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Constructing a Wireless Sensor Network and Internet of Things-Based Indoor Air Quality Monitoring System

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Abstract:

Because of the harmful impacts on human health, indoor air quality is an important issue, especially in settings where smoking is present. To find out how much smoke is in a room, a smoke detector is an absolute need. This project aims to develop an indoor air monitoring system using IoT and WSN to facilitate user-friendly air quality monitoring. The research procedure included a testing system, a development system, field observations, surveys, and library research. As part of the process of developing an application, you must analyze, design, implement, and test it. The application for monitoring air quality levels was built using an online programming language, a MySQL database, and an Arduino board. The air pollution level was monitored using a web-based application and a MQ-2 smoke-detection sensor. The data findings may be displayed by the indoor air quality monitoring equipment via an internet-accessible website. Users may view the data gathered from the smoke-level measurements in the monitored area. The application's feasibility and usefulness as an IAQ monitor have been validated by system testing.

Keywords: IAQ in interior spaces, air quality monitoring system, sensors, WSN

INTRODUCTION

People spend a disproportionate amount of time inside compared to outside, hence the air we breathe has a significant impact on our health. Smoking and the incineration of refuse are two examples of human activities that degrade indoor air quality. The impact of indoor air quality on human health necessitates proactive measures (Alves et al., 2020; Aung et al., 2019). There is a significant correlation between the amount of time people spend indoors and the likelihood of exposure to air pollution, making homes particularly vulnerable to this form of pollution (Becker et al., 2000). Direct and indirect effects of indoor air pollution on health are possible. Asthma, hypersensitivity pneumonia, influenza, and other viral infections are among the direct health issues that might develop after exposure, along with headaches, nausea, and muscular exhaustion. Other symptoms include irritation of the eyes, nose, and throat. In contrast, indirect health effects, such as cancer, heart disease, and lung illness, might manifest years after exposure and are notoriously deadly and difficult to cure (Sedyaningsih, 2011).

There are differing amounts of pollutant materials in outdoor areas and inside spaces, such as homes, offices, and public buildings. Smoke from cigarettes, cooking, or even the use of burn treatments to keep mosquitoes at bay is one cause of the rising levels of indoor pollutants (Kemp & Kemp, 2019). The ever-increasing capabilities of science and technology inspire individuals to design practical and life-saving products that can ward off hazards like fire and cigarette smoke (Guo et al., 2020). Modern technology has enabled the automated design of many facilities to aid human activities in controlling the indoor climate, which necessitates a higher degree of security (Gabriel et al., 2019). This is particularly true in areas where toxic gases like carbon monoxide gas, smoke, and open flames are present. Room fires and toxic gas poisonings may be prevented in this way (Becker et al., 2000). Charcoal, or CO, is a byproduct of the combustion of regular cigarettes; both men and women who

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start smoking regularly contribute to this air pollution (Guo et al., 2020). This means that not only may the environment be impacted, but also other people who smoke in a passive manner. In addition to carbon monoxide gas, the combustion of cigarettes releases a plethora of additional substances (Huang et al., 2020). Another possible health risk is inhaling secondhand smoke while cooking, which may cause symptoms like coughing and eye strain. So, this
To prevent the room from being too polluted, it is necessary to foresee the circumstance (Heo et al., 2019).The estimated yearly mortality rate in affluent nations from air pollution in homes is 67% in rural regions and 23% in urban areas; in developing countries, however, the rate is 9% in urban areas and 1% in rural areas, out of total deaths. More than 2 million people die every year from pneumonia, making it the top cause of mortality among children less than 5 years old

RELATED WORKS:

