Improvement of the quality in smart toilet

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Abstract

The development of people in society is influenced by social and economic factors in everyday life, which is why any age group and type of people must be included in our environment and must be offered the independence necessary for a normal life. The focus is on the elderly and disabled people. For helping them, we offer smart toilets, so that they no longer have to worry about basic needs, feeling safe and free to visit places such as malls, hotels, cinemas and concerts. To achieve this goal, the quality of public spaces and the quality of public bathrooms should be improved. Using high technology, this paper aims to develop an intelligent toilet system, especially for the elderly and people with disabilities. In addition to all the benefits of this smart toilet, an air quality monitoring system can be included to start cleaning procedures. It has been shown

that humidity, temperature, amount of water, VOC, O_2 have a great impact on human health. The study began in the iToilet project, which developed a solution that led to a prototype for home use including the ability to adjust the position and height of the toilet and other auxiliary means using several different technologies. Moreover, it was necessary to develop this concept in public spaces, and the Toilet4Me2 project made this possible by exploring and implementing this concept. Furthermore, the Toilet4Me2 system includes an armrest, vertical adjustment mechanisms, tilting lift function and a shower unit, along with emergency identification and detection facilities, plus optional supplements. These facilities are dedicated to elderly and / or disabled users, either able to walk or in a wheelchair.

Keywords: *Smart Toilet, air quality, elderly and disabled people.*

1. Introduction

People's daily life has a major social and economic impact on their development as individuals in society. This is the reason why all the categories should be integrated into our living environment, giving them a chance to be completely independent. The most vulnerable persons are the elderly and people with disabilities. They depend partially or entirely on someone's help, thus affecting their desire to participate in social events or even leave their homes [1]. Smart toilets are playing an important role in daily life, especially in public spaces. There was an essential requirement for the comfort of the user when they were using the smart toilet: self-reliance and autonomy. The lack of attention for public areas can lead to isolation, resulting in this way wider consequences like depression, loneliness and low self-confidence. Providing public smart toilets becomes a necessity due to their accessibility, cleanliness, maintenance, easy design and hygiene. Using this type of toilet, they don't have to worry about basic needs, feeling free to visit places like malls, hotels, cinemas and concerts [2].

To reach this goal, the quality of public spaces, respectively, the quality of public bathrooms should be improved. Using high technology, it can be developed a toilet system which will increase the comfort of using a bathroom. Toilets are an important factor in hospitals, grocery stores, different types of industries, restaurants, etc., because the employees' health improves.

This article is based on the study done in the first project, iToilet, where smart toilets targeted the private environment. Subsequently, the research expanded, reaching the current project, Toilet4me2, in which smart toilets are adapted for the public environment, thus helping people to become more independent and want to go out for various activities.

This paper proposes a smart toilet prototype that is addressed especially to the elderly and people with disabilities. The toilet is designed for public spaces and can deliver a safer and cleaner environment for the users. The used technology allows services like height and tilt lift, arm support, shower, remote control, voice control, emergency detection, personalized setting, self cleaning and automatic light

and door lock. Also, the system includes a number of sensors used for air quality monitoring. Based on these parameters values, the self-cleaning decision will be made. For system testing, a series of questionnaires were used.

In addition, for the analysis of the air quality in the toilet, the coarse particulate matter (PM_{10}), which is less than 10 micrometers in diameter, fine particulate matter ($PM_{2.5}$), which is less than 2.5 micrometers in diameter, humidity and temperature. However, the exposure of SO_2 on human inhalation for asthmatic people in a concise time at concentration gives more significant effect to trigger the asthmatic symptoms compared to PM_{10} and $PM_{2.5}$ [3]. Asthma is a heterogeneous disorder of the conducting airways involving chronic inflammation, declining function and tissue remodeling. The inflammation causes wheezing, breathlessness, chest tightness, and cough for asthmatic individuals, particularly at night and/or early morning.

The rest of the paper is organized as follows. Section 2 explores the state of the art of smart toilet systems. Section 3 discusses the Internet of Things sensors and their benefits. Section 4 investigates the relevant instruments of the system architecture and platform. Section 5 brings conclusions and explains future work.

2. Related work

There are already some smart toilet systems, and the solution proposed in this article comes in addition to functions that existing systems do not have. In the following paragraphs will be briefly presented some solutions already implemented.

One example already implemented is a smart toilet system that uses IoT sensors (odor sensor, IR sensor, sonic sensor and RFID sensor). This intelligent toilet system will perform the following functions: closing and opening the toilet lid, the infrared sensor tracks the dirt accumulated in the toilet and will trigger an alarm. After activating the alarm, the cleanliness of the toilet will be improved by monitoring the activity of the sweeper. Also, this smart toilet system will reduce water consumption [4].

