

Indoor Air Qualification

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Özetçe— İç hava kalitesi, uzun vadede yaşam kalitesini etkileyen önemli bir etkidir. Yoğun bakım üniteleri gibi hassas bölgelerdeki hava kirliliği oranlarında ani değişiklikler ciddi sonuçlara neden olabilir. Bu alanın yeni fikirlere ve geliştirilmiş ürünlere ihtiyacı vardır. Bu nedenle havanın kalitesini ölçen ve gerekli değerleri gösteren gerçek zamanlı bir model geliştirdik. Bu modeli geliştirirken, gerekli sensörleri, iletişim cihazlarını ve mikroişlemcileri kullanarak bir sensör ağı elde ettik. Gerekli iç hava kirliliğini ölçülmesini sağlayan bu model, çeşitli eklemeler ile geliştirmeye açıktır.

Anahtar Kelimeler— İç hava kalitesi; sensör ağı.

Abstract— Indoor air quality is an important influence that affects the quality of life in the long term. Sudden changes of the air pollution rates in sensitive areas such as intensive care units, baby care rooms can cause serious consequences. This area needs new ideas and improved products. For this reason, we have developed a real-time model which measures the quality of the air and shows the necessary values. When developing this model, a sensor network is obtained by using necessary sensors, communication devices, and microprocessors. This model is open to development with a variety of joints despite it does provide the requirements for indoor air pollution.

Keywords— indoor air quality; sensor network.

I. INTRODUCTION

Air pollution is an increase of pollutants in the air that change the structure of the environment. It breaks down the natural structure. In fresh air, there are 78% nitrogen, 21% oxygen and 1% other gases, dust, water vapor and so on. The changes in these rates impair the ecological balance by affecting the natural life.

We can examine air pollution in two categories, natural and artificial. If we examine the causes of artificial pollution, the unconscious human community as the greatest cause can be shown as an example. Forest fire, disasters, and volcanic activity can be shown in this category. Toxic gases, especially those resulting from forest fires, play an important role in increasing air pollution. Resources such as gas and coal used for energy production, industrialization, vehicle usage and heating release a gas such as CO₂ and CO to nature. Increasing industrialization in direct proportion to the ever-

increasing number of human populations affects air pollution in the worst way.

The World Health Organization has published a final report showing that around 3 million deaths per year have occurred due to open air pollution. In addition, the shared report stated that indoor air pollution may also be lethal. An estimated 6.5 million deaths in 2012 (11.6% of all global deaths) were associated with indoor and outdoor air pollution (WHO, 2010).

One of the most important and biggest problems of environmental pollution is to control indoor air pollution. The domestic air pollution resulting from the use of solid fuels in developing countries will be higher. This leads to increased health risks. Chemical substances in enclosed spaces cause an increase in medical problems such as asthma, autism, childhood cancer. Reduced tobacco consumption, reduced use of synthetic products, and increased use of recyclable materials help to reduce concerns about indoor air pollution.

Large-scale studies on indoor air pollution are being carried out. These studies are computer-based and observation of data was provided with weather sensors and Arduino-Uno assistance.

A. MOTIVATION

One of the most important and biggest problems of environmental pollution is to control indoor air pollution. The domestic air pollution resulting from the use of solid fuels in developing countries will be higher. This leads to increased health risks. Chemical substances in enclosed spaces cause an increase in medical problems such as asthma, autism, childhood cancer. Reduced tobacco consumption, reduced use of synthetic products, and increased use of recyclable materials help to reduce concerns about indoor air pollution.

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B. CONTRIBUTION

We mentioned some projects and topics about indoor air quality. There is a need to improve models and projects in the

light of this information. We have developed a project because of the contribution of clean air to the infant development and the vital value of the baby care unit in hospitals. When babies are concerned, the models and applications to be developed have a precise design. In this study, Air quality is measured in the environment where infants are present by creating sensor network with highly accurate air quality sensors. This measurement was made to inform the parents of the results and to warn them of poor quality. At the same time, it prepares the ground for the implementation of machine learning algorithms that will be needed in the future.

II. RELATED WORKS

There are some studies and works about air quality control and arrangements. One of the biggest projects is the Village Green Project. The U.S. Environmental Protection Agency (EPA) has developed an innovative prototype air and weather measurement system, called the Village Green station, to provide new ways for communities to learn about local air quality.(Surunovich, 2015). EPA has created a system that measures ozone and fine particle pollution in the air. Since these pollutants can cause health problems at levels that exceed national air quality standards, the EPA has made restrictions in this area. The system they set up in these limits uses daylight and wind as an energy source. The system measure gases like Ozone and nitrogen dioxide. In addition, particulars in the air can be measured with this system.

