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A Design on the Base Technology of In-Home Health Care Smart Basin for Tap Water Context Awareness for the Poor Strata

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Abstract: There are many countries having extremely low drink water despite the rich water resources. And there are also countries having rich drinkable tap water but having aged water pipes and other basins. In particular, the poor strata also drink water with visible heavy metals. Meanwhile, there is a great development in the electronic appliance companies in the world that have produced smart refrigerators, smart washing machines and other new home appliances based on artificial intelligence. However, previous studies have focused on new home appliances but have not focused on base technology of water pipe related to basis in the existing deteriorated buildings. With this in mind, this study considered the method of smart technology to existing water basins with low cost. The proposed product is expected to be used easily by the poor strata as a result of evaluation of installation cost and economical efficiency.

Key words: Wireless sensor network, sensors, in-home health care, smart basin, water context awareness, water, old home

INTRODUCTION

The appearance of the 4th industry in recent years, ICT convergence, big data utilization and new IoT technology have become key issues and it is more important as an infrastructure to maintain overall social system. In the water industry, there are active technical developments and pilot projects for smart water management. There are many countries having extremely low drink water despite the rich water resources. And there are also countries having rich drinkable tap water but having aged water pipes and other basins. In particular, the poor strata also drink water with visible heavy metals. Even if the state has already implemented a policy to change water pipes, there is no way to know when the poor strata should change because the basin is already provided.

Meanwhile, the interest in the elderly who have officially entered the aged society has been increasing and the interest in the lonely elderly living alone in the poor strata is also increasing. The quality of their life was not good when it was examined. In the elderly people who live alone, many were sick and majority could not use electricity abundantly, but they used to shower and drink water with water in undrinkable heavy metals (Fig. 1).

Therefore, this study proposes smart basin base technology for in-home health care monitoring to

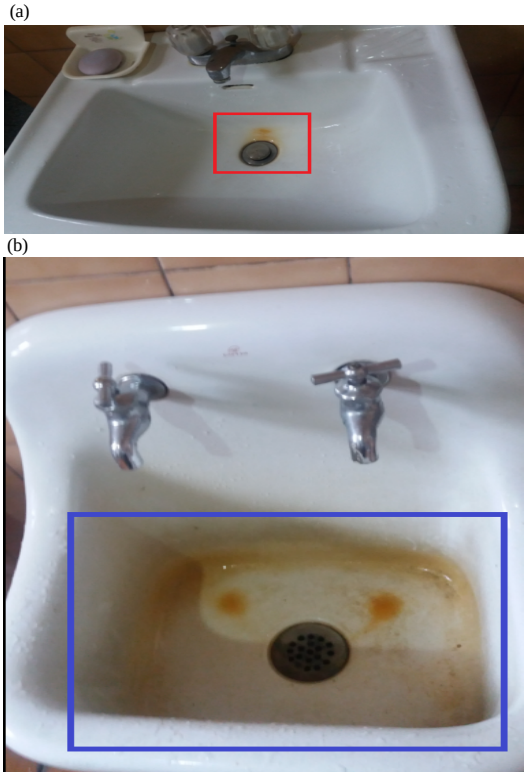

Fig. 1: Example of water in undrinkable heavy metals: a) heavy metals at red position and b) Heavy metals at blue position

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recognize the water resource context awareness for the poor strata. This study is about the installation of sensors to the basin with low cost. Chapter 2 in this study is on the related studies and chapter 3 is on the installation cost and economical efficiency as a proposed system conclusion.

Literature review: The contemporary era is the period when a smart meter connected to the home water meter with a wireless network is installed, the smart meter with information such as flow rate, temperature and water quality through the home gateway in the integrated operating system is managed and various big data of the accumulated data are analyzed. The remote monitoring and control of tap water supply facilities using ICT has already been commercialized and smart water management technology from real-time bidirectional water information service using IoT sensor has satisfied the advanced demands of consumers (Huh, 2017; Ngu and Huh, 2017).

