Usability Assessment of a Virtual Fitness Platform on Smart TV for Elderly Health Promotion

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Abstract. The elderly maintain healthy by exercise and friendships connection which not only can reduce the cost of social care but also can contribute their knowledge and experiences to help the younger generation. This study is aimed to investigate the usability and functionalities of the fitness platform with multi-user virtual situations on smart TV service content, which was developed by the author. The main modules of the platform include limb movements driven by motion sensing interaction with Kinect, contactless graphical user interface, alternative 3D avatars and situational environments, synchronous interaction of distributed multi-users, and interface of unified computing health data. Group interview and a questionnaire were designed to evaluate the feasibility and usability associated with using the virtual fitness platform. A total of 40 elderly users assess this set of content service. The results of this study showed that most of the users are satisfied by the system functionality and usability. Furthermore, the platform also offers the interface for data connecting the wearable devices which assist in increasing the effectiveness of the real time elderly health maintenance.

Keywords: Elderly health promotion · Virtual fitness platform · Motion sensing · Smart TV · Usability assessment

1 Introduction

Adherence to exercise regiments and attending social activities can enable elderly population, in particular those residing in apartment based housing situated in urban setting, to improve their quality of home life, to allow these people to maintain fitness and health even in an environment where resources for mild exercise, such as playgrounds or parks are limited [1]. In addition, to provide equivalent beneficial effects to society with cost effectiveness of providing sustainable older people care enable this population to contribute their knowledge, wisdom and arsenal of experience to the younger generation. However, with regards to the maintenance of fitness, this is often affected by level of exercise intensity and frequency, both of technology and enhancement of urban dwelling older people's health which are often altered as a result of perseverance, peer motivation, weather, and environmental conditions [2, 3].

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Therefore, a smart TV based multi-user virtual system was developed by author, which is pertinent in providing this population with interactive healthy activity and social network functionality, whilst being easily manipulable by the distributed elderly at home. The main modules of the system include limb movements driven by motion sensing interaction with Microsoft Kinect, contactless graphical user interface (GUI), alternative 3D avatars and situational environments, synchronous interaction of distributed multi-users, and interface of unified computing health data. Furthermore, the platform also offers the interface for data connecting the wearable devices which assist in increasing the effectiveness of the real time elderly health maintenance.

This study aimed to verify the functionality and usability of the fitness platform with multi-user virtual situations on smart TV (FMVSTV) service contents. Group interview and a questionnaire were designed to evaluate the feasibility and usability associated with using the virtual fitness platform. A total of 40 elderly users, who were investigated at home individually or gathered in a community, assess this set of content services. The results of this study are hoped to be efficacious to improve existing FMVSTV to meet the practical needs of further enhanced effectiveness elderly being able to maintain their fitness and health.

2 Related Work

2.1 The System Framework of FMVSTV

Smart TV for the elderly at home is just the same as smart phone for the young people to go out. However, smart TV is more like smart phone applications shown on a big screen and is more suitable for the elderly to use interactive applications [4]. The first generation of web TVs are only enable the users to browse the internet and thus are called Web TV or internet TV. The second generation of web TVs which realize diverse online application functions by means of such software as widgets are called connected TV and the new generation of connected TVs which have not only web browsing & diverse online functions but also additional functions such as internet information search engines as well as application store are named smart TVs. The smart televisions now have capability up to the internet and there are various benefits, including [5, 6]:

- Web browsing: Smart TV has built-in web browsers allowing user to surf the internet and view web pages, photos and videos. However, some are much easier to use than on personal computers.
- Apps: Apps on smart TVs either come pre-loaded, or are available to download from an app store. Most smart TVs offer TV and film streaming on services and social networking on Facebook and Twitter.
- Additional services: Cable service providers offer additional services such as online gaming on Smart TV to differentiate from the competitors, as well customisable home screens and recommendations of things to watch based on users' personal tastes.

In order to implement the functionalities of FMVSTV, the system goals are formulated as following: (1) developing the fitness treatment for elderly at home, (2) conducting distributed elderly users to their interaction by the implementation of avatars driven by motion sensing technology, (3) implementing the virtual reality application by Unity 3D program on protocol of Apps for Android TV to construct the real time feedback mechanism and data management of the system, (4) integrating all of the requirements that were elicited from the subjects of elderly and care staff to develop the UI-UX and communication feedback modules.