Distributed Air Quality Monitoring is another project about air quality control. This project uses taxis as Q resource for portable stations. The system uses taxis to collect air quality data across the city in near Realtime. An Android-based project was developed that includes particle counts carried by latitude, longitude, temperature, humidity, pressure, and air. (PM10 - particles with a diameter between 2.5 and 10 μm , PM2.5 - fine particles with a diameter of 2.5 μm or less). (Puderer, 2017). The software is designed to collect and analyze data on a regular basis. This analysis is stored in the Google Cloud Platform to evaluate the results later. Figure down below shows the data flow of the system;

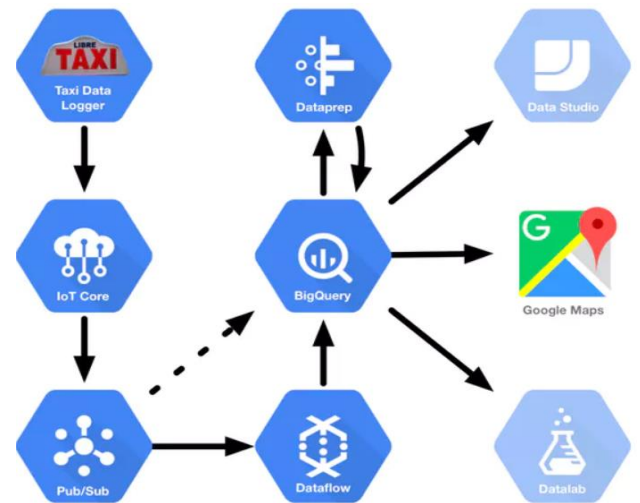


Figure 1: Distributed Air Quality Monitoring Data Flow. (Figure is taken from hackster.io)

Here is the project's embedded system inside taxi sign;

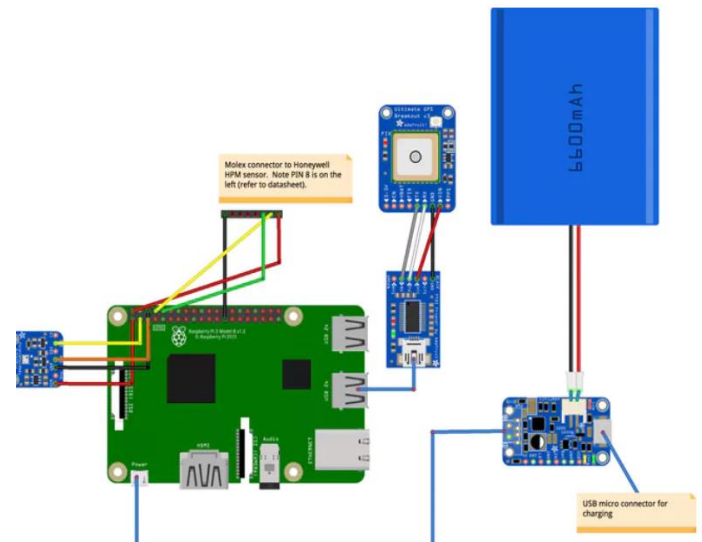


Figure 2: Distributed Air Quality Monitoring System. (Figure is taken from hackster.io)

Some theoretical studies have been made about indoor air quality. One of the important ones above all of them is the study of the health effects of nonindustrial indoor air pollution. Most people are located indoors for about 22 hours each day. Negative health effects may occur due to exposure to air pollutants during this period. Particulate matter is the most common air pollutants encountered in gas-covered areas such as ozone, nitrogen dioxide, carbon monoxide and sulfur dioxide. For the purpose of the system, it can be explained as follows; Allergists can be said to create a longer-lasting and cleaner air environment in enclosed spaces. The exposure of special substances to the indoor environment and the effects

on health can be given as the main methods of the system. (Alexis, et al., 2007). At the end of this study, it is the primary aim to evaluate patients' reactions to allergic and non-allergic triggers and to learn how outdoor air pollution affects the indoor environment.

III. OUR STUDY

A. ARDUINO UNO

In this study, Arduino UNO has been used to implement sensor network. Arduino Uno is a microprocessor based on ATmega328P. It supports all the components needed to run a microcontroller. In addition to having a USB cable for power support in the project, power can also be supplied with an AC-DC adapter or battery.

