Study on the Establishment of Indoor Environmental Health Housekeeper System--Using Environmental Sensing and Consultation as an Example

Abstract: The study integrates the two concepts of “health” and “intelligence” to develop a healthy environment iMOD (integrated Multi-media On Demand) sensing consultation system. By applying Android operating system and combining the intelligent tablet computer, the iMOD system interface includes: home page of environmental sensing, knowledge base of healthy environment consultation, and setting interface. The environmental sensing factors include environmental noise (Leq), illuminance, temperature and concentrations of carbon dioxide. The healthy environment consultation includes: common problems, health influence, evaluation standard, detection method, improvement method and maintenance management. The setting includes relevant parameter setting of environmental sensing and caution setting of management.

The study is to propose an integrated environmental sensing consultation system optimizing man-machine interaction, to display sensed environmental dosage situation correctly and make it as an intelligent housekeeper system in accordance with dynamic sensory reaction of tablet computer triggered by environmental dosage information, care for users’ health and improve living quality.

Key, Indoor Environmental Health, Sensing, Consultation, iMOD

Introduction

1) Research Motives

According to estimate of the World Health Organization (WHO) in the “World health report 2002”, 36% of lower respiratory tract infections and 22% of chronic obstructive pulmonary diseases are due to the indoor air pollution. In 1997, the indoor environment expert, William Fisk, from the Lawrence Berkeley National Laboratory estimated that the productivity losses caused by the sick building syndrome reach 15,000 to 38,000 million USD per annum [1]. As pointed out by the American College of Chest Physicians (ACCP), most people spend more than ninety percent of their time staying in different indoor places; over one third of time of office workers stay in the office buildings, and whether the office environment is healthy or not has great impacts on the health and work efficiency of these office workers.

The research units of Taiwan government have been aware of the seriousness of the issue of indoor environment, attach importance to and conduct related studies on the indoor air quality (IAQ). According to the Environmental Protection Administration (EPA) and Environmental Analysis Laboratory, EPA has commissioned the Graduate Institute of Environmental and Occupational Health, National Cheng Kung University and Department of Architecture, National Cheng Kung University for investigations on the indoor air quality of office spaces in the north, center and south of Taiwan [2]. The results reveals that the cancer risk caused by formaldehyde in general office environment is one hundred times higher than 10-6 determined by the WHO, and the hazard index is also far larger than the standard value. 1. To summarize related factors impacting on the indoor environment, the important factors include: (1) building configuration and structure system; (2) architectural equipment system; (3) indoor decoration and use behaviors; (4) overall use management and utilization program [3].
Therefore, a lot of indoor environment problems result from bad management, such as opening and air conditioning pipeline not cleaned in office environment, too many persons, furniture and business equipment, high frequency of chemical detergent use etc. [3]. Aiming at the exposure dose in the indoor environment for offices of Taiwan people, the Executive Yuan has enacted and implemented the “Indoor Air Quality Management Law” on November 23, 2012, which establishes good regulations for preventing indoor air pollution in Taiwan.

2) Research Purposes and Significance

The present research ponders over the trend of future life and attempts to integrate the concept of environmental intelligence with the issue of health and develop an application program of “health guarantee in indoor environment”, i.e. the iMOD (integrated Multi-media On Demand) of health in indoor environment, which is an environmental health management system integrating the environmental sensing and able to respond to human needs. In addition to the meaning of integration, i may also represent interior, intelligence and information. It can use the real-time information or images to remind the users, provide the information about current environmental exposure dose and help the health management in the interior environment indoors to maintain the quality of indoor environment and ensure the health of users and their high work efficiency, so that it not only improves the users’ health, but also their life quality and work efficiency.

The research contains: the integration of the three domains: “intelligence”, “digital” and “health”. “Intelligence” refers to the construction of a logical system of triggering environmental events and responses, “digital” includes the integration of electromechanical information and image operation of user, and “health” is the essence of the research that focuses on establishing the database of healthy environment knowledge and guarantee methods, including sensing of environmental exposure dose, human body health effects. Besides mastering perception and responses of human body and selecting the proper environmental measuring methods, it also comprises the consulting services for health guarantee in indoor environment at any time and promptly provision of related healthy environment knowledge and guarantee methods; it may provide assistance to the health management of indoor environment and periodical maintenance, clean and care.

Therefore, the research takes the houses and offices as the space setting and environmental health management as the principle, with the primary purpose of constructing the application program of “health guarantee in indoor environment”, so as to provide visual health management of indoor environment and create a healthy indoor environment, including: (1) environmental factor alarm and prompt of management information; (2) visualized interface according to user’s need setting and use situation; (3) guiding the user to solve the indoor environmental problem by band to guarantee quality.

Literature Review

1) Related Work on Indoor Environment and Health
According to the “Study on Comprehensive Indicators of Building Indoor Environment Health Control” for 2003, 2005 and 2006 in Taiwan, Taiwan people attach the greatest importance to the indoor air environment (22.5%), followed by thermal environment (14.2%), acoustic environment (13.7%), lighting environment (12.7%) and electromagnetic environment (11.3%). Also, people staying indoors generally encounter dry or irritated eyes or eye strain (59.4%), abnormal tiredness or drowsiness (41.6%), memory or attention deficit (38.4%), headache (30.5%), chest tightness (29.0%), and sneeze (25.8%). These symptoms are closely related to the indoor environment quality [4].

