DESIGNING AN EFFICIENT ENVIRONMENTAL SENSOR MAP INSIDE UNIVERSITY CLASSROOMS

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Abstract. *This paper presents the design of an efficient environmental sensor map to be used inside university classrooms. There are a lot of studies presenting the negative effects of air pollution and influences on health, as well as how it affects academic performance of students, but currently there are no monitoring systems of air quality inside academic institutions. This paper proposes a design for an efficient IoT system consisting of multiple interconnected devices that have sensors monitoring levels of air pollution, dust, light, temperature and humidity in classrooms. It also provides real time feedback and emergency alerts, as well as a friendly user-interface with a map of sensors placed in different parts of the classrooms inside universities.*

Keywords*: sensor map, air quality, monitoring, Internet of Things(IoT), system, device.*

Introduction

There are numerous studies presenting the negative effects of air pollution and how it influences the health of people [1], as well as academic performance [2], but currently there are no monitoring systems of air quality inside academic institutions. Besides air quality, parameters such as light, humidity and temperature affect the comfort of students. In order to provide optimal values for these parameters, there is a strong need for an efficient monitoring system. This monitoring system should consist of multiple sensors, because the parameters can vary from one part of the room to the other, and also because there are multiple sources of light, windows, doors in the room, and there is a need to analyze these parameters in different parts of the room as well as provide direct feedback. In case of an emergency, the system should send alerts to the people.

Environment quality and effects case study

Air pollution - is an acute problem, the result of the interaction between natural and anthropogenic environmental conditions around the world. It has a detrimental effect on human health, affects food security, contributes to climate change and worsens the environment.

Effects of air pollution on academic performance. According to a study performed in the USA, air pollution has a direct influence on academic performance of students. The research showed that schools located in areas with the highest air pollution levels had the lowest attendance rates - a potential indicator of poor health - and the highest proportions of students who failed to meet state educational testing standards. For schools already in existence, they recommend that their environmental quality should be investigated and improved if necessary [2].

Indoor Smoke. In addition to air pollution, indoor smoke from air pollution in households poses a serious risk to the health of people. The 2005 WHO Air Quality Guidelines (AGD) [1] provide global guidance on thresholds and maximum allowable levels of major air pollutants that pose a health risk. They are applied worldwide, based on expert assessment of available scientific data regarding **particulate matter (PM), ozone (O_3), nitrogen dioxide (NO_2)** and **sulfur dioxide (SO_2)** in all WHO regions.

Light levels. One of the most important parameters of the modern workplaces is the illumination of the workplace, which affects not only labor productivity and production indicators, but is also directly related to human health.

According to *EN 12464 Light and lighting - Lighting of workplaces - Indoor work places* [3], for each category of jobs developed their own standards. Some of them are listed below:

Table 1

Activity	**Illumination (lux, lumen/m^2)**
Easy Office Work, Classes	250
Normal Office Work, PC Work, Study Library, Groceries, Show Rooms, Laboratories	500
Normal Drawing Work, Detailed Mechanical Workshops, Operation Theatres	1000
Detailed Drawing Work, Very Detailed Mechanical Works	1500 - 2000
Performance of visual tasks of low contrast and very small size for prolonged periods of time	2000 - 5000

System requirements

- The system shall be able to collect data from sensors at store on the cloud;
- The system shall be able to collect data about light levels, temperature and humidity in different parts of the room and show this data real time;
- The system shall have a display data in a web User Interface in real time;
- Th system shall be able to send data via wi-fi;
- The system shall have a method for showing values of parameters for each device in a simple, human readable way;
- The system shall be able to measure gas levels once in 10 minutes at least;
- The system shall be able to send alerts and notifications on mobile devices in real time if there is at least one parameter that is not in the specified range and presents danger;
- The system shall be low-cost;
- The system shall be compact and easy to customize for any room.

Architecture Design and Modeling

All the heavy computing required for the charts and graphs for the Web Interface is done on the cloud, which makes the system not too reliant on the local microprocessor. The values from sensors are sent to a REST api, which processes and inserts the formatted data into a database. The api is then used to fetch the sensor data for the actual sensor map. Both the api and the database are hosted on a remote server. Having the ability to access the sensor map remote is essential and that's what the cloud provides. Furthermore, the same backend system can be used by multiple local sensor boxes, which allows for scaling and easier distribution.

