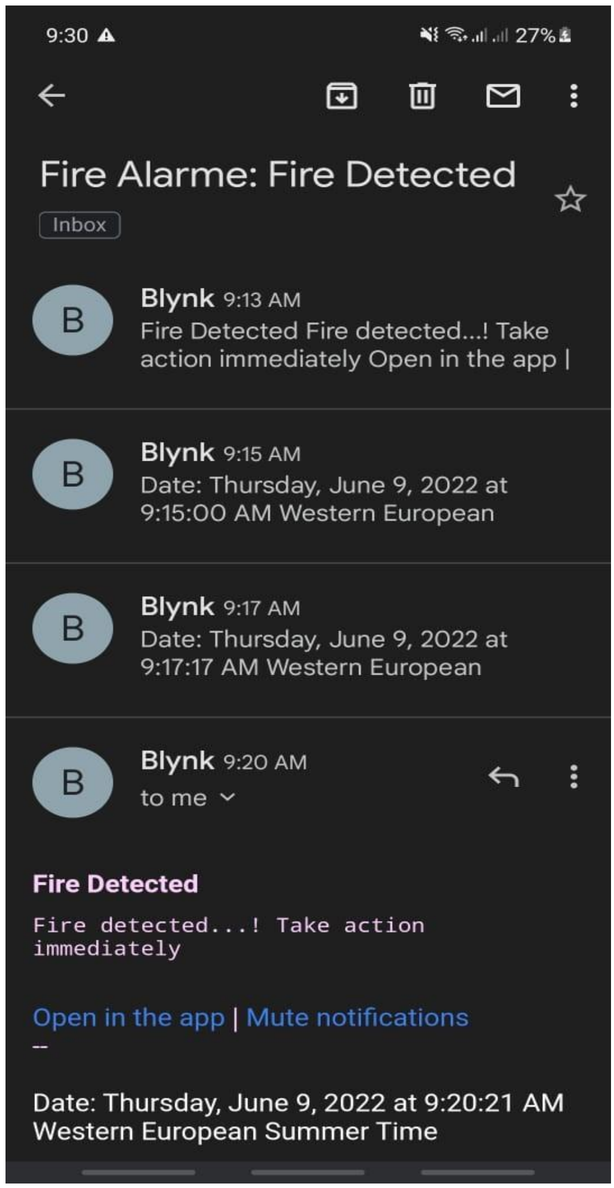

Figure 15. The alert message

The fire control service can be automatically notified as part of this project's future improvements.

Final results of the developed prototype (Figure 16):

Figure 16. Experimental set-up

7. Conclusions

The main purpose of this paper lies in creating a prototype of an intelligent city called I-CITY based on the (Iot) Internet of Things modelled in 3D. This work is carried out in 3 phases: in the technical studies section, we defined all the components necessary for the operation of the modules: sensors and microcontrollers. In the programming part, we developed programs and codes for the model. In the execution part, we printed the objects in 3D and assembled the model successfully. I-CITY is essentially composed of Smart parking, Fire alarm system and Air quality monitoring system. First, Smart Parking aims to address parking problems in cities with large populations. Second, Fire alarm system identifies a fire and transmits the alert message to the user by notification. This system also contains a fire extinguisher to automatically extinguish the fire. Finally, Air quality monitoring system collects information from their environment to allow us to detect air pollution such as CO_2 and polluting gases.

Acknowledgements

We thank the Moroccan Foundation for Advanced Science, Innovation and Research (MASciR) for their technical and financial support.

Appendix

Smart Parking

```
#define BLYNK_TEMPLATE_ID &quot;TMPLQ6ESTRC6&quot;
#define BLYNK_DEVICE_NAME &quot;Parking&quot;
#define BLYNK_FIRMWARE_VERSION &quot;0.1.0&quot;
#define BLYNK_PRINT Serial
#define APP_DEBUG
#include &quot;BlynkEdgent.h&quot;
//D0
int p1 = 16;
//D5
int p2 = 14;
//D4
int p3 = 2;
WidgetLED spot1(V0);
WidgetLED spot2(V1);
WidgetLED spot3(V2);
Servo tap_servo;
Servo tap_servo1;
void setup()
{
Serial.begin(115200);
delay(100);
pinMode(p1, INPUT); // Setting sensors to input
pinMode(p2, INPUT);
pinMode(p3, INPUT);
BlynkEdgent.begin();
pinMode(sensor_pin,INPUT);
tap_servo.attach(tap_servo_pin);
pinMode(sensor_pin1,INPUT);
tap_servo1.attach(tap_servo_pin1);
}
void loop() {
BlynkEdgent.run();
int sens1 = digitalRead(p1); // Saving Values os sensors
```

```
int sens2 = digitalRead(p2);
int sens3 = digitalRead(p3);
Serial.println(sens1);
Serial.println(sens2);
Serial.println(sens3);
if (sens1 != 1) {
spot1.on();
} else {
spot1.off();
}
if (sens2 != 1) {
spot2.on();
} else {
spot2.off();
}
if (sens3 != 1) {
spot3.on();
} else {
spot3.off();
}
val = digitalRead(sensor_pin);
val1 = digitalRead(sensor_pin1);
if (val==0)
{tap_servo.write(0);
}
if (val==1)
{tap_servo.write(180);
}
if (val1==0)
{tap_servo1.write(0);
}
if (val1==1)
{tap_servo1.write(180);
}}
```

