



Exploring the critical quality attributes and models of smart homes



Tainyi (Ted) Luor^{a,*}, Hsi-Peng Lu^b, Hueiju Yu^c, Yinshiu Lu^d

^a Graduate School of Management, National Taiwan University of Science and Technology, No. 43, Sec. 4, Keelung Rd., Da-an District, Taipei 106, Taiwan

^b Department of Information Management, National Taiwan University of Science and Technology, No. 43, Sec. 4, Keelung Rd., Da-an District, Taipei 106, Taiwan

^c Department of Advertising, Chinese Culture University, No. 231, Sec. 2, Jianguo S. Rd., Da-an District, Taipei City 106, Taiwan

^d Graduate School of Management, National Taiwan University of Science and Technology, No. 43, Sec. 4, Keelung Rd., Da-an District, Taipei 106, Taiwan

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ABSTRACT

Research on smart homes has significantly increased in recent years owing to their considerably improved affordability and simplicity. However, the challenge is that people have different needs (or attitudes toward smart homes), and provision should be tailored to individuals. A few studies have classified the functions of smart homes. Therefore, the Kano model is first adopted as a theoretical base to explore whether the functional classifications of smart homes are attractive or necessary, or both. Second, three models and test user attitudes toward three function types of smart homes are proposed. Based on the Kano model, the principal results, namely, two “Attractive Quality” and nine “Indifferent Quality” items, are found. Verification of the hypotheses also indicates that the entertainment, security, and automation functions are significantly correlated with the variables “perceive useful” and “attitude.” Cost consideration is negatively correlated with attitudes toward entertainment and automation. Results suggest that smart home providers should survey user needs for their product instead of merely producing smart homes based on the design of the builder or engineer.

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1. Introduction

The term “smart home” may refer to a residence equipped with technology, which allows the monitoring of its residents and/or encourages independence and the maintenance of normal healthy condition. Given that different people have varying needs, the provision of assistance must be tailored to each individual. Considerable research in this area has been undertaken worldwide [1]. A smart home system may integrate electrical devices inside a house. Similar to the film of *Living Tomorrow*, which is a concept house (Fig. 1), a smart home may contain those techniques for building smart systems and controlling domestic activities, such as electrical equipment automation and home entertainment systems, and those used for building automation to control domestic activities for different events, such as lighting control, power control, home telemonitoring, home networks, and health care. Smart home devices can be connected by a computer network to allow control using a system, such as a personal computer (PC). These devices can also facilitate remote access using the Internet. Appli-

ances and environment can communicate in an integrated manner by combining information technologies with the home systems, and this integration induces security benefits, energy efficiency, and convenience.

Chan et al. [1] described a selection of projects on smart homes in developed countries. After examining various technologies available, discussing advantages and disadvantages, and analyzing their effects on modern society, Chan et al. proposed future perspectives on smart homes as part of a home-based health care network. They also argued that the smart home system will consist of hospital-based health professionals who provide teleconsultations, virtual visits, and other health-related issues. In their proposed future perspectives of smart homes, smart homes in daily life will provide devices capable of home appliance control (heating, air conditioning, bath water control, windows, doors, water outlets, electric power, cooker, and bed) [2,3]. However, the lack of studies related to user needs is a major barrier to the implementation of health care and live comfortable technology in smart homes. Inadequate comprehension of user needs and poor demands for products and services to be used in smart homes are partly explained by the fact that the industry tends to be dominated by suppliers that provide a technology – push rather than a demand – pull approach, engendering user disappointment [4,5]. Numerous past studies have focused on smart home research. For example, Cemi et al. [6] demonstrated

* Corresponding author.

E-mail addresses: a384@ibfc.com.tw (T. (Ted) Luor), lu@mail.ntust.edu.tw (H.-P. Lu), hjyu@sce.pccu.edu.tw (H. Yu), jessica-lu@yahoo.com.tw (Y. Lu).



Fig. 1. Snapshot of Living Tomorrow.

the direction and trends of smart home research after reviewing 465 smart home publications that appeared in 194 journals from 1997 to October 2010. They argued that smart homes can improve the quality of life of aged and disabled persons, particularly those who may require institutional care or caregivers. The authors also indicated that the number of studies on smart homes increased during the period of 1997 to 2010, which suggests the rising influence of smart homes. They also asserted that smart home research has attracted an increasing number of researchers during the 14 years covered by the study.