Air quality monitoring is crucial for identifying contaminants that pose a threat to ecosystems and the well-being of all living things. In order to stop the growing problem of air pollution, it is crucial to keep an eye on data on pollutant gases (Schieweck et al., 2018). Field measurements and laboratory analysis findings are both necessary for accurate smoke level assessment. A system based on Wireless Sensor Networks (WSNs) is one of the control and monitoring systems that is now under development (Kristianto et al., 2019). Nodes in a WSN can sense, regulate, and communicate their physical characteristics in order to engage with their surroundings (Pule et al., 2018).
Industrial monitoring projects, environmental monitoring, and medical telemetry are just a few of the many uses for WSN. Since the operating requirements of this WSN-based application vary, many technicians choose to implement WSN designs that are specific to their needs. For instance, extensive network coverage, excellent security, and a lot of bandwidth are necessities for military surveillance. Security, dependability, and real-time access are necessary for industrial monitoring applications (Kemp & Kemp, 2019; Kristianto et al., 2019; Pule et al., 2018). The system was built on top of internet of things (IoT) technology and also uses WSN. Using the internet, data may be sent in both directions using IoT technology (Santoso & Sari, 2019; Sari et al., 2017). With IoT, it's easy to connect any number of physical devices to any network, no matter where you are. After positioning the sensor in a suitable location for monitoring, data analysis may be performed to determine the next course of action. Sensors and processing devices are now integrated into many devices, allowing for better management and monitoring of diverse systems (Khare et al., 2020; Saleh & Hamad, 2017).
A room air quality monitoring device was developed by Lesmana and Rahayu (Lesmana & Rahayu, 2016) utilizing the following sensors: MQ131 for O3 gas, GP2Y1010AUOF for dust or particulate matter (PM10), and MQ7 for carbon monoxide (CO). The LabVIEW program was used to display numerical and graphical data on a computer screen. For the benefit of users, the data from the room air quality index measurement was provided using the Air Pollution Standard Index, which is a government-regulated air quality index (PSI in Indonesian ISPU). Studying the design of indoor air quality monitoring systems with TCP/IP communication based on ATMEGA16 microcontroller (Kim et al., 2012) and conducting research on smoke sensor-based pollution detection systems with SMS (Short Message Service) alerts and Arduino-based alarms (Tri et al., 2016). Users were given warnings and information by this air quality monitoring system after it detected the room temperature and potentially harmful air levels (such carbon monoxide levels).
After doing research to identify the intensity of forest fire smoke, Peng and Wang (Peng & Wang, 2019) developed an algorithm that blends deep learning characteristics with manual features. In metropolitan areas, air quality was checked at a number of stations. In most cases, these stations

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just record the sensor's readings and add them to a database (Yu et al., 2017). According to Abraham and Li (2014) and Kušljevic et al. (2014), data was primarily acquired from several communication networks and processed in numerous locations for statistical analysis and measurement findings. While statistical processing and analysis were often done offline, measured data collecting was typically done online.
Ku and Bourgouin (2018) also used the Atmospheric Transfer Modeling system and the International Monitoring System to study the effects of dust in the Sahara Desert. Air pollution studies were conducted at Vila Real, Portugal, with the primary goal of evaluating the impact of urban pollution on historic urban structures. Another study that backed up the findings was an EIS on the city's historic structures (Silva et al., 2020).

1. METHODS

This research employed library research, surveys and fieldobservations, system development and testing system. The application development stage included analysis, system design, implementation, and testing.

1.1. System Component

Arduino UNO is a microcontroller board that uses ATmega328. Arduino has 14 digital input / output pins of which 6 can be used as PWM outputs, 6 analog inputs, a 16 MHz crystal, USB connection, power jack, ICSP header, and reset button. The UNOis the most used and documented board of the wholeArduino family. Arduino technical specification shown in Table 1.

Table 1. Arduino technical spesification

Item	Specification
Microcontroller	ATmega328P
Operating Voltage	5V Input Voltage (recommended) 7-12VInput Voltage (limit) 6-20V
Digital I/O Pins	14 (of which 6 providePWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) ofwhich 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
LED_BUILTIN	13
Length	68.6 mm
Width	53.4 mm
Weight	25 g

ESP8266 is an integrated chip component designed forthe needs of today's connected world. This chip offers acomplete and integrated Wi-Fi networking solution, which can be used as an application provider or to separate allWi-Fi networking functions from other application pro-cessors. ESP8266 has on-board processing and storage capabilities that allow the chip to be integrated with sen-sors or with certain device applications via input outputpins with only short programming. ESP8266 was devel-oped by a developer from China named "Espressif". TheESP8266 series products are currently still in the develop-ment stage (current R&D: esp8266-32). ESP8266 itself isequipped with GPIO (General Purpose Input / Output). With this GPIO we can perform input or output functionslike a microcontroller. For example, the ESP8266-01 serieshas 2 GPIOs, while the ESP8266-12E series has an analogread pin and several digital pins.