Accordingly, the analysis approach of service experience engineering was manipulated to establish the system framework of fitness service with motion sensing technology on smart TV [7, 8]. It was integrated and implemented with 2D/3D computer graphics technology, contactless and intuitive user interface design, multimedia database, motion sensing interaction by Microsoft Kinect sensor, synchronous/asynchronous fitness treatments, virtual reality app for smart TV by Unity 3D, and protocol of Apps for Android TV. Figure 1 illustrates the modular architecture of FMVSTV. There are six modules namely: System manipulation module for content editor to manage the service elements and materials; Alternative virtual situations module for presenting the immersive multiple scenes; Avatars and interactive objects module for users to choice the alternative avatar in fitness and social communication; Natural body language driven module for processing joints coordinates data from Microsoft Kinect sensor immediately; Virtual reality interface module for users to control and manipulate the service contents in intuition; and Physiological data management module for user and medical staff to maintain the detected data.

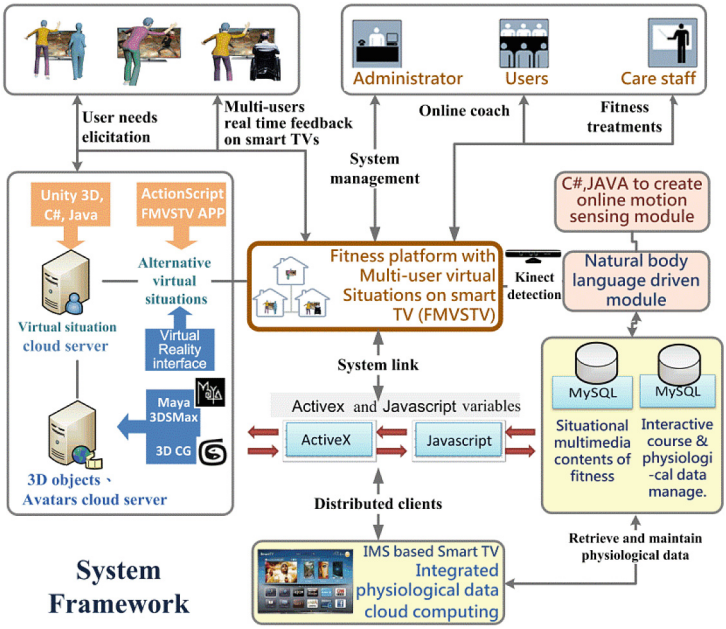


Fig. 1. The modular architecture of FMVSTV

2.2 User Interface Design for Elderly

By the year 2025, one in five of the Taiwanese population will be aged over 65, and meanwhile Asian countries will have most elderly population and will be the fastest growing in the world [9]. Nowadays, the population imbalance between the elderly who require daily care and caregivers is being one of global social issues since the population aging advances. In order to avoid the negative effects of population aging, people believe that the information and communication technology can support the daily lives of the elderly persons at the early stage for increasing active aging [10]. Accordingly, designer must develop handy interface for use by elderly to enable them to educate or entertain themselves, interact with the society, challenge themselves by completing task achievements and increase their changes of doing productive jobs such as writing, using emails, network communications and other computer manipulation.

There are three major barriers encountered by the elderly in their using of computer technologies which include the eyesight degeneration, memory degradation and cognition. Eyesight problems, such as prone to feel tired, are one of the major factors causing physiological burden of the elderly. Memory degradation causes them to become unable to quicken the paces at which they learn new things, resulting in their efficiency in handling difficult tasks being lower than those of groups of younger age. These frustrating and negative emotions will further affect their cognition and become the psychological factors preventing them from learning computer knowledge as they feel old and unfit for high-tech products or fear they are going to cause damage to such products during their learning process [11]. It is fortunate that the restrictions caused by degradation in eyesight and memory can be ameliorated by user interface design to enhance the positive feelings of the elderly for their acceptability and cognitive ability [12]. As mentioned above, a certain number of studies about user interface design for elderly in smart home have been conducted. Thus, this study was issued at the usability of interactive content service on smart TV for indoor use. It was presented with GUI based on contactless display and 3D virtual situation applications as an example of a practical use of the system.

2.3 A Natural User Interface

The first implementation of natural human-machine interaction was defined on voices and gestures to refer to a natural user interface (NUI) by Massachusetts Institute of Technology [13]. In the concept of a NUI, it is expected that the adjective “natural” will shorten the time that users spend in learning. This purpose will be achieved by the most natural, intuitive, and simulative method for obtaining experience such as the movements of human body, gestures, or language, which enables the users to understand how to interact with computers in the shortest possible time without resorting to the traditional media tools such as mice and keyboards.