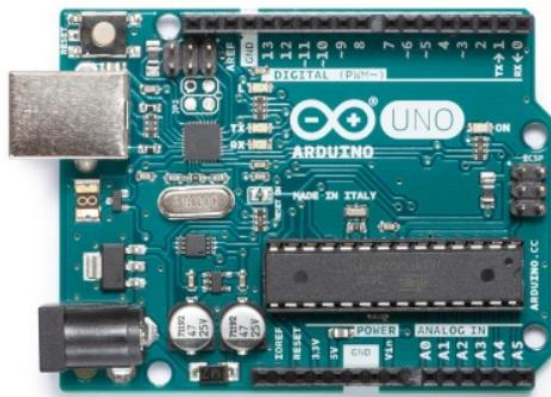


Figure 3: Arduino Microprocessor. (Figure is taken from arduino.cc)

B. MQ-135 AIR QUALITY SENSOR

This is an air quality sensor for detecting a wide range of gases. Since it works in harmony with Arduino, it is easy to use for displaying the values of gases such as NH₃, NO_x, alcohol, benzene, smoke, and CO₂ measured in the air and outputting the values. MQ-135 has a long working life and stability with high precision and fast response time.



Figure 4: MQ-135 Air Quality Sensor. (Figure is taken from playground.arduino.cc)

The output of this sensor gives us an Air Quality Index(AQI) value to criticize air quality according to AQI table that EPA published.

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
<i>When the AQI is in this range:</i>	<i>...air quality conditions are:</i>	<i>...as symbolized by this color:</i>
0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

Figure 5: Air Quality Index Table. (Figure is adapted from ("A Guide to Air Quality and Your Health," n.d.)

To understand table better EPA published meaning of different level of health concern that expresses by each category.

Good. The AQI value in the area is between 0 and 50, indicating that it is not at risk.

Moderate. An AQI value of between 51 and 100 indicates that the air quality is at an acceptable level. However, pollution in this range can cause health problems in the restricted human population.

Unhealthy for Sensitive Groups. When the AQI values are between 101 and 150, there may be certain health effects on people susceptible to pollution. For the majority of the population, there is no general health condition.

Unhealthy. When AQI values are between 151 and 200, many individuals in the community may face health problems. It can cause serious effects on sensitive people.

Very Unhealthy. AQI values from 201 to 300 indicate that each individual in the community can face significant health problems.

Hazardous. When the AQI value is more than 301, it is the case that the general public is exposed to the health problems in an extreme way.

C. nRF24L01

It's an RF transceiver for the 2.4 GHz ISM (Industrial, Scientific, and Medical) band. It includes the Enhanced ShockBurst™ hardware protocol accelerator supporting a high-speed SPI interface for the application controller. It has a range which is totally adequate for an indoor area that serves our purpose in this study. We used Nrf24l01 2.4 GHz Radio/Wireless transceiver to send values that received by nodes to the server. On the other hand, we can say it provides communication between nodes.

D. SERIAL PORT MONITOR

This program is used to listen and analyze communications between devices in network systems. In this study, the Serial port monitor has been used for listening communication between two sender nodes and receiver-one. The sender nodes get a real-time measurement of air quality index. System's schematic has been shown in Figure 6.

#	Time	Function	Direct...	Status	Data	Data (chars)	Data length	Req. length	Port
9577	20/12/2017 09:04:49	IRP_MJ_DEV...	UP	STATUS_SUCCESS	00 00 00 00...	.....	20		COM5
9578	20/12/2017 09:04:49	IRP_MJ_READ	DOWN					4	COM5
9579	20/12/2017 09:04:49	IRP_MJ_READ	UP	STATUS_SUCCESS	2d 3e 20 48	-> H	4		COM5
9580	20/12/2017 09:04:49	IRP_MJ_DEV...	DOWN						COM5
9581	20/12/2017 09:04:49	IRP_MJ_DEV...	UP	STATUS_SUCCESS	01 04 00 00	....	4		COM5
9582	20/12/2017 09:04:49	IRP_MJ_DEV...	DOWN						COM5
9583	20/12/2017 09:04:49	IRP_MJ_DEV...	UP	STATUS_SUCCESS	00 00 00 00...	.....	20		COM5
9584	20/12/2017 09:04:49	IRP_MJ_READ	DOWN					3	COM5
9585	20/12/2017 09:04:49	IRP_MJ_READ	UP	STATUS_SUCCESS	61 7a 61	aza	3		COM5
9586	20/12/2017 09:04:49	IRP_MJ_DEV...	DOWN						COM5
9587	20/12/2017 09:04:49	IRP_MJ_DEV...	UP	STATUS_SUCCESS	01 04 00 00	....	4		COM5
9588	20/12/2017 09:04:49	IRP_MJ_DEV...	DOWN						COM5
9589	20/12/2017 09:04:49	IRP_MJ_DEV...	UP	STATUS_SUCCESS	00 00 00 00...	.....	20		COM5
9590	20/12/2017 09:04:49	IRP_MJ_READ	DOWN					4	COM5
9591	20/12/2017 09:04:49	IRP_MJ_READ	UP	STATUS_SUCCESS	72 64 6f 75	rdou	4		COM5
9592	20/12/2017 09:04:49	IRP_MJ_DEV...	DOWN						COM5
9593	20/12/2017 09:04:49	IRP_MJ_DEV...	UP	STATUS_SUCCESS	01 04 00 00	....	4		COM5
9594	20/12/2017 09:04:49	IRP_MJ_DEV...	DOWN						COM5
9595	20/12/2017 09:04:49	IRP_MJ_DEV...	UP	STATUS_SUCCESS	00 00 00 00...	.....	20		COM5
9596	20/12/2017 09:04:49	IRP_MJ_READ	DOWN					3	COM5
9597	20/12/2017 09:04:49	IRP_MJ_READ	UP	STATUS_SUCCESS	73 0d 0a	s..	3		COM5

