Sensor-Based Indoor Air Purification System

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Abstract

Industrial development has brought convenience, but it is causing serious air pollution due to exhaust fumes and dust. In particular, it is very important to clear the polluted air periodically because we spend most of the day in an enclosed space in the current coronavirus situation.

Therefore, we intended to design a system that automatically forms an optimum indoor environment such as air quality, temperature, and humidity by utilizing Smart Home. Smart Home is a new type of housing that provides various forms of automated services based on IoT. It is possible to communicate with users and home products, and various services can operate automatically even if users are not at home.

This project designs a Smart Home model that measures fine dust and air quality for air management and automatically controls inside air quality, by using IoT. Also, it is intended to design a Smart Home using a mobile device to control it.

Keywords— IoT, Air-conditional Sensor, Automatic system, Air purification

1 Introduction

The problem of air quality has long emerged. Over time, the problem is fine dust due to the China and accelerating air warming. In fact, it is difficult to change the current air problem in a short period of time. Instead of focusing on the air quality of the entire planet, we thought about ways to protect our health even in this environment. When you are outside, you can respond to bad air quality through actions such as wearing a mask, but the method is not appropriate indoors. In addition, according to the survey below, people are relatively dull in air quality indoors, despite having more factors that can affect air quality than outside.

Fortunately, since the indoor space has a fixed range, it is relatively easy to solve this problem with something like a current air purifier. Given that people's awareness

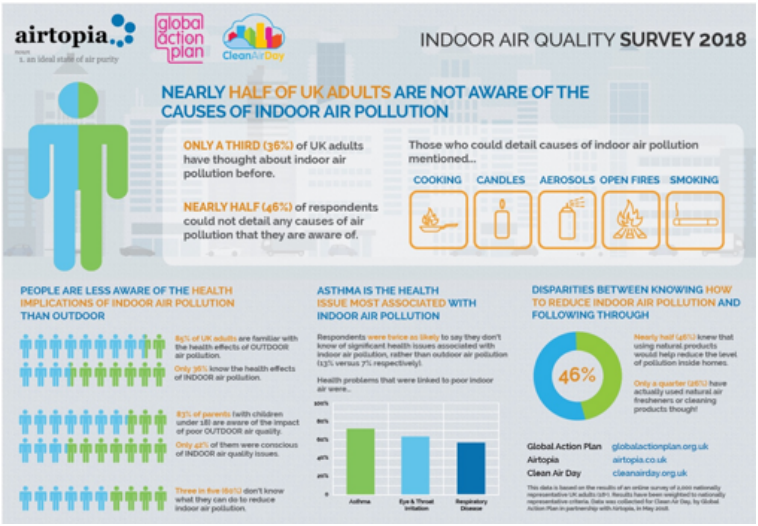

Figure 1: indoor-air-quality-survey

of managing indoor air quality is still insufficient, We thought it should be automatic and simple to control it. We came up with the idea of building an indoor air quality control system by incorporating the idea of smart home technology. In short, it is an automatic air quality care system that integrates various home appliances such as air conditioners, air purifiers, humidifiers, and window-type ventilation systems that control air quality and controls them based on air quality analysis. It is expected that smart technology will be able to fill in what people are missing through this.

2 Background

There are multiple factors that constitute good air quality. Therefore, finding a comprehensive definition is hard. One way of measuring indoor air quality - sometimes referred to as IAQ - is the level of indoor air pollution.

Indoor air pollution is usually defined as the "chemical, biological and physical contamination of indoor air." [2] Hence, it is measured in particles detected in the air. Some of the more common pollutants are nitrogen dioxide and carbon monoxide, but there are a myriad of other pollutants that can be found. These pollutants also do not necessarily all enter from the outside into one's home, but are often emitted by appliances inside the house. An overview of common pollutants and their sources can be found in Figure 2.