Most of foreign countrie's environmental control systems use RFID technology and as the control signals, they employ external sensors and voice recognition. Rus *et al.* (2008) proposed the voice control Smart house to control devices with the voice recognitions. Corcoran *et al.* (2002) proposed the Universal Plug-n-Play (UPnP) to provide services to the wireless home network users with their PDAs and mobile phones or wearable devices. The user can send out the requests with his voice or user interface to the home server and in this case, the inconveniences caused by the pre-set areas and pre-recorded voice commands can be overcome. Hwang *et al.* (2009) introduced RFID-based multi-user access control algorithm for the UPnP Smart home. The users are required to carry RFID tags to monitor their access situations automatically, so that, many additional RFID detectors have to be installed in each different place.

Also, Helal *et al.* (2005) and Liau *et al.* (2008) suggested wireless smart floor technology in which pressure sensors had been mounted to detect the location of the residents. Power gen proposal how to make a simple water level indicator at home. Nowadays, the brain computer interface-based smart environmental control system is an issue (Ou *et al*., 2012) (Fig. 2).

In the components of intelligent housing an environmental sensor is a term that covers all sensors sensing various information installed in a fixed place in the house. Representative environmental sensors include gas, smoke and temperature sensors related to housing safety, PIR sensor (also called as motion sensor), a crime prevention device and door open sensorusing a

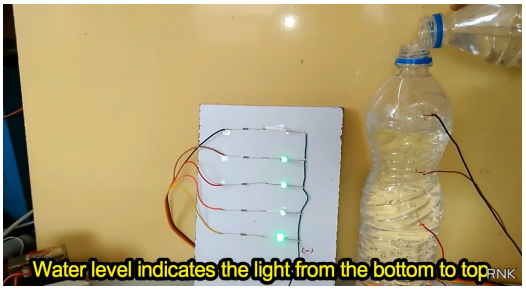

Fig. 2: How to make a simple water level indicator at home

magnetic switch. Besides, all sensors installed in a specific place in the house and things are environmental sensors.

Information detected by each sensor node is transmitted and processed to home gateway in a wired and wireless manner. Many R&D methods took place that detects ADLs using various sensors and methods. Representative research results are as follows.

A method suggested by Tapia in House_n6) of MIT is introduced (Tapia *et al.*, 2004). While many other methods recognize Ads using the in-home movement information of residents (elderly people), the proposed idea is to recognize a special ADLs by detecting the movement of major objects or change of device status (power ON/OFF, etc.). Detailed explanation on the PDA base program that helps a developed sensing module and that helps activity record of residents is specified by Intille *et al.* (2003). The sensing module uses magnetic and lead switch or piezoelectric switch to detect open/closing of drawer or door and saves the detection information and time information using embedded clock in the memory. The saved data is collected and analyzed by individual module later. The proposed method uses the naive Bayesian network classifier and detects the upper concept ADLs such as 'preparation of lunch', 'use of toilet' and 'use of washing machine.' For the experiment, 80 sensors are installed in two houses (1 bedroom apartment) and tests are performed for 2 years to evaluate the performance of the proposed method in various aspects. This study provides a useful base result on the range of recognition of the complicated everyday life using multiple simple sensor outputs (I/O). As such the remote monitoring method using the detection of device use has been already proposed before. In particular, George Lucy of Japan already developed i-POT7, a product that is available for remote monitoring of a single aged person using a kettle, one of major home applies to Japanese in 1997. And it has been sold and operated till now. Besides, a remote monitoring method using TV was also proposed (Nambu *et al*., 2000). "Base Technology of

In-Home Health Care Smart Basin for Tap Water Context Awareness" in this study is the first attempt in the basin area.

Many studies have focused on installing new smart devices. However, there is a lack of research about the old buildings as it has lack of economic feasibility.

MATERIALS AND METHODS

Trend of the elderly living alone: There is an increasing number of the elderly living alone in the whole world and there is active research on heath care for the elderly living alone in countries including in the USA and Japan. However, there are little base researches in Korea and there are limited prototypes besides "Parent Safety IoT" product by LGU+.

The proportion of elderly people in the world including Korea is increasing every year. This is due to the extension of the life expectancy and the decrease in the birth rate. While the number of the elderly is increasing, the number of the younger generation who is able to support them is decreasing. According to Fig. 3, data provided by the UN, the population aging is a global trend.

