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Smart In-Cabin Air Monitoring System using IoT Technologies

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Abstract: This research develops a monitoring system that improves the safety of people in the car. Continuous monitoring of in-cabin air quality is an important step in achieving a safer environment inside the cabin. Using oxygen, carbon dioxide, and temperature sensors to monitor those variables at all times, combining them with an Arduino to process those variables. In the event of approaching danger levels, a message is generated and sent to the owner of the car alerting them of the changes in the variables. This step allows the owner to resolve the situation without compromising the security of the vehicle. If the readings continue to depreciate, the Arduino will roll down the windows slightly allowing fresh air into the cabin, message the driver again to inform them of the action taken and alert the authorities to act immediately in case medical assistance is required. Cars have become the most common means of transportation in the world. While car crashes are looked at as the source of deaths related to vehicles, lack of oxygen and cabin overheating-related deaths have been rising. Many scenarios can lead to deaths in a stationary car such as children being left inside a car alone, parents unintentionally leaving their children in the back seats while rushing to work in the morning, and napping or sleeping in the car. Those scenarios are dangerous because of the effect of low oxygen, high carbon dioxide, and high temperature on humans. Oxygen deprivation and high carbon dioxide intake negatively affect the human brain.

Keywords—Carbon Dioxide, Oxygen, Degrees Celcius, Carbon Monoxide, Liquid Crystal Display, Heating, Ventilation, and Air Conditioning.

I. INTRODUCTION

In the contemporary tapestry of modern living, the prevalence of automobiles has become synonymous with convenience, offering unparalleled personal mobility. For instance, delving into the alarming statistics on child fatalities within vehicles adds a poignant layer to the discussion. The staggering numbers, such as the average of 38 children under the age of 15 dying yearly in the United States alone, immediately captivate the reader's attention and set the stage for a critical exploration of the negative consequences associated with car usage. This approach would not only engage the audience but also establish a strong foundation for addressing the dual nature of cars their undeniable benefits and the potential hazards they pose [1,2]. Moreover, the current years, cars are one of the most common means of transportation in the world. Due to the benefits of having one's own car, there are a plethora of cars around the world today [3]. Cars simplify the process of managing performance and personal life which are one of the most important factors that increase the rate of car production. On the other hand, cars cause many negative consequences starting from pollution that affects both people and the environment up to car accidents that cause severe injuries or even death [4].

The motivation behind this research stems from a profound desire to unravel the intricacies surrounding child fatalities in vehicles, moving beyond mere statistical revelations. Delving into the human, societal, and environmental dimensions, this study aims to shed light on the darker aspects of car usage and motivate a

paradigm shift toward safer and more responsible vehicular practices. The primary objectives of this research are threefold: firstly, to comprehensively examine the factors contributing to child fatalities in vehicles, encompassing both immediate and underlying causes; secondly, to propose and develop an innovative system for monitoring oxygen and carbon dioxide levels within car cabins, coupled with temperature monitoring, to prevent fatalities due to prolonged exposure; and thirdly, to explore the broader societal and economic ramifications of such incidents, providing a holistic understanding of the costs and implications associated with child fatalities in vehicles [5, 6].

Many people think that human losses are the result of reckless driving. Losses can happen even whether it is driven or parked. Having a nap inside the car or abandoning children inside the car while leaving to get a chore done quickly, might cost their life [7-10]. In fact, an average of 38 children under the age of 15 die yearly in the United States only, and in both 2018 and 2019, 53 children died after being lifted in a vehicle [11,12]. In addition, many scenarios of children being inside a car alone could happen. If a parent forgot to drop off their child at school in the morning and went to work instead, they might forget about them and unintentionally leave them in the back seat, especially if they were quiet or sleeping in a rear seat [6,8]. Also, sometimes the parents leave their children inside the car to do quick chores but it takes more time than expected. In some cases, the parents do not even know that someone was inside the car. In that case, two factors are affected. The first factor is a decrease in the percentage of O2 and an increase in the percentage of CO2 because of the breathing process in closed vehicles, where the body takes in O2 from breathing fresh air and gets rid of CO2 through exhaling. If this process happens in a closed vehicle for a period of time, the O2 percentage in the air will be below the safe concentration (19.5%). SGX Sensortech [2,13,14] claims that after 15 minutes in the car, the O2 level will reach 19.1% with only two people inside the vehicle. Initially, it causes a rise in heart rate, in addition to impaired muscle coordination until it ends with death. The second factor is the car's cabin overheating due to continuous exposure to the sun. A study performed by Jan Knoll, of the University of San Francisco, shows the temperature inside an idle car reaches 31.67°C in just 10 minutes when the outside temperature is 21.11°C. In 20 minutes, the temperature got to 37.22°C. In an hour, it gets to 45°C. This research develops a new system responsible for measuring and monitoring the oxygen and carbon dioxide rate inside the car cabin in addition to the temperature using the appropriate equipment. If there are any changes (decreases) in O2 levels, the system informs the car owner and the police station. If no action takes place in getting the situation to a critical point, the windows will automatically roll down allowing fresh air into the enclosed car cabin. This is where the last notification will be sent to the driver notifying them that the windows have rolled down for emergency purposes.