In 2010 Microsoft Corporation reiterated the importance of the NUI within Microsoft Kinect, a motion sensing I/O device, which could be used in the future

potential of contactless interface design. Kinect can detect user limb movements and signal the device that an interaction is occurring in motion sensing mode [14]. It can let users to perform three-dimensional interaction including manipulation displayed virtual objects and communication with each other by driven individual avatar in the virtual environment. Consequently, implemented for assuming Kinect functions, the interface of FMVSTV provides users to manipulate the contactless GUI displayed on the screen and to move interactive virtual objects to the expected destinations by their gestures in virtual situation.

3 Methods

3.1 Function and Content Characteristics of FMVSTV

Exercise is crucial to the health of body and brain for the elderly, but that doesn't mean they have to work out in parks or at gym. FMVSTV is designed to apply the skeletal tracking function of Kinect sensor, and to combine with the home based exercise for the elderly healthy living. There are 10 sets of moves in the virtual reality interface module, which were developed by professional medical staffs and hoped to help the elderly to boost metabolism, combat stress, improve memory and slim waistline. The design characteristics of functions and contents are described and shown in Table 1.

3.2 Experimental Tasks and Measurements

In order to confirm whether the comprehensive design of FMVSTV is feasible used at home and in facilities that the experimental tasks carried out by 40 subjects in the age range of 60–80 (6 elders at home and 34 elders in three daycare facilities) in the two experiments were as follows.

For Experiment I, each subject was invited to experience the functions of registration, tutorial, selections of avatar, virtual situation and aerobics, and processed health data; meanwhile, they completed three sets of aerobics with smart wrist band. After the tasks each elder finished the questionnaire of usability evaluation. For Experiment II, the same previous 5 subjects at home affiliated with 7 elders who were recruited from the original 34 subjects in one daycare facility to participate the investigation. A total of 12 subjects were invited to actual use the FMVSTV 8 times in 8 weeks, scheduled at 30-minute per time, including 2 times of 3 elders in a group online synchronization. During the field study period, qualitative methods such as observation and depth interview were executed to explore meaning and perceptions to gain a better understanding which encourages the interviewees to share rich descriptions of phenomena and to propose their suggestions.

A questionnaire used in Experiment I, which was adapted from the standard usability evaluation of virtual reality application [15]. This questionnaire contains two parts: (1) the basic subjects information, and (2) the usability evaluation included six major variables, such as Recognizability, Interface/Usability, Contactless/gesture control, Presence, Attitude to use, and Enjoyment. Each item were listed on a 7-point Likert

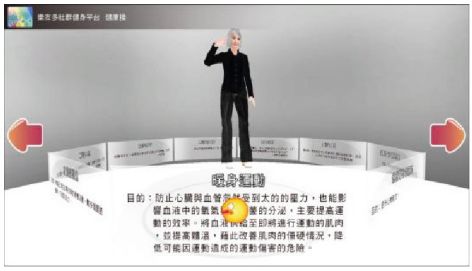
scale with 1 signifying “strongly disagree” and 7 being “strongly agree”. In addition, Experiment II focused on the observation accuracy of the user interface manipulation and to encourage users to propose specific improvement opinions for the FMVSTV. Either the implementation of Experiment I or Experiment II, each time of usability survey has two research assistants who help the elderly to complete all of the tasks.

Table 1. The design characteristics of functions and contents in FMVSTV

In order to maintain elderly cognitive functionality, the registration interface was developed as the pattern verification. Registered users enter selected pattern sequence initially by gesture control to pass validation.	
Interactive user guide was edited the actual use of skimming videos and the feature descriptions of the platform as tutorial.	
There are different genders, ages and styles of avatars for users choose to implement role-playing and to enhance the pleasure of use.	
Image based and model based of virtual reality techniques were applied to create the multiple situations for users to choice and simulate the scenes of outdoor exercises what they want.	

(*Continued*)

Table 1. *(Continued)*

There are 10 sets of moves in the virtual reality interface module, which will auto-demo moves content after chosen and are hoped to help the elderly to boost metabolism, combat stress, improve memory and slim waistline.	
System presents a virtual coach at the center of the screen and shows the briefing of the aerobics at the upper right corner. The lower right corner is the user's avatar where five corresponding points will make green/red feedback to show results of the user's joints coordinates which match or not with coach's synchronously.	
The avatars and interactive objects module offers visual and vocal social interaction functions and series the built-in Facebook and Twitter of smart TV. The social networking function also presents the percentage of correct moves done by each player in real time.	
Users health data, heart rate and body temperature, are collected by the smart wristband, such as blood pressure can be keyed in by gesture control. Data will be sent to cloud server and shown in various statistical graphs for user to catch real-time status.	