According to the US Bureau of Statistics 'The Aging World (2015)' Korea expects to be the world's second largest country with an elderly population (over 65) by 2050. This means an increase in the number of elderly people with a working ability that should be supported by younger people which can lead to an increase in the burden of care and a decrease in the quality of welfare. It seems to be a serious social problem in Korea.

Status and trend of related technology development: Various energy and resource saving technologies have been developed from direct water-saving technology that improved hardware such as water and toilet, to smart SOC technology which combines IT widely and to manage energy and resources efficiently. Water-saving technology is based on exponential method, flood time control, method of reducing inflow volume, quantitative index method and closet bowl water-saving technology includes use water control type, urine and feces distinction type and use quantity reduction toilet development. With regard to water, smart water technology that uses IT to manage water resources, water meter technology to measure the amount of water used and remote transmission technology to transmit measured flow values and data from sensors have been developed.

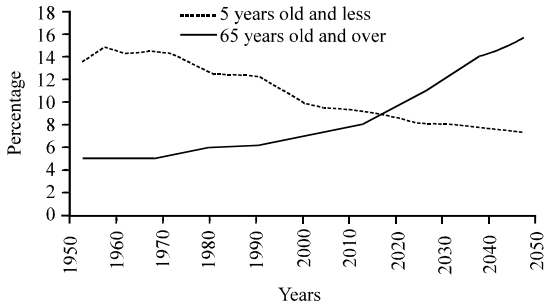

Fig. 3: Ratio of 5 year old and less and the ratio of 65 years old and over in the world population between 1950 and 2050

RESULTS AND DISCUSSION

In-home health care monitoring smart wash basin base technology: In elderly households where the elderly live alone, the water supply method that supplies water to necessary area by the water pressure of the supply pipe is used. The water pressure required in this method is obtained from the following equation.

$$P > P_1 + P_2 + P_3$$

Where:

- P = The water pressure (kg/e) required for the water supply line
- P_1 = Water pressure required for the main valve, etc. (kg/cm^2) and usually 0.3 kg/cm^2
- P_2 = Water pressure corresponding to the height of the main valve at a higher position in the water supply pipe (kg/cm^2)
- P_3 = Pressure loss of the pipe from the water supply pipe to the valve at the higher position (kg/cm^2)

Accordingly, when the structure is the two-story building or the structure of the three-story building, the minimum hydrostatic pressure of the water supply pipe becomes large. Figure 4 shows this method.

The operation method of the water pump is divided in to constant speed method and speed change method. In the constant speed method, multiple pumps are installed to operate the number of pumps corresponding to the water supply amount and the speed change method is a method of adjusting the amount of water by changing the number of pumps corresponding to the water supply amount by a variable speed motor. In either method, the pump is operated according to the automatic control and the control is performed by detecting the change in the pressure or the flow rate of the discharge pipe. The problem is that when the discharge pipe is aged, the heavy metals are mixed and released. Therefore, this study proposes a solution by installing the equipment in Fig. 5.