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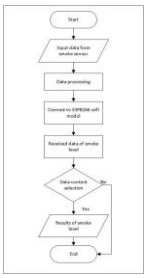
MQ2 smoke sensor is a sensor that is usually used to de-termine air quality or to determine the content that occursin the air. The MQ2 sensor is made from gas-sensitive ma-terial, SnO2. If the sensor detects the presence of gas inthe air with a certain level of concentration, the sensor will assume there is smoke in the air. When the sensor detectsthe presence of these gases, the sensor's electrical resistance will decrease. By utilizing the working principle ofthis MQ 2 sensor, the smoke content can be measured.

1.2. System Design



The flowchart of the smoke level monitoring systemdesign is presented in the following Figure 1, which illustrates the process of the system started by switching on the device so that the sensor works, as aresult the sensor will transfer data to Arduino Uno and subsequently received by the ESP8266 WiFi module and send to the smoke level monitoring website.

Figure 1. Flowchart of system

The Block diagram illustrates the workflow of the system, starting from the smoke detection by the smoke sensorMQ-2. MQ-2 sensor serves to determine the presence of carbon monoxide gas where this sensor is used to monitor smoke levels.
Accordingly, the data is sent to Arduino and the wifimodule ESP 8266, the data will eventually be sent tothe database server via the internet. The monitoring system can access the data of the smoke content on the database server via the internet, as shown in Figure 2.

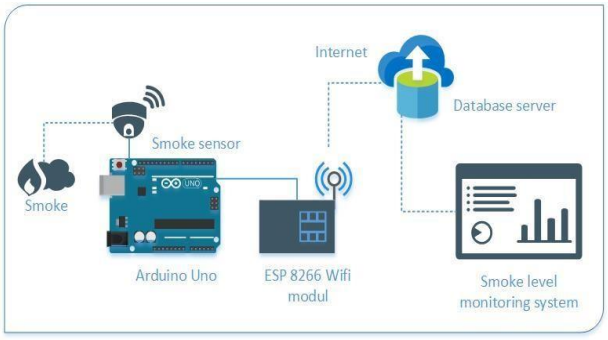


Figure 2. System block diagram

System testing is done by running the device and applications. In this study, the transparent box is usedas a prototype of room installed smoke sensors.Furthermore, it can be seen the smoke level that is displayed through a web-based system monitoring application.

2. RESULTS AND DISCUSSION

System test results in the form of graph and table. The data on the graph shows the value of smoke leveland time. The test results are presented in Figure 3 and Table 2. Smoke level sensor values are displayedin the form of a numerical line graph in ppm (parts per million). Figure 3 shows the highest point of smoke content which is 262 ppm at 16:02:28, while the smoke level is almost stable at 15:54:39 until 16:00:31, with a value of 64 ppm.

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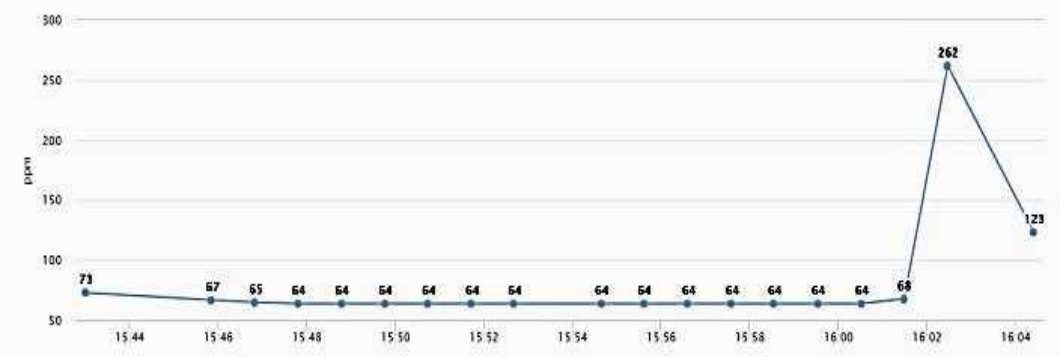

Figure 3. System results graphic

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Table2. System testing results