Air Quality Monitoring

```
#include &quot;Adafruit_CCS811.h&quot;
#include &lt;Wire.h&gt;
#include &lt;Adafruit_GFX.h&gt;
#include &lt;Adafruit_SSD1306.h&gt;
#define SCREEN_WIDTH 128 // OLED display width,
in pixels
#define SCREEN_HEIGHT 64 // OLED display height,
in pixels
#define OLED_RESET -1
Adafruit_SSD1306 display(SCREEN_WIDTH,
SCREEN_HEIGHT, &amp;Wire, OLED_RESET);
Adafruit_CCS811 ccs;
void setup()
{
Serial.begin(9600);
display.begin(SSD1306_SWITCHCAPVCC, 0x3C);
//initialize with the I2C addr 0x3C (128x64)
delay(500);
display.clearDisplay();
display.setCursor(25, 15);
display.setTextSize(1);
display.setTextColor(WHITE);
display.println(&quot;CCS811 Sensor&quot;);
display.setCursor(25, 35);
display.setTextSize(1);
display.print(&quot;Initializing&quot;);
display.display();
Serial.println(&quot;CCS811 test&quot;);
if (!ccs.begin())
{
Serial.println(&quot;Failed to start sensor! Please check
your
wiring.&quot;);
while (1);
}
while (!ccs.available());
}
void loop()
{
if (ccs.available())
{
if (!ccs.readData())
{
Serial.print(&quot;CO2: &quot;);
Serial.print(ccs.geteCO2());
Serial.print(&quot;ppm, TVOC: &quot;);
Serial.println(ccs.getTVOC());
display.clearDisplay();
display.setTextSize(1);
display.setCursor(20, 0);
display.print(&quot;Air Quality&quot;);
display.setTextSize(2);
display.setCursor(0, 20);
display.print(&quot;CO2:&quot;);
display.print(ccs.geteCO2());
display.setTextSize(1);
display.print(&quot; ppm&quot;);
display.setTextSize(2);
display.setCursor(0, 45);
display.print(&quot;TVOC:&quot;);
display.print(ccs.getTVOC());
display.display();
}
else
{
Serial.println(&quot;ERROR!&quot;);
display.clearDisplay();
display.setTextSize(2);
display.setCursor(0, 5);
display.print(&quot;ERROR!&quot;);
while (1);
}
}
delay(1000); }
```

Flame Detection System

```
#define.
BLYNK_TEMPLATE_ID.&quot;TMPLqbM--8XS&quot
```

```
;
#define BLYNK_DEVICE_NAME &quot;Fire Alarm
#define BLYNK_FIRMWARE_VERSION
&quot;0.1.0&quot;
#define BLYNK_PRINT Serial
#define BLYNK_DEBUG
#define APP_DEBUG
#include &quot;BlynkEdgent.h&quot;
#define flamePin 2
#define ledPin 12
#define relay 14
int flame;
void setup()
{
Serial.begin(115200);
pinMode(flamePin, INPUT);
pinMode(ledPin, OUTPUT);
pinMode(relay, OUTPUT);
delay(1000);
BlynkEdgent.begin();
}
void loop() {
flame = digitalRead(flamePin);
Serial.print(&quot;Flame Sensor&quot;);
Serial.println(flame);
delay(1000);
if (flame == HIGH)
{digitalWrite(ledPin, LOW);
digitalWrite(relay, LOW);
}
else
{digitalWrite(ledPin, HIGH);
digitalWrite(relay, HIGH);
}
if (flame == LOW)
{
Blynk.logEvent(&quot;fire_detected&quot;);
}
BlynkEdgent.run();
}
```

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