2) Environmental Sensing Technologies

At present, the environmental sensing technologies are still being developed in Taiwan by academic and civil research institutes like Industrial Technology Research Institute, Institute for Information Industry and Architecture and Building Research Institute, Ministry of the Interior. The related monitoring equipment and information integration technologies are becoming mature. Research teams has successfully integrated instruments and devices in the past [5], including monitoring of various indoor environment factors, such as temperature, relative humidity, concentrations of CO, CO\(_2\), weather information (wind speed, wind direction, outdoor temperature, relative humidity, rainfall), as well as air conditioning equipment and electric window etc., connecting indoor sensors by wires, sending message to the transmission points of Zigbee, and transferring message of spaces through ZigBee communication module to Access Points between pipes each floor, which connect to the control panel by network wires; the small weather station outdoors is connected to the control panel by wires and the real-time environment message of all spaces is sent to the control computer. By using the program, the control computer receives all indoor and outdoor (small weather station) environment messages, computes by the program logic and drives related devices (transom window or total heat exchanger) for controlling environment, so as to achieve a healthy, convenient and comfortable environment by the intelligent techniques.

3) Human-Machine Interface and Energy Saving & Healthy Applications

The HMI (Human-Machine Interface) already develops from the Graphic User Interface (GUI) in the past and the Tangible User Interface (TUI) to, such as: Natural User Interface (NUI) using the five human senses for interaction and the Multimodal interaction interface, and the environment-perception human machine interface are being paid increasingly more attention to [6]. Related researches integrate the environmental sustainability or health issue to remind the user of economic or healthy life by intelligent life products, e.g.: the power-aware cord through ambient information display [7], use of mobile phones to remind users of maintaining the green transportation habits and achieving the effect of carbon emission reduction [8], several LED lamps replacing water meter to promote water conservation in the shower [9], and use of inAir system for sharing the indoor air quality measuring and display results and thus changing human behaviors to improve indoor air quality [10].
**Research Method**

The research designs the iMOD sensing and consulting system for indoor environment health based on the results of related work. As shown in Figure 1, the system is designed in aspects of expert consulting and user operating. The visualized interfaces are operated on the Android system and the architecture includes the three main interfaces: Environmental Sensing homepage, Health Environment Consulting Knowledge Base and Settings. Environment Sensing has four different interfaces: acoustic, light, hot and air environments; Health Environment Consulting contains: Common Indoor Environment Problems, Health Impacts, Assessment Criteria, Measuring Methods, Improvements and Maintenance Management; Settings compromises the Environmental Dose Response Settings and the Environmental Device Management Settings. The iMOD sensing and consulting system uses the intelligence Pad as the terminal device to prompt the warnings of environmental factors and proper management message, and guide users to solve indoor environmental problems by their own preferences and use situations to guarantee the quality.

**Figure 1 iMOD Sensing & Consulting System Architecture**

**Results and Discussion**

According to the architecture in Figure 1, the App homepage of the iMOD Sensing & Consulting System is shown in Figure 2, where all integrated environmental monitoring information is clearly seen. Three shortcut keys are put on the top in the right to respectively navigate to the Health Knowledge Base (KNOW), HELP and SET. The central environment information can connect to the environmental monitoring situations. For example, if the environmental dose is excessive, the message will display in red, connect to Improvements for a solution. The radar diagram in the lower place can help the user to judge whether the environment is comfortable and healthy.
As shown in Figure 3, the environmental factors monitoring can be displayed in visualized simple charts, including mainly environmental noise (Leq), illumination, temperature, relative humidity and CO\textsubscript{2} concentration; the real-time measured values, the past mean values, maximum and minimum values and comprehensive assessment scales etc. are displayed. Health Environment Consulting Knowledge Base gives explanations and suggestions on problems and causes of different environmental factors, and is divided into 6 parts: Common Indoor Environment Problems, Health Impacts, Assessment Criteria, Measuring Methods, Simple Improvements and Maintenance Management. As a result, the user can understand and cognize the changes in ambient environment and feedback and maintain the indoor environment he or she stays in.

![Figure 3 iMOD Visualized Sensing Interface](image-url)
The iMOD system can be set according to use situations, as shown in Figure 4. It comprises the Environmental Dose Response Settings and the Environmental Device Management Settings. The former can set the environmental dose criteria, warn time, warn type, warn ring, warn picture and notice sound volume to one’s own preferences; the latter sets the warning and self-inspection schedule for measuring instruments, lamps and air conditioners, for improving the service life and efficiency of building devices.

![Figure 4 SET Interface of iMOD Application](image)

The research designs the above-mentioned visualized interface for the system integrating the handheld device to guide the user to improve environment by hand, set the response alarm and periodical self-inspection according to need. User’s simple operation of managing and maintaining environment is the emphasis of the research. Various environmental factors are simplified and integrated to combine the environmental factors impacting human health with life technologies. In addition to displaying environmental changes, it fuses into active and passive guidance design to make itself amicable and popular among people.

**Conclusion and Suggestions**

This study investigated indoor environmental factors on user’s demand, integrated the application with handheld device and simplified the user’s learning time and operating of iMOD sensing and consulting system interface, in order to quickly obtain effective and substantively helpful information. Considering the cost, the visualized interface of iMOD sensing and consulting system has the basic functions integrating intelligent, digital and health functions to ensure simple operation, maintain the environment and user’s health and implement the health guarantee and management of indoor environment.

**References**