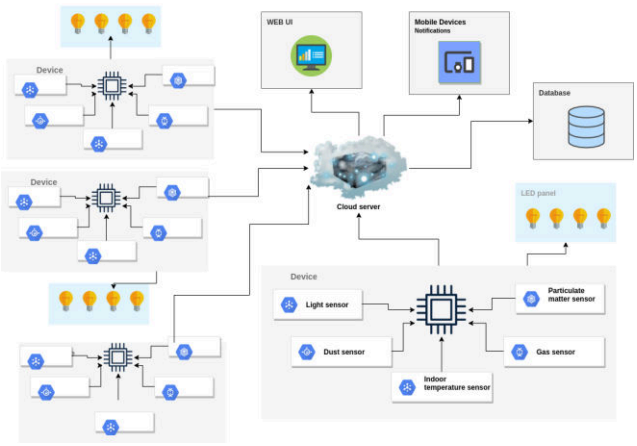

Figure 1. System architecture

The system contains multiple devices, each containing a light sensor, a dust sensor, a particulate matter sensor, a gas sensor, a temperature sensor and a humidity sensor. The sensors will be connected to an Arduino development board that will transmit data through wi-fi module to a server. The server will display an User Interface and send notifications to mobile devices. Each sensor device will have an LED (Light Emitting Diode) panel, each LED showing values of each parameter in a corresponding color scale.

For building the system, the following components will be necessary:

- Sensors;
- Development board with mictrocontroller;
- RGB(Red-Green-Blue) LEDs(Light Emitting Diodes);
- Jumper wires;
- Breadboard/plastic case;

The User Interface (UI) consist of different graphs showing values of parameters, as well as a map of the entire room with data for each sensor, as well as calculated intermediate values between sensors. It will be built using HTML, CSS and Bootstrap.

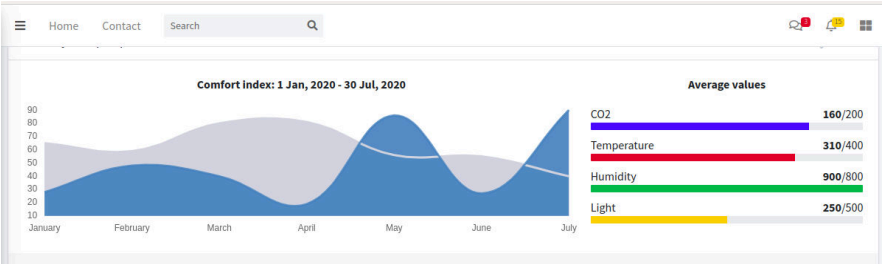

Figure 2. Device signal acquisition (UI)

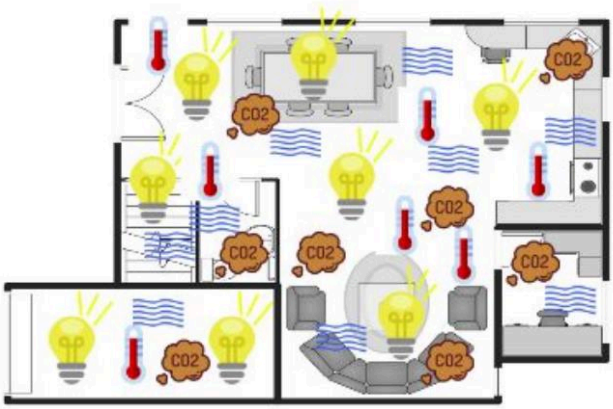

Fig.3 Environment Mode

Implementation

The hardware consists of development board, wi-fi module, sensors and LEDs. The following implementation with the following sensors is proposed:

- *Groove light sensor* - used to detect the light itensity of the environment;
- *Gas sensor MQ4* - used to detect levels of toxic gases;
- *Humidity sensor DHT22* - used to measure temperature and humidity in the room;
- *Grove - Dust Sensor PPD42NS* - used to measure the dust concentration;
- *Arduino Mega*, for its power, as well as multiple I/O pins and wide availability;
- *EMW3166 WiFi module* - allows users to remotely control and take readings from sensors via the Internet. It will connect to the network and automatically send data to the server - so they will automatically get to the map.

Conclusions

This paper presented the design of an indoor sensor map system that is proposed to be used in academic institutions, for example universities. The system architecture, components list as well as cloud specifications and UI visualisations were presented. The system makes it possible to constantly monitor parameters such as air pollution, temperature, light, humidity and adjust their values to be most optimal for human health as well as efficient working and studying.

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