Chan et al. [1] proposed a key organization in smart homes and three types of service, namely, hospital services (physicians, therapists, nurses, and medical practitioners), safety services (formal providers, informal caregivers, home security, and social services), and daily life services (education, reminders, health program, shopping, banking, library, civil services, entertainment, TV, and movies), which are linked to the home-based health care system. However, only a few studies have explored the needs of users. Thus far, the functions of smart homes mentioned in previous studies, particularly safety and daily life services, are seldom discussed or examined.

To explore users' different needs related to smart homes, the functions of smart homes in the film of Living Tomorrow in this study are arbitrarily classified into three major functions, namely, entertainment, security, and automation. A survey was conducted after the respondents watched the film. Users' need of functions provided in smart homes is classified by adopting the Kano model. A person's intention to start a specific action is derived from his or her attitude on the way to the behavior. A research model was also proposed and analyzed to determine user attitude toward using the multiple functions of smart homes.

2. Literature review and research framework

2.1. Living Tomorrow project

Living Tomorrow is a concept house of the future founded in 1991 in Brussels by architects Peter Bongers and Frank Belien. Their mission was to create a platform where a number of companies could show their innovative designs. Everything in the Living Tomorrow project provides a clue of what can be expected in future homes. The project showcases the most innovative technologies that can be integrated into future daily life and working environments. Living Tomorrow opened its first "House of the Future" in 1995 and immediately attracted attention. For example, a den-shaped "cocoon" bed with a TV and a computer in the bathroom equipped with smart mirrors that remind people to brush their teeth and take vitamins is advanced. The entrance, auditorium, event hall, administration office, exhibition room, and kitchen are located on the ground floor. More exhibition rooms, a small restaurant, and other secondary facilities are located four levels above. The house also features a kitchen with, among many other

amenities, a digital whiteboard that allows residents to use a touch-sensitive screen with built-in handwriting recognition. When the user creates a shopping list on-screen, the list can be converted into a neatly typed page so that everyone can read it. The next step would be to use an internet connection to automatically order the list online from a favored supermarket. The Living Tomorrow whiteboard also displays extra screens so the user can monitor bills, messages, and water consumption.

Concept constructions are being outfitted with ingenious inventions because more clients intend to incorporate high-tech elements into their homes. Given the prevalence of digital media, people can easily disguise technology, and everything is more simple and streamlined. One development that people absolutely adore is streaming, a control hub that operates lighting, heating, and sound. "Houses can be networked so that everything from the bedside lamps to the underfloor heating is controlled system and centrally." Smart home technology is the shape of things to come. Products are becoming more advanced and easier to use.

2.2. Functions of smart homes

A system that consists of "intelligent" components in the sense of context awareness or decision support properties may be installed in a smart home. "Smart home" is a term used to describe a residence that is equipped with technology that allows the monitoring of its inhabitants [1]. The functions of smart homes in the film of Living Tomorrow are arbitrarily classified into entertainment, security, and automation. These functions are explained below:

2.2.1. Home entertainment (ENT)

Home entertainment may refer to a home cinema or a home theater. A home entertainment system reproduces a movie theater experience and mood using video and audio equipment. It may also refer to a media center electrical device or a home theater PC or a device that syndicates both. In recent years, other types of consumer electronics, including gaming systems and dedicated media devices, have intersected to video and music content management. Although computers with some of these capabilities have been available since the late 1980s, the word "home theater PC" initially appeared in the mainstream press in 1996. The term "media center" denotes the specialized product software designed to operate on standard PCs. In this study, home entertainment includes the following functions: touch-screen buttons to play music, TV, quick web links for shopping, online information, and news.

2.2.2. Home security (SEC)

Some researchers have analyzed the topics related to home security. For example, the PROSAFE project in Toulouse in France supports autonomous living and sounds alarms in emergencies. Infrared (IR) sensors implanted in the ceiling of the flat allow mobility and activity [7]. The University of Ostrava in the Czech Republic has developed a smart apartment to study individual activities with IR sensors [8]. Weight and vital sign sensors are linked through a CAN network for data processing, and an alarm is transmitted in urgent situations [9]. The HIS project in Grenoble is an apartment with IR sensors for activity assessment.

The current study focuses on two aspects of home security, namely, physical and house security. Physical security refers to security measures designed to protect personnel from harm. House security denotes security measures for defending unauthorized entrance to facilities, equipment, and resources, and for watching over property from damage or harm, such as espionage, theft, and terrorist attacks. Both aspects of home security involve the use of multiple layers of interdependent systems, which include security guards, CCTV surveillance, protective barriers, locks, access control protocols, and numerous other techniques. Smart home security

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