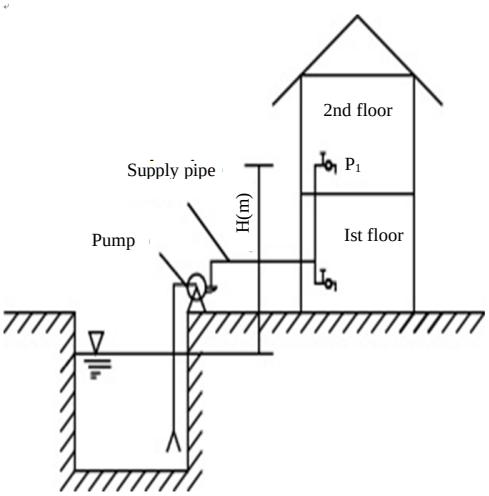

Fig. 4: Pump direct connection piping method and its problem

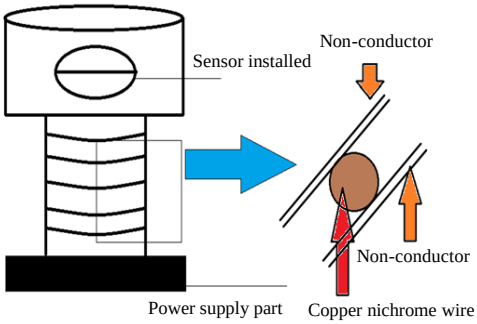

Fig. 5: Proposed smart basin base technology

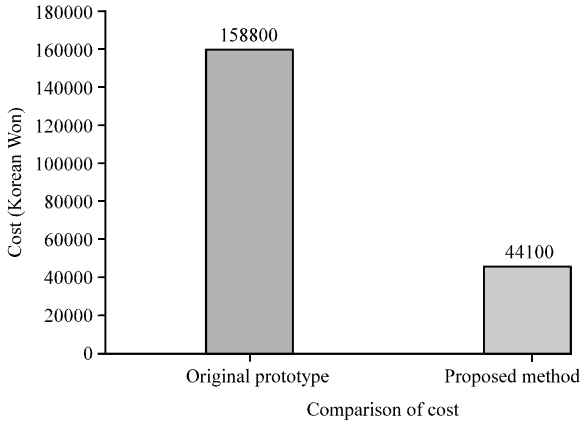

Fig. 6: Installation cost and economic feasibility of the proposed system

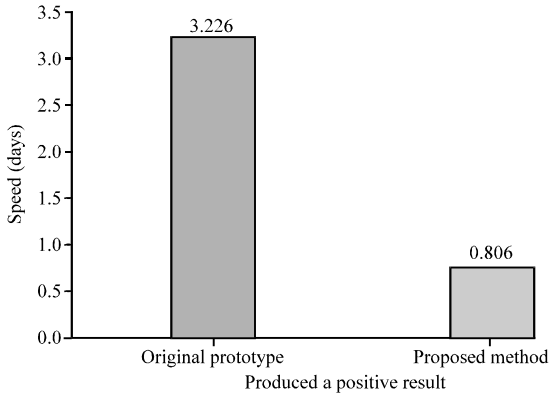

Fig. 7: Produced speed a positive result

Figure 5 shows the inside of the part indicated by an arrow in the center and the portion where the human hand touches and the part which comes into contact with water is used as a nonconductive body. The reason for the groove is to make a joint with rubber. The main supply battery of the original supply part is a battery and the microprocessor at the lower part controls the temperature and pressure of the water inside the water pipe to measure water quality and to inform the replacement period of the water pipe. The prototype will be released after the paper is published and a patent application has been filed.

There are countries where natural resources are rich but the drinking water is scarce and also, even if tap water is available, there are many cases where the water pipes and sink have become too decrepit that people cannot drink it. Especially, many of the poor still drink the water mixed with heavy metals visible to them. Thus, an In-home Healthcare Sink platform technology has been developed in this study motivated by the idea that the much benefits can be achieved if any heavy metal residues in the water pipe and sink can be detected prior to drinking water. The products manufactured by global electronics companies are evolving rapidly introducing AI-based products such as smart refrigerators or smart washing machines. However, as their focus lies on the new products only and not many research works have been conducted for the platform technology relevant to the water pipes and the connected sinks in the old building, this study attempts to find a solution to the problem of how to apply the smart technology-based system to them at low costs. The system was designed to be affordable enough for the poor to easily install it. This has been validated by the evaluation of its installation cost and economic feasibility. The proposed design and idea will be subjected to patent application following the future extended study (Fig. 6 and 7).

CONCLUSION

There are many countries having extremely low drink water despite the rich water resources. And there are also countries having rich drinkable tap water but having aged

water pipes and other basins. Therefore, this study proposes an in-home healthcare smart basin base technology for the water resource context awareness for the poor strata. This study considered the method of smart technology to existing water basins with low cost.

The difference in cost between proposed method and the existing original prototype. While there may be a difference from network manufacturers, about 158800 Korean won is generally known to be spent on original prototype construction. If proposed method is constructed as proposed in this study, however, only 44100 won which is about 72.23% reduction of the cost is needed.

Also, the proposed product is expected to be used easily by the poor strata as a result of evaluation of installation cost and economical efficiency. As a result of test bed test on the customer satisfaction, it produced a positive result.

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