4 Data Analysis and Results

The SPSS statistical software was used to analyze the collected and processed data. For each question on the questionnaire, the mean and standard deviation were computed with respect to the statistical results. A report was proposed to the major findings of this study with regards to the visual recognizability, interface usability, contactless and gesture control, presence, attitude to use, and enjoyment.

A total of 40 elders were recruited and assessed the FMVSTV, 11 males and 29 females, with an average age of 68.9 years (SD: 8.4). 94 % of elders reported that using the set of fitness activity can increase their frequency of exercise at home (mean 5.9). 82 % of them showed that the interaction with others by motion sensing features can enhance their exercise motivation (mean 5.7). They also agreed that the FMVSTV is feasible and acceptable (mean 5.8). 61 % of elders considered that the graphic registration interface as the pattern verification is recognizable (mean 5). 73 % of elders indicated that the manipulation of interfaces by motion sensing is easy to learn and operate (mean 5.5). 86 % elders considered the feedback information such as pulse rate and actions completeness that provided help them to understand themselves performance in each section of fitness activity (mean 5.9). 76 % of them indicated the social interaction module was useful and interesting but it was missing some of the entertainment features (mean 5.7). 77 % of elders reported this content service on smart TV which was conducive to the activation of everyday life (mean 5.9). 88 % of elders indicated that the virtual fitness platform is enjoyment and satisfaction with it for activation of life, and are willing to continue to use (mean 5.7).

For Experiment II, the interviews were semi-directive (open questions) and held at elder's home or in co-discovery where the participants were in one daycare facility.

In co-discovery the functionalities of the system to assess were presented to the participants one after another and each participant had time to use them before being questioned or in the period of synchronous distributed interaction. The most understanding comments and suggestions were summarized as follows: (1) Adding some information regarding daily life, such as health-care knowledge. (2) The icon colors could be a little more vibrant and rejuvenating and shading effects could be added to the words. (3) The avatars of the fitness coaches may be a muscleman and famous figures. (4) Vocal teaching and voice interface, such as Taiwanese driver, may be useful for the elderly. (5) The social interaction function is useful and interesting but it is missing some of the entertainment features such as KALAOK, blowing ping pong balls, jumping lattices or digital gambling games. (6) When selecting avatars, a function may be available for a close-up or zoom-in of their faces. (7) The performance of the coach selection may be adjusted based on the preference of the users. (8) Provide sound effects to remind the users when their heartbeat reaches a certain rate.

5 Conclusion

This paper presents the result of the investigation that aimed at assessing the functionality and usability of the fitness platform with multi-user virtual situations on smart TV. In the beginning, it appeared that the elders' weak skills of ICT experiences and functional limitations of user interface had an impact on elders' confidence in playing FMVSTV. But the elderly quickly learn to use the platform by the help of research assistants and finally give the overall contents of positive reaction. They also believe that continued use of the service will help maintain healthy. Obviously, the FMVSTV offers elderly users with new and exciting ways such as contactless and gesture control, motion sensing interaction, driving avatar in virtual situation on smart TV and emerging social network to maintain their fitness and health at home. It has been found

during the experimental process that most of the elders show their greatest interest in the contactless and gesture interface manipulation not only by giving it positive remarks but also taking great pleasure in trying it. Therefore some subsequent modifications will be made to enhance the usability of FMVSTV on the basis of the suggestions which obtained from the interview with the assessment subjects as mentioned in the end of preceding paragraph. In addition, one of the aspects that need improvement is how to reduce the extra cognitive load for learning to manipulate the platform and add more helpful feedback.

In the future smart TV will be the center of Digital Convergence to smart home devices. However, this study has argued that in addition to ensuring usability of interactive service content on smart TV for elders, makers need to make sure that there are substantial perceived benefits for elderly users so that they are willing to invest their valuable time and energy in what could potentially be a rich and rewarding experience. In other words, who can explore and understand the needs and motivations of elderly users of smart TV, will build useful programs by setting mutually satisfying goals between organization and elders, and producing positive feelings in all of daily service contents for the elderly.

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