In another article, the main control of a smart toilet is done through a screen that can be controlled by eye movement or by clicking on a hologram similar to the screen itself. This panel can also control air purifiers, internet connection but also music player, thus creating a safe and clean environment improving the health of employees. Before leaving the toilet, a warning message will be sent in case the user has not washed his hands. After using it, an automatic cleaning will be done where the seat will be sanitized, but also the adjacent components. Due to the major problems identified within the urban sanitation systems, solutions have been proposed that must be considered in order to solve them using smart and green urbanism practices with some innovative designs [5].

Another existing example includes an intelligent toilet system that measures certain physiological parameters, such as: ECG, bioelectrical impedance, body fat ratio and body weight. Also, this intelligent toilet system offers the function of health management. Bioelectrical impedance and ECG are measured using electrodes mounted on the smart toilet seat. These measured parameters are sent to an online platform via Bluetooth and certain graphs can be made to monitor health [6].

Another example of an intelligent system already implemented is for public toilets, which are constantly facing a lack of hygiene. In order to replace the hiring of a man to take care of hygiene monitoring, an intelligent automated system was used. IoT sensors were used to measure the water level in the tanks, to find out what the water is used for, or to detect the presence of a person in the toilet. With this data transmitted to the platform, graphs can be made and the cleanliness of the toilets can be predicted. The sensors are connected to the Raspberry Pi, which processes the data and uploads it to the Cloud [7].

3. IoT sensors devices

Special air quality control devices are effective in finding the source of pollution. These tools are used to detect areas that cause allergies or similar symptoms. They can successfully detect temperature, humidity and different pollutants. Indoor Air Quality (IAQ) is a terminology of air quality within and around buildings which is pertinent to the health and comfort of the indoor occupant. The duration of time that people spend in the toilet and the risk to health posed by indoor air are the issues that encourage researchers to conduct the study on indoor air.

For analysis of the air quality inside the toilet room, it is necessary to install the following devices: monitoring unit of toilet maintenance air quality and thermal comfort unit. In Fig.1 is presented the diagram of a smart toilet in our concept.

Fig. 1. Schematic diagram of toilet environment

The monitoring unit of toilet maintenance allows access control, temperature, humidity, pressure, the time spent in the bathroom, if there is a flood, the amount of water consumed, and luminosity [8]. Air humidity has a few health effects. In case of too low humidity, unwanted effects such as skin dryness, eye irritation and respiratory problems occur. A moisture level above normal (45% - 55%) favours the

appearance of mold and fungi that affect humans, walls and furniture. If humidity is high, problems such as rheumatism, allergies and respiratory problems occur.

The sensors that can be mounted on the monitoring unit are:

- Temperature, humidity and pressure;
- Luminosity;
- Water amount consumed
- Liquid level (flood)
- Time spent in the bathroom – as a system alarm

4. Architecture of the system

The amount of time spent in the toilet and the health risk of indoor air are the biggest problem that encourages researchers to carry out the study of indoor air. In addition, humidity, temperature, oxygen, VOC and CO_2, which may have adverse effects on humans inhalation, such as asthmatic symptoms. However, the exposure of humans breath to VOC for asthmatic individuals over a short period has a significant effect on triggering asthmatic symptoms. Asthma is a heterogeneous airway disease involving chronic inflammation, remodelling of tissues. For asthmatic individuals, inflammation causes wheezing, lack of air, chest pressure and cough, especially during the night or early in the morning.

Air humidity has several effects on health. If humidity is high, there are problems such as rheumatism, allergies, and respiratory problems. Thus, the following precautions are required: proper ventilation of the toilet, hygienic conditions, and installation of indoor air quality sensors to have greater accuracy and correctness regarding the level of indoor pollution. A smart toilet indicates the status of our one's own health by using all of the sensors installed in the bathroom can help to reduce fall injuries, or respiratory problems that usually occur with the elderly people. For this reason, we propose a smart device equipped with gas sensors suitable for use as a pollution analysis system. Its utilization will revolutionize the existing methods of screening and keeping track of one's health status, for it opens a platform where toilets can be an ideal place to perform a daily check up of the cleaning especially on a daily basis.

The acquisition platform is composed of modular acquisition nodes (Waspmotes) and the Meshlium device, which acts as IoT-Gateway. The data acquisition modules connect via 4G / WiFi to the Internet or another (private) network to which Meshlium is connected and sends data to it. Once parsed in the Meshlium, the IoT gateway stored the data in a MySQL database that ensures local persistence of data. Sending data to Cloud is done through a software component that serializes data to an MQTT broker. Next, the Adapter component (a software application developed in Python programming language), is basically an MQTT client that subscribes to several topics and stores the data received from the sensor in the database [9]. Data visualization is then realized with an open platform for analytics and monitoring, Grafana. The data flow architecture is presented in Fig.2, and in Fig.3 can be observed the Libelium air quality monitoring node installed at the site location. The Libelium data logger is configured to measure and send data at 15 minutes intervals.