Poor air quality is a bigger health hazard than most people are aware of. According to the Royal College of Physicians, a minimum of 99 000 Europeans died due to the effects of long-term indoor pollution exposure in 2019, though the number of undetected cases is expected to be much higher [3]. The impact of indoor air pollution

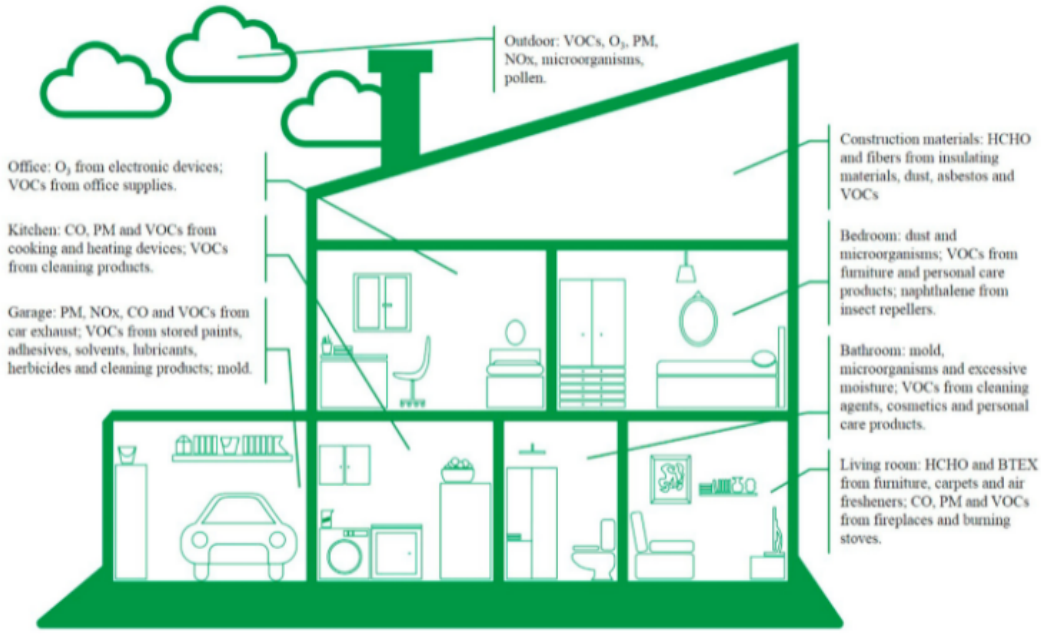

Figure 2: indoor-air-conditioning system

is even more significant in less developed countries. For the continent of Africa, indoor and outdoor pollution is named as the number one cause of death, being believed to have attributed to 1.09 million deaths in the year of 2019. Indoor pollution itself is ranked as number four accounting for 636 611 deaths in the same year [5].

A lot of the possible health issues caused by exposure to polluted air are centered around respiratory illnesses. Acute Respiratory Infections (ARIs) are one of the illnesses that can be caused by indoor air pollution. A subtype of ARI - Acute Lower Respiratory Infection (ALRI) - has been measured to increase its likelihood to appear in children by 78% when exposed to indoor air pollution. This number is significant when considering that ALRI is reported to cause a million deaths per year in children under the age of 5 [4]. Listing an exhaustive overview of all the possible diseases caused by indoor air pollution would go beyond the scope of this proposal, but several academic researches suggest that they are various [3, 4, 11].

Apart from the level of indoor air pollution, factors such as humidity also contribute to the overall indoor air quality. Though less dangerous than air pollution, improper humidity or temperature levels can lead to their own set of problems. Places that do not lie in the optimal humidity levels can encourage the spread of viruses and therefore increase the risk of infection [7]. Too low humidity can also contribute to asthma whereas too high humidity might make a person feel more exhausted and in extreme cases can raise the risk of suffering a stroke [7]. Another factor is room temperature. There have been studies that support the belief that high room temper-

atures can affect human health, especially the respiratory system [9].

Apart from the health risks that suboptimal air quality entails, less severe but non-negligible aspects such as focus, energy levels and all in all comfort can be affected. Therefore, maintaining an optimal air quality should be a high priority in everybody's home.

3 Motive and Objective

As the air quality deteriorates year after year, people's quality of life is getting worse. We cannot avoid coexisting with bad outdoor air quality today. Therefore, we need to keep the indoor air quality good as opposed to the bad outdoor air quality. The reason we chose this theme is to make the indoor air quality better as opposed to the outside weather and air quality. In addition, by controlling the air conditioner and air purifier with mobile device, you can manage the humidity and temperature inside while working outside, so you can stay home with perfect air quality at any time.

We will maintain desirable indoor air using IoT and embedded systems, which are key technologies in the 4th industry. And we will create a smart home model that controls temperature and humidity. For managing air condition, a sensor that measures fine dust and air quality, a controller that controls the air conditioning system according to the air quality, and a smart home that can be controlled using a mobile device are to be produced.