Figure 6: System's Communication Flow in Serial Port Monitor as Table View

The data flow of the components of the system has been shown in Figure 6. Specific information of the package 'hazardous' is given in Figure 7. The package includes time, address, data and the decimal value of NODE2.

```
[20/12/2017 09:04:49] Read data (COM5)
4e 4f 44 45 20 32 20 2d 20 33 32 36 2e 30 30 2d  NODE 2 - 326.00-
3e 20 48 61 7a 61 72 64 6f 75 73 0d 0a          > Hazardous..
[20/12/2017 09:04:56] - Close port COM5
```

Figure 7: System's Communication Flow in Serial Port Monitor as Table View

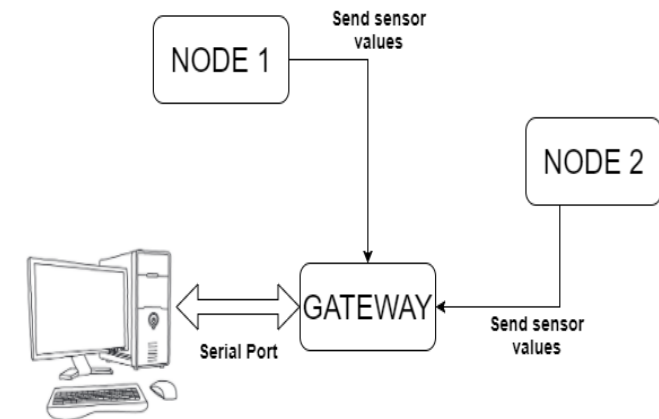


Figure 8: Project's Network System

IV. RESULTS

A. CONCLUSION

In this paper, the importance of air quality is introduced. The project has been implemented in order to quickly recognize the change of harmful gases in the air and to guarantee the human life and provide a better living space. A sensor network has been set up to achieve our goals.

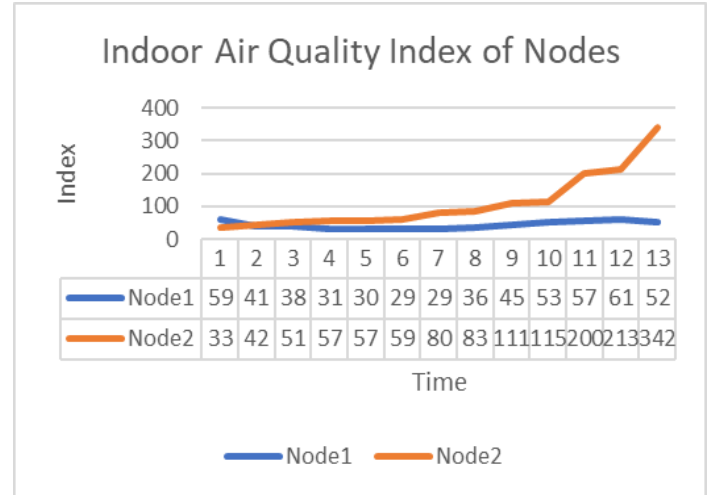


Figure 9: Indoor Air Quality Index of Each Node

In Figure 8, the output of the sensor network system is given as graph. When we analyze the figure, there are two different nodes which include two sensors to get the index of air quality. These nodes are placed in two different points of the indoor area. When these values are interpreted according to Figure 5;

Node 1: It has an environment which has generally good air quality. It can be seen that the values have increased to over 50 in some intervals. It shows that restricted human population can be affected by air quality in existed area.

Node 2: In the light of output values of Node 2, it has an increasing index of air quality which will influence human health negatively. The values after time 11, shows that air pollution should be cleaned as soon as possible. Otherwise, general public can be exposed.

B. FUTURE WORK

In future work, many different implementations could be added and make the system more secure and effective. Developing the system that supports microprocessor will be one of our goals in the future. Converting the system smaller design is our main priority for the next studies. The system will be improved for more sensitive computations of air quality values.

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