This study aims to make significant contributions to the field by proposing a novel system for monitoring and mitigating the risks associated with leaving children unattended in cars. The developed system, equipped with state-of-the-art technology, not only detects critical changes in oxygen and carbon dioxide levels but also automatically intervenes by rolling down windows to introduce fresh air. Additionally, the research seeks to contribute to the broader discourse on vehicular safety by examining the societal and economic impacts of child fatalities, providing valuable insights for policymakers, healthcare professionals, and the public at large. Through these contributions, this research aspires to pave the way for a safer, more responsible approach to car usage, with a particular focus on protecting the most vulnerable members of our society and our children.

II. BACKGROUND

To better understand the different aspects of our research, we turned to further research in relation to each aspect.

1. CAR INTERIOR OXYGEN MAINTENANCE

In this research the exploration begins with a positive focus on advancements in car technology. An electronic device, discussed in the referenced article [4], showcases the potential to enhance safety. This device utilizes the AT89C51 microcontroller and a gas sensor to maintain oxygen levels within the car. Such innovations contribute to a safer and healthier environment for passengers. If a critical situation arises, the device sets off an alarm and provides proper ventilation and vibration to the child seat. The AT89C51 is a powerful microcomputer that offers a highly flexible and cost-effective solution for many embedded control

applications. Additionally, the device is equipped with a gas sensor or detector that detects the presence of various gases in an area and alerts the control system to easily shut down the process [25,26]. These detectors are important as many gases can be harmful to living organisms, including humans and animals. They provide warning via various signals, such as alarms and flashlights, when dangerous levels are reached. The ADC0808 data acquisition device is also used, which is an 8-bit monolithic CMOS device that offers high speed, accuracy, minimal temperature dependence, excellent long-term accuracy, and minimal power consumption.

2. CAR SAFETY

The goal of this research is to create a car-specific gadget that will help us solve a major problem in our daily lives by enabling parents to save the lives of their children who are stranded in vehicles for an extended period of time [14,15]. Our gadget primarily detects the concentration of carbon dioxide (CO2) by receiving readings from several sensors coupled to an Arduino and processing those inputs in the microcontroller. Moreover, introduces a groundbreaking gadget designed to address a significant concern children stranded in vehicles. By detecting carbon dioxide levels and utilizing multiple sensors coupled to an Arduino, the gadget ensures swift response and alerts parents and emergency services, exemplifying the positive impact of technology on child safety. If there is a person inside the closed automobile, which is identified by the motion sensor, the device measures the temperature, humidity, and carbon monoxide (CO) levels inside and compares them to predetermined parameters. If they were excessive, the system takes action. When there are no humans present and CO2 and CO concentrations are low, the device opens the driver's window a certain amount before sending a message to the parents' designated phone number. If the parents are too late, the device sends a message to emergency personnel containing the coordination of the car based on GPS readings.

The moment parents start utilizing this gadget inside their automobiles, their worries about their kids' safety will evaporate since it reacts so fast to any changes that occur within the vehicle, delivering alerts to both the parents and the emergency services if necessary. Manufacturers can include this device as a new option in new cars or just add it to any car; the only requirement is that the model of the car must be newer than 2010. The research scope can be defined to include car manufacturers and car accessory shops, where the device will be well installed and operated because it requires knowledge in the field of cars.

3. CAR CABIN AIR QUALITY CATEGORIZATION

New research suggests that using measurement systems can provide more reliable information [16, 17]. These systems typically use air parameter sensors and a computer to control the air exchange system in a car's cabin. Around 10% of vehicles now come equipped with Air Quality Sensors (AQS), which are crucial for measuring physical quantities necessary for HVAC control systems to adjust their settings. AQS can also detect unwanted gases and odours and activate actuators to adjust the flow of air in and out of the cabin, providing protection against various traffic exhaust gases. Sensor systems can monitor many parameters without user intervention, but the type of data produced by a monitoring device is still a major challenge in air quality control. The data obtained is used to automate the modification of indoor air parameters and adjust the ventilation, heating, and cooling systems accordingly [18,19]. This process requires parameters set by the driver through the computer system. The data collected for autonomous air quality management is essential for automobile driving, as it allows drivers to avoid repeatedly adjusting indoor air settings.