No	Time	Smoke level (ppm)
1	16:04:25	123
2	16:02:28	262
3	16:01:29	68
4	16:00:31	64
5	15:59:32	64
6	15:58:33	64
7	15:57:35	64
8	15:56:36	64
9	15:55:37	64
10	15:54:39	64

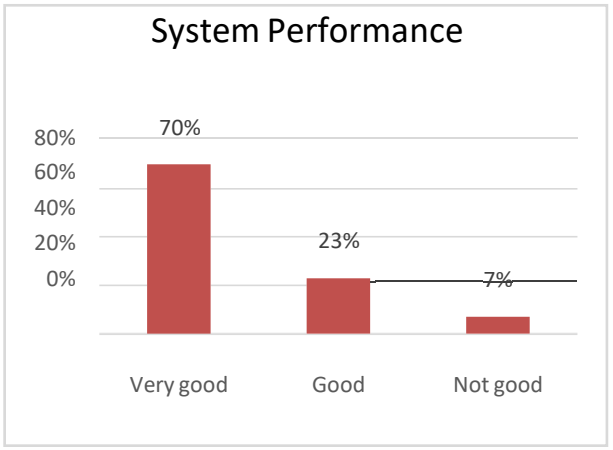

Table 2 shows the results of the system testing whichwas carried out between 15:54 and 16:04.

The tests were conducted by 30 respondents to determine the overall system prototype performance,by assessing a number of parameters, namely: system performance, the use of prototype, and accuracy of the displayed data, as served in Figure 4, Figure 5 andFigure 6.

Figure 4 explains the System Performance that generally can be categorized as 'Very good' and is shown through the user test results of 70%. Figure 5

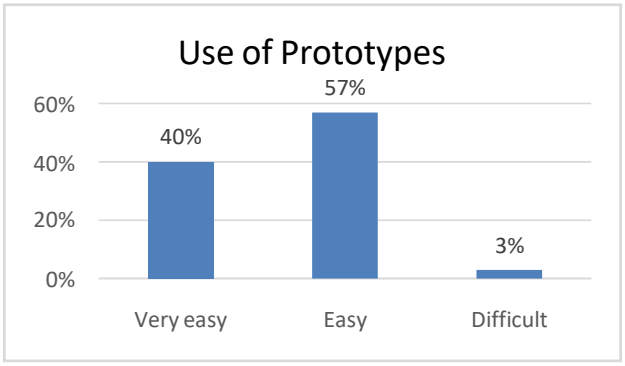

Figure 5. Use of protoypes

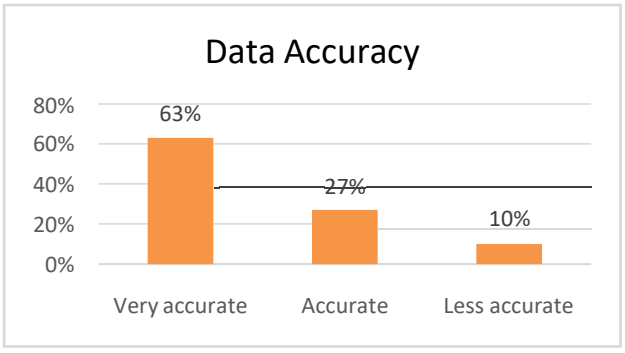

Figure 6. Data accuracy

The smoke sensor device series consists of MQ-2 sensors, Arduino UNO Microcontroller and Wifi ESP 8266 Module can be used to detect smoke in a room,and can be used to determine the level of smoke in the surrounding environment. The monitoring systemapplication can provide information on the results ofweb-based smoke content monitoring. The advantageof a web-based monitoring system application is thatit can be accessed from anywhere, thus, the smoke levels in a room can still be monitored.

3. CONCLUSION

Finally, the ability of the prototype system to detect smoke levels in a room is shown. The web-based smoke level monitoring system may also show the current smoke levels in a room and can be accessed over the internet. But there are still several problems with the present study: the prototype system is still very small-scale, the smoke content can only be measured indoors, and there was only one smoke sensor utilized in the experiment. Consequently, more research prototype systems may be built with a broader scope or in outdoor settings, and integrated with other sensors such inside light and temperature sensors.

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