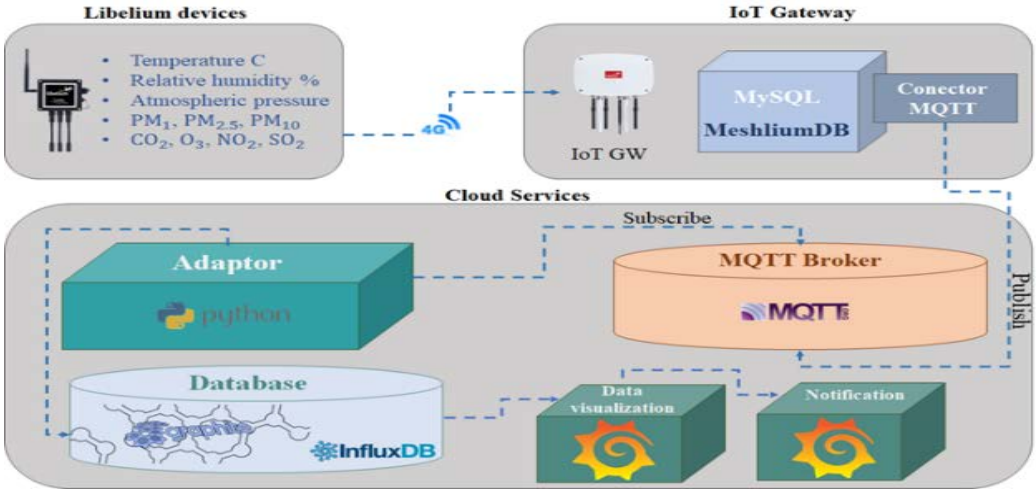

Fig. 2. Data flow architecture

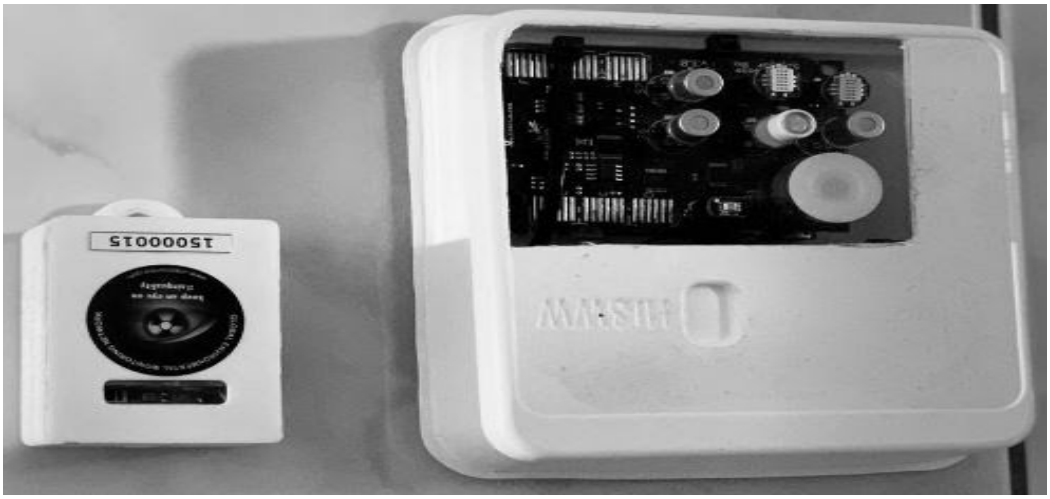

Fig. 3. Monitoring sensors

The overall reference architecture for transmission of data from Air quality monitoring unit and monitoring unit of toilet maintenance will be a Big Data based architecture for IoT devices and will include communication protocol between the server and the platform: MQTT and HTTPS.

These are the communication/ integration options of the smart toilet used and will depend on several factors:

- Temperature, humidity, pressure, air quality parameter
- Alert when the level of water increase, entrance sensor
- Battery: periodicity of the communication

5. Conclusion

In conclusion, improvement of the air quality in a smart toilet for elderly and people with disabilities can provide new enterprise and business solutions for the barrier-free tourism area. The need to study in-depth the innovations and new markets and, possibly, the development and evaluation of prototypes in real life is a step towards introducing older people or people with disabilities into everyday life.

Projects like Toilet4me2 may contribute to a positive development in thinking about shaping public and semi-public spaces to enable older people or disabled people to better participate in public life.

As future work, we plan to implement new sensors so that the smart toilet can be connected through an application on the users' smartphones to enable/disable certain functions of the smart toilet and collect data from it. This way, we can create a database using that data and improve the developed prototype's design based on the information obtained from the users.

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