4. ARDUINO GPS VEHICLE TRACKER

Morallo conceptualised a solution to track a vehicle using a GPS module for location detection paired with a GSM module to deliver the location to the recipient [7]. The user can send a “Track Vehicle” SMS to the system and will receive an SMS containing the longitude and latitude of the vehicle's location. The brain behind the system that ties all the components together is an Arduino microcontroller board, used to make the system function as intended. The GPS receiver, NEO-6m module, uses a built-in ceramic antenna providing it with strong search capabilities using satellites. It provides the longitude and latitude of the device location with the correct Coordinated Universal Time (UTC). NMEA format is used to transmit the location data in real time. This data includes time, coordinates, and other important information [26]. It is

able to communicate with Arduino using the TX and RX pins for serial communication. The SMS containing the location details is sent using a SIM900A chip module. This chip provides low-power GSM/GPRS at frequencies of 850/900/1800/1900MHz for voice, SMS, etc. The GSM extension known as Global Packet Radio Service (GPRS) provides faster data transmission rates. A wireless gadget called a GSM-GPRS MODEM connects your device to the GSM and GPRS networks. For a network link to be established, both the tool and the phones must have the same SIM card. They also have an International Mobile Equipment Identity (IMEI) number, which is used for identification on mobile phones. Both the GPS and GSM modules are powered with a 12-volt power supply [22].

5. OXYGEN DECLINE IMPACT STUDY

This experimental study was conducted in pigs using a comparative design [20]. The pig breeds Sus scrofa from the Veterinary Department of the Pertanian Bogor Institute was used as an animal model. This S. scrofa pig breed is a suitable and well-calibrated model for studying human respiratory and circulatory mechanisms. As Swindle detailed, the pig organ system is 90% similar to the human organ system, not only anatomically but also functionally. In this study, castrated boars aged 2–3 months and weighing 15–24 kg were used. A pig has a typical heart rate of 55-80 beats per minute and an expected respiratory rate of 32-58 beats per minute. In this study, the example calculation method "rule of thumb" by Roscoe (1975) was used. The researcher decided to use five pigs for this study because pigs are classified as large animals. From these five pigs, the researcher took two samples from each pig at two different times. Between two sampling periods, pigs were 'washed out' to recover and return to normal. During the recovery (washout) process, pigs were housed in cages similar to the adaptation process. Prior to cage placement, pigs were given an antibiotic (long-acting oxytetracycline) at a dose of 1 ml/10 kg body weight and an analgesic (flunixin-meglumine) at a dose of 1.1–2.2 mg/kg body weight intramuscularly. did. The recovery process took him 7-10 days [21]. This study was conducted in the laboratory of the Department of Surgery, the Radiology Department of the Reproductive Clinic, and the Veterinary Pathology of the Pertanian His Bogor Institute. The pig farm was located at the Veterinary Animal Cage Laboratory (HELAB) of the Pertanian Bogor Institute. All-inclusive pigs met the following criteria:

Boars (S. scrofa) 2-3 months old, weighing 15-24 kg, respiratory rate 32-48 beats per minute, heart rate 55-80 beats per minute, normal behavior and activity, anatomical abnormalities none, no proof [26]. The aim in this research to highlight the advancements and benefits associated with car ownership and transportation convenience. Subsequently, we have been delved into the potential challenges and negative aspects, fostering a comprehensive understanding of the problems matter.

III. METHODOLOGY

The proposed solution to solve such a problem is to monitor different gases within the cabin using appropriate sensors and take appropriate actions accordingly. Fully automating the system gives the best results due to unavailability of humans at all times.

1. ENHANCING AIR QUALITY MONITORING WITH SENSORS.

This study revolves around creating a monitoring system that increases the safety of passengers in automobiles. The method used to achieve that is continuously monitoring different gas levels in the car's cabin using oxygen and carbon dioxide sensors and thermometers to monitor the temperature. The Winsen ME2 O2 is a great oxygen sensor. It has a lot of properties that are necessary for a system like this, such as long life, a typical detection range (0～25% Vol), operating conditions of (-20℃～50℃), and perhaps a very important feature, virtually no influence from CO2, CO, H2S, NOx, and H2. As for the carbon dioxide sensor, the MQ135 provides Carbon Dioxide (CO2), Ammonia (NH3), Sulphur (S), Benzene (C6H6), and other harmful gases and smoke readings. It is specifically designed to detect the concentration of carbon dioxide in the air, which is one of the primary greenhouse gases responsible for global warming. It is widely used in various applications such as indoor air quality monitoring, greenhouse gas monitoring, and pollution control systems. This sensor can be easily interfaced with microcontrollers and can provide an analog output proportional to the concentration of CO2 in the air. These sensors, in combination with an Arduino Uno R3, provide a prime system that can continuously monitor oxygen, carbon dioxide, and temperature levels. The

Arduino Uno R3 is a single-board programmable microcontroller the size of a credit card. Code can be uploaded to the Arduino board using the Arduino Integrated Development Environment (IDE). This means the board can be programmed based on the user requirements for it to perform the needed functions. When considering the diversity of modules that can be utilized with the Arduino board to create systems as a solution to problems, the possibilities are endless. This makes the Arduino Uno R3 the perfect intermediary between the sensors' readings and actions taken by the system when necessary. Given that ordinary batteries do not have a long-life cycle and that the system must be operational at all times, connecting the system to the car's battery for power is the ideal method of delivering power to the system.