The user can check the air quality and temperature inside the house at any time during outdoor activities, and if the mobile device determines that the air quality is bad, the user can remotely operate the air purifier. In addition, when the temperature and humidity inside the house are out of the range which is specified by the user, the temperature and humidity can be adjusted by using an air conditioner or a humidifier.

4 Expectations and Effects

1. Even if there are elderly or children in the house, or even if is a large house, automatic ventilation is working.

2. It helps respiratory health and disease prevention by managing air quality automatically.

3. Even when you are outside, the system can automatically check the air quality to prepare for emergencies such as fires, gas leak.

5 Problem Statement and Proposed Solution

Currently, there are two major problems in the operation of devices (air conditioners, humidifiers, air purifiers, ventilation systems) involved in air quality. The first is

that each device operates independently. In order to obtain the desired air quality, the user must operate each device individually and set detailed operations. This greatly impairs the user's user experience in that not only the user's effort is required, but also the operation methods of the devices must be individually mastered. Second, it is difficult for users to know what the optimum air quality is. Optimal air quality does not exist in one absolute state, but is a relative state that is fluidly changed due to various external factors. For example, the optimum indoor temperature differs for each season, and the optimum humidity to be maintained is also different depending on the indoor temperature.

In addition, in order to determine whether to ventilate, it is necessary to consider the concentration of fine dust outside or the temperature difference between indoors and outdoors. Since various external factors are involved in the optimum air condition, it is difficult for the user to properly understand the optimum air condition. To solve these problems, this proposal devised a system to manage all devices related to indoor air condition in an integrated way.

The air quality integrated management system is largely divided into two levels and operated. The first is a user-level program that is installed and operated on the user's mobile device. The program receives the user's operation command for each device and transmits the command to the control level program. In the program, the user can turn on/off the power and automation functions for each device, and set detailed actions. In addition, the current indoor air condition can be checked, and the user program provides the user with an air quality score evaluated based on the current air condition.

The air quality evaluation score is based on the error of each indicator between the optimal air condition and the current air condition. The control-level program collects data to control each device and gives appropriate commands to the devices accordingly. In order to determine the proper operating state of each device, the control program uses the user command information received from the user program and the indoor and outdoor air quality measurement data.

In this case, the air quality measurement data may be received from a sensor installed inside each device, or if necessary, a separate sensor may be installed outside to collect data from the sensor. The air quality integrated management system composed of user program - control program - air quality control devices is operated by interacting with user commands, air quality conditions, and operation status of each device. Assuming that the user is exercising indoors, the corresponding system may operate as follows.

1. The user lowers the desired indoor temperature through the user program due to the increase in body temperature due to exercise.

2. As the desired room temperature decreases, the control program commands the humidifier to maintain a higher humidity.

3. The indoor carbon dioxide concentration increases due to the user's exercise.

4. The control program collects carbon dioxide concentration data from the air

quality sensor.

5. Gives a ventilation command to the ventilation system based on indoor carbon-dioxide concentration data, external temperature, and fine dust concentration data

6 Planning & Role

This Air quality control system controls air quality by referring to other air quality control-related devices. This includes air conditioner, ventilation system, air purifier, and humidifier. This system is able to control each device with ON/OFF, manual mode and also control air quality automatically with Automatic Mode by using a Mobile application. Specific schedule for building this mobile application is described below.

1. Proposal (∼3/27)

2. SW Specification (∼4/3) - Requirement Specification: Analyze requirements / Specify requirements / Validate requirements - Design Specification: Architectural design / Database design / Interface design / Component design

3. SW Development (∼5/8) - Programming: Create a mobile application - Testing: Reveal application bugs and errors - Debugging: Fix bugs and errors

4. SW Validation (∼5/29) - Component Testing: Test individual components à whether each buttons work properly - System testing: Test entire system(Application) - Customer testing: Tested by actual customer à make someone use this application

5. SW Evolution (∼6/12) - Evolving application to meet customer needs

6.1 Member Role

UI / UX designer: designing ui and ux for our application
: **Jeongmin Cha(Team leader), Joonsun Baek**

Application developer: building our application
: **Seyeon Park, Sungjoon Lee**

System developer: develop application on system level
: **Jingyu Lee, Hangyu Kim**

Server / DB developer: create and manage server(DB)
: **Maike Helbig**

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