From Dechnology to Humart

A Case Study of Applying Nature User Interface to the Interactive Rehabilitation Design

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Abstract. Some elderly with reduced mobility usually stay their own familiar environments and watch TV or do nothing. In addition, due to the lack of exchanges or proper physical activities, their physical and psychological status tends to imperceptibly become unhealthy. This study applies natural user interface and ceramic crafts regarding the integration of sensing technology with a multimodal interactive components, proposes the design of an interactive rehabilitation device based on video and audio context, and performs an on-site inspection, in order to assist subjects in alleviating negative emotions, promoting physical and psychological health, and reducing the home care stress of nursing personnel, as well as to establish a demonstration model for the use of digital aids in home care environments.

Keywords: Natural user interface · Interactive device · Rehabilitation

1 Introduction

Since the coming of an aging society, the issue of elderly home care has been concerning gradually in various countries around the world. Some experiments have been verifying that, the environmental factors established in the healing process, such as color, light, sound, material, and structural design appearance of other facilities, are found to be beneficial to health recovery [1]. With pleasant, user-friendly facilities will attract the elderly and improve their satisfaction with health care, which has become the approach advocated by the healthcare industry in marketing [2, 3]. Coyle [4] recommended that, to strengthen the collaboration between health professionals and computer science research provides a solution to the development of software and hardware for mental health treatment. Since the novel development of numerous care tools through

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information technology, as based on information technology set up around the arena of elderly home care, have certainly become the necessary facilities of relevant home care or nursing sites. Furthermore, some studies highlighted that, it is necessary to proactively participate in the initiatives of stakeholders according to various aspects, such as design, development, implementation, and assessment, which can help understand the needs and behaviors of the groups involved [5–7]. Many allegedly interactive technologies developed based on user-centered concepts have been innovatively spread to medical and nursing fields. However, a study found that, it is difficult for general users to learn to operate computer-based human-computer interactive control systems. Moreover, it is difficult to overcome relatively mediocre operating skills [8]. Therefore, an increasing number of interactive systems with simplified operation have been continually developed. Some studies intended to investigate the fulfillment of "user-sensitive response generation systems (USRGS)" [9–11].

Caregivers can obtain information feedback regarding cognitive status of the elderly to further develop appropriate healing programs through the operation of user-sensitive response generation systems (USRGS). To the elderly, the information of physical, psychological, and cognitive impairment and degradation is sensed, but they must still undergo rehabilitation through the occupational therapist's arrangement of physical activities. Many healing and care facilities are either deficient in the staffing of occupational therapist or employ too few occupational therapists to take care numerous the elderly. As a result, they cannot fully take care of the elderly. Therefore, healing and care facilities have an urgent need for a series of simple and effective interactive rehabilitation systems, where the elderly is not required to learn anything in particular, in order to assist the elderly in self-healing and improve their participation in rehabilitation activities. In recent years, the "postural control system using a natural user interface (NUI)" has been widely applied to daily life [12, 13]. Consequently, an increasing number of developers have applied the NUI concept to the human-computer interaction of rehabilitation systems. Although healing systems that integrate sensors with NUI development have been available, to date, the development of an interactive device that considers the spirit of the elderly and uses some images to assist in healing has not been observed. Therefore, this study developed an interactive rehabilitation device integrating plants images with NUI and somatosensory technology to investigate three types of the elderly that require occupational therapy: the elderly with reduced mobility, the elderly admitted to ER, and bedridden the elderly, in order to respond to sensory perception, spiritual healing, and limb sensitivity, as well as to meet the needs of healing and recovery.

2 Literature Review

2.1 Natural User Interface

Natural user interface (NUI) is a general term used by human-computer interface designers and developers, and refers to the effective hiding and maintenance of the invisible parts of a user interface, which facilitates users to naturally and continually become familiar with gradually complicated interactive methods during operation

processes. The word "natural" is contrary to most computer interfaces, as most inter-faces use artificial control devices, and users must intentionally learn to operate them [14]. Past studies in experimental psychology verified that, physical actions, including gestures, can exert functions in problem solving when promoting information transfer [15–17]. Kaushik and Jain [18] mentioned that NUI has three trends: multi-touch, voice, and gesture interaction. In an information system, users most