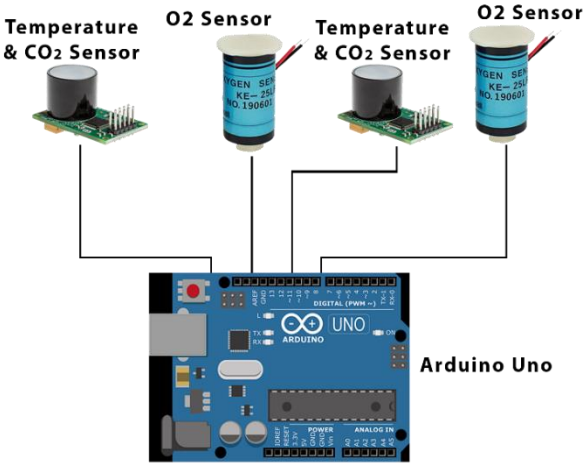

FIGURE 1. Sensor readings are sent to the Arduino

2. AUTOMATED FRESH AIR SYSTEM FOR VEHICLES

The information on how decreased oxygen levels can lead to adverse effects on human health. This research has been emphasized the dangers associated with oxygen deprivation, such as impaired cognitive function, drowsiness, and, in extreme cases, the risk of unconsciousness or other severe health complications. This clarification provided the aim to underscore the critical importance of maintaining optimal oxygen levels in the car for the safety and have been-being of the occupants.

If the oxygen and carbon dioxide levels in the car reach a critical level, which means no action was taken to resolve the emergency, the car's windows will be automatically rolled down to neutralize air quality as a last resort solution. The Arduino Uno R3 will be directly wired to the window motors to roll them down when necessary. This allows the Arduino to turn on the motor even when the car is not running, giving control to the microcontroller when the car is not being used. This method is beneficial due to not requiring the engine to be turned on which avoids wasting fuel. These steps are accomplished with the help of a relay. If the in-cabin levels of oxygen, carbon dioxide, and temperature were to reach a critical level, the Arduino Uno R3 utilizes the relay connected to it to close the motor circuit, allowing fresh air to enter the car by rolling down two of the windows one-fifth of the way down. That is done due to safety and security concerns with rolling a window down completely.

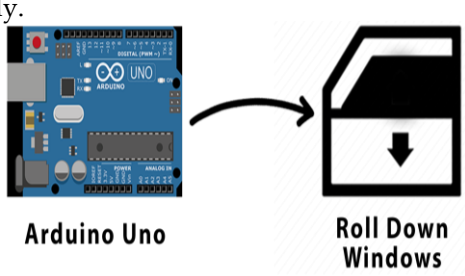

FIGURE 2. Arduino sends a signal to take action

3. STRENGTHENING VEHICLE SECURITY ALERTS

Due to security concerns regarding the automated actions taken when neither the owner nor a police officer is present in the vicinity of the vehicle, three messages are sent to ensure both safety and security. The first message is labelled as “Medium Danger”, which is sent to the vehicle's owner to inform them that the O2 level is currently at 20.2% and the CO2 level is at 0.08%. If no positive changes occur, meaning the sensor readings do not return to the standard percentage rates, a second message is sent to the nearest police station to notify and provide all the details needed, such as the cars color, model number, license plate, location, and danger level, so they can assess the situation and provide the necessary assistance with an ambulance or the right tools, if needed, that could help the critical situation. Then the third and final message named “High Danger” is sent to notify the owner that the car's windows have been rolled down due to the decrease of O2 levels to 19.5% and the increase of CO2 to 0.1%. This allows the owner to avoid any incidents of possible theft of belongings from the car or theft of the car itself. These actions are made possible using a module with a SIM900 chip connected to the Arduino. The module has GSM support for sending alert messages with custom details included in them, which further demonstrates and proves that this method is a suitable approach to achieve this objective.

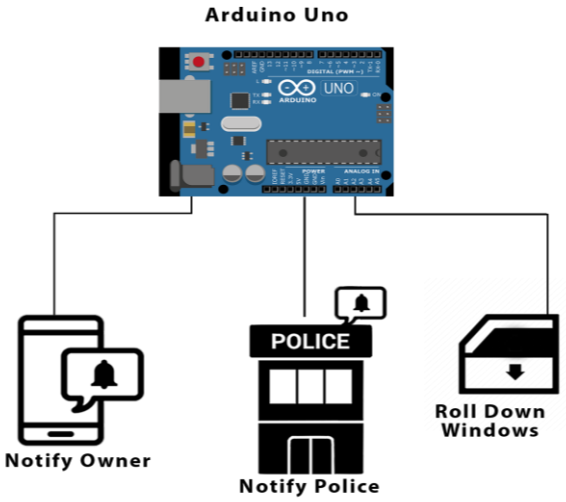

FIGURE 3. Arduino ensures actions are taken when needed

4. AUTOMATED LOCATION WARNINGS FOR EFFICIENCY

The system created, notifies the owner of the car when there is a small drop in oxygen, or a small increase in carbon dioxide, and temperature. This move prompts the owner to react quickly considering they are closest to the vehicle. In some cases, people tend to share their car with others due to the costs of owning one, which is the reason for alerting the nearest police station, to take swift action. This notification should include the vehicle's exact location, using a GPS NEO-6M module, as well as the vehicle characteristics, such as its model, color, license plate, etc., for easier and faster identification of the vehicle by the authorities. Using the GPS will be useful in cases where the owner is not present at the time, or if paramedics are required to provide medical assistance to the person in the vehicle. The same SIM900 module is used in this step to achieve our goals. The chip has GPS capabilities, which allow access to the location of the car when paired with the GPS antenna. This is utilized when attempting to identify the nearest police station and to include the location of the vehicle in that same alert sent.

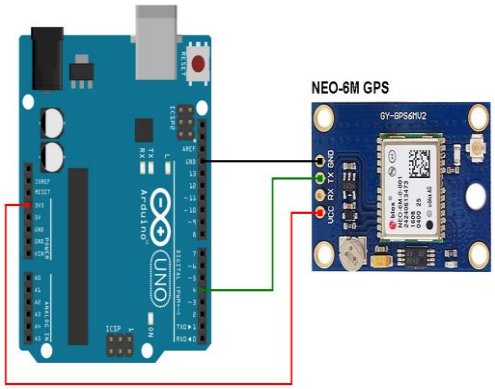

FIGURE 4. GPS connected to the Arduino

IV. DISCUSSION

Oxygen, carbon dioxide, and temperature sensors are used in making the system which are the readings the system functions based on. To alert the owner and authorities, a GSM module is used, and to give accurate location to the authorities a GPS module is utilized. In addition, servo motors are used to emulate car windows in our prototype model.

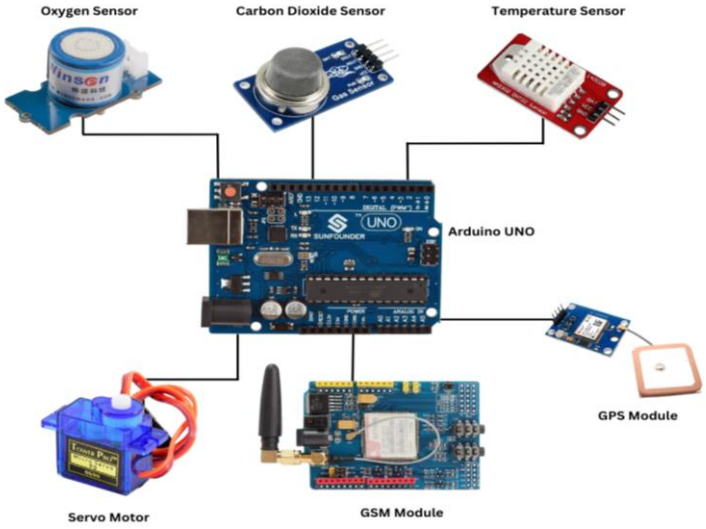

FIGURE 5. Whole System

1. OXYGEN SENSOR

The Winsen ME2 O2 sensor is a highly reliable and efficient device used to monitor the oxygen level in closed areas. This sensor is designed with advanced electrochemical technology that ensures accurate and precise measurements of O2 concentration in the range of 0-25% vol. It has a long lifespan with low power consumption, making it ideal for continuous monitoring applications. The sensor's compact size and easy installation process make it suitable for various industrial and medical applications, including oxygen concentrators, ventilators, nitrogen generators, and gas analyzers. Moreover, the sensor comes with advanced features such as high stability, fast response time, and automatic temperature compensation that ensure accurate and stable readings even in harsh environments. Thus, the Winsen ME2 O2 sensor is an excellent tool for monitoring closed areas' O2 levels and ensuring safe and healthy environments.

2. CARBON DIOXIDE SENSOR

The MQ135 is a gas sensor that detects carbon dioxide (CO2), ammonia, Sulphur dioxide, benzene, and smoke. Widely used in air quality monitoring systems, especially in enclosed areas such as automobiles, homes and offices. When measuring CO2 levels, the MQ135 provides accurate and reliable data. It is equipped with a preheating circuit that stabilizes the sensor's output, making it more accurate and reliable in measuring CO2 levels. The MQ135 features high sensitivity to CO2, which is essential in monitoring indoor air quality since excessive CO2 concentrations can lead to health problems such as headaches, fatigue, and decreased cognitive function. Therefore, monitoring CO2 levels can help prevent these negative health effects. The sensor's high sensitivity and fast response time make it ideal for indoor air quality monitoring. It also has a low power consumption, allowing it to be used in battery-powered devices, and has a long lifespan of up to five years. The MQ135 is widely used in various applications, including air quality monitoring systems, HVAC systems, and smart homes for maintaining healthy and safe living conditions.

3. TEMPERATURE SENSOR

The DHT22 is a basic digital temperature and humidity sensor. It uses a thermometer to measure the surrounding air temperature and sends a digital signal to the data pin every 2 seconds. The most important technical features are that it reads the temperature from -40 to 80°C with ± 0.5°C accuracy, is relatively small in size (27mm x 59mm x 13.5mm), very light weighted (2.4g), and includes 4 pins, 0.1" spacing, 3 to 5V power and I/O. This temperature sensor is perfect to muster the air Ambient air temperature, especially in enclosed spaces, with high accuracy. The increase in temperature causes many side effects for people, like heat stroke.

4. GPS MODULE

The NEO-6M module is a GPS receiver designed for navigation and positioning applications. It is a compact and robust module that can provide precise positioning data with high accuracy and reliability. It uses the Global Navigation Satellite System (GNSS) to determine its location and time. The NEO-6M module features a built-in ceramic patch antenna and supports up to 50 channels for GNSS positioning. It is capable of tracking multiple constellations, including GPS, GLONASS, Galileo, and QZSS. The module also has a fast time-to-first-fix (TTFF) performance of less than one minute under optimal conditions. It communicates with external devices using a serial interface and supports various communication protocols, such as NMEA, UBX, and RTCM. It operates on a voltage range of 2.7V to 3.6V, making it suitable for low-power applications. Various applications could use this module, such as asset tracking, vehicle navigation, marine navigation, and geocaching. Its compact size, accurate positioning, and low power consumption make it an ideal choice for these applications.

5. GSM MODULE

The SIM900 GSM Shield is a powerful and versatile cellular module. It can be easily programmed using an Arduino-compatible sim shield. Due to security concerns, actions are taken automatically if the owner or a police officer is not near the vehicle. A second message will be sent to the vehicle owner informing them that Their car windows have been rolled down and if the car's air conditioner is on. This allows the owner to avoid any possible incidents of theft of his belongings from the vehicle or theft of the vehicle itself. These procedures are made possible and easy and this method is an appropriate approach to achieve this goal. The unit has GSM support for sending alert messages with custom details embedded in If the owner or a police officer is not close to the car, automated actions are conducted out of security concerns. A second message will be sent to the vehicle owner notifying them that Their car windows have been rolled down and whether the car's air conditioner is on. This enables the owner to prevent any potential occurrences of theft of the car or of his possessions from the vehicle. This strategy is an appropriate way to accomplish this goal because it makes these operations possible and simple. The device may send alarm messages with customized details, thanks to GSM support.

6. SERVO MOTOR

The TS90A servo is a powerful and reliable 360 degrees micro-servo with a variety of features that make it ideal for use in robotics, RC vehicles, and other applications. It has a high torque output of up to 1.5 kg/cm,

making it suitable for controlling larger loads. The servo also has a precision metal gear train that provides smooth and accurate movement, as well as an efficient motor that delivers fast and responsive performance. Additionally, the TS90A has a wide operating voltage range (4.8V-7.4V), which ensures compatibility with different power sources. Its compact design and low weight also make it easy to install and integrate into various research's. Overall, the TS90A servo is a versatile and reliable choice for those looking for a high-quality micro-servo to incorporate into their researches.

7. ARDUINO

The Arduino UNO is a microcontroller-based platform that can be used to create and develop a wide range of IoT researches. It allows developers to easily control and manipulate sensor data, automate tasks, and create interactive devices with embedded intelligence. The board can collect and process data from sensors, communicate with other devices through various connectivity options such as Wi-Fi, Bluetooth, and cellular networks, and even interact with the physical world by controlling actuators such as motors and LEDs. In addition, it has a large community of users who provide support, libraries, and code examples, making it easy for developers to get started and create innovative IoT solutions. Therefore, the Arduino board is an essential tool in any IoT research, providing a versatile and accessible platform for prototyping, testing, and deploying IoT applications.

V. EXPERIMENTAL RESULTS

To test our model, we utilized a CO2 fire extinguisher with our prototype. A CO2 fire extinguisher is pure pressurized CO2 in the cylinder. The system was turned on and CO2 from the fire extinguisher was put into the model to create an oxygen deficient environment inside. This led to a quick decrease of O2 and a quick increase of CO2, which caused the system to quickly invoke the required actions. The following figures show the three stages the system went through during the tests.

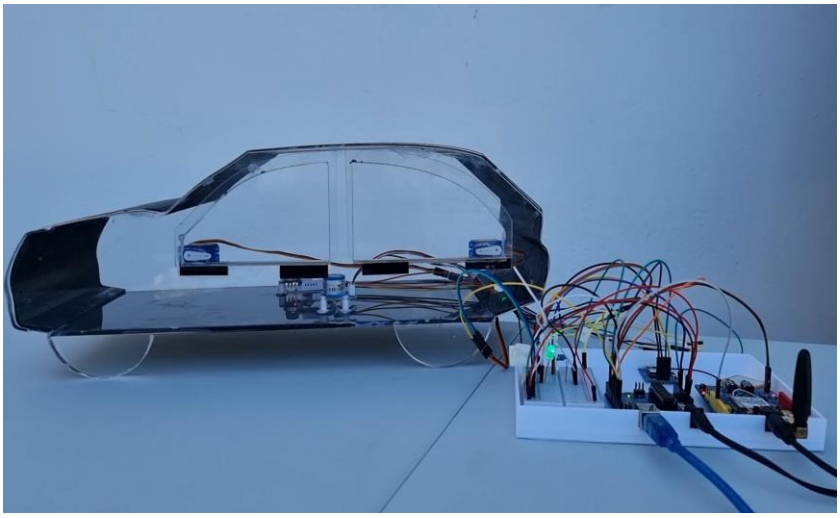

FIGURE 6. System test - normal level

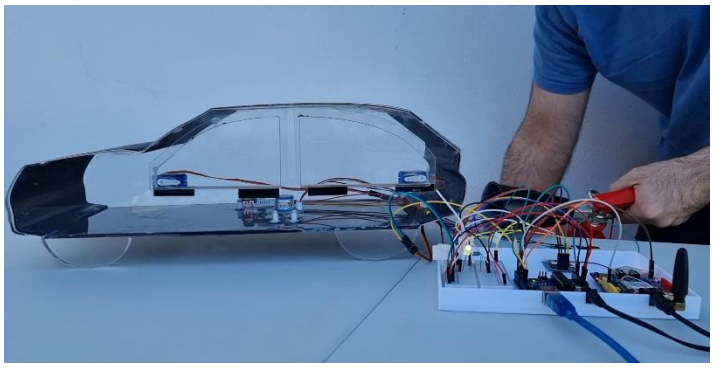

FIGURE 7. System test - Low danger level

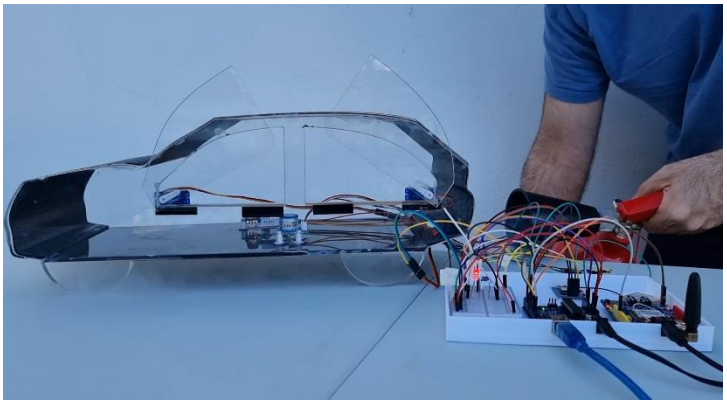

FIGURE 8. System Test - High Danger Level

Table 1. Sensor Readings - Normal Level

Time	Oxygen (%)	Carbon Dioxide (%)	Temperature (°C)
16:16:57	20.8	0.04	27.6
16:16:59	20.8	0.04	27.6
16:17:00	20.8	0.04	27.6
16:17:02	20.8	0.04	27.7
16:17:03	20.8	0.04	27.6
16:17:05	20.8	0.04	27.6

Based on the provided sensor readings in TABLE 1, it appears that the environmental conditions are relatively stable and within normal levels. The oxygen levels remain constant at 20.8% throughout the recorded time intervals. This suggests a stable and sufficient oxygen supply, which is within the typical normal range for breathable air. Moreover, the carbon dioxide levels are consistently low at 0.04%. This is within the normal range for outdoor air and indicates adequate ventilation, as elevated levels of carbon dioxide could be a concern for indoor environments. However, the temperature remains relatively constant

around 27.6 to 27.7 degrees Celsius. This suggests a stable and comfortable temperature range, likely within the normal operating conditions for the environment being monitored.

Table 2. Sensor Readings - Danger Level

Time	Oxygen (%)	Carbon Dioxide (%)	Temperature (°C)
16:19:30	20.8	0.05	27.6
16:19:32	20.2	0.07	27.6
16:19:33	20.1	0.09	27.6
16:19:35	20	0.08	27.6
16:19:37	20	0.12	27.6
16:19:38	19.7	0.1	27.5

In TABLE 2, the sensor readings indicate a deviation from normal levels, suggesting a potential danger. However, The oxygen levels are relatively stable around 20.8% initially, but a sudden drop to 20.2%, 20.1%, and eventually 19.7% is observed. A decreasing trend in oxygen levels may indicate a potential reduction in the breathable air supply. Also, Carbon dioxide levels show an increasing trend, starting from 0.05% and peaking at 0.12%. Elevated carbon dioxide levels could suggest poor ventilation or the presence of pollutants in the environment, which may pose health risks. The temperature remains constant at 27.6 to 27.5 degrees Celsius, indicating no significant change in the environmental temperature. However, the combination of decreasing oxygen levels and increasing carbon dioxide levels is concerning and indicates a potential air quality issue.

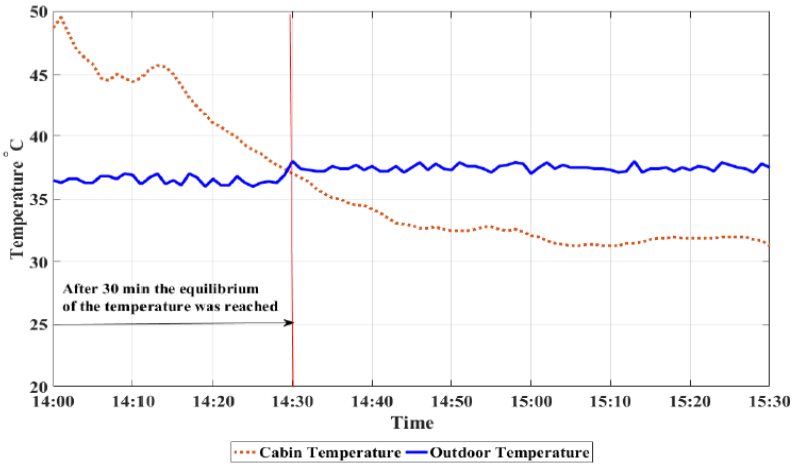

FIGURE 9. Results of before and after action

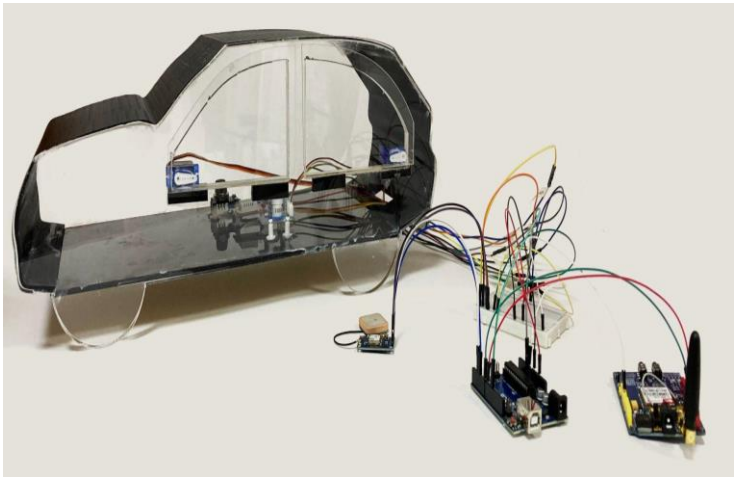

FIGURE 10. Research prototype

VI. CONCLUSION

In conclusion, the primary objective of this research was to enhance the in-cabin air monitoring system with a focus on safeguarding drivers during prolonged stays in their automobiles, especially during periods of rest. The necessity for such a system arises from the common practice of enclosing vehicle cabins, driven by concerns about external air pollution or the desire for increased personal safety. By implementing a comprehensive monitoring system that tracks carbon dioxide (CO2), oxygen (O2), and temperature levels within the cabin, this research aims to provide drivers with timely alerts and support, mitigating potential health and safety risks associated with prolonged stays in enclosed spaces .The main purpose of this research is to improve the in-cabin air monitoring system that alerts drivers to the dangers of extended automobile stays, particularly sleeping and supports them in avoiding any problems. Cabins may be frequently enclosed due to worries about exterior air pollution or car safety. Unfortunate situations can be avoided with a system that monitors the CO2, O2, and Temperature levels and then alerts the owner, when necessary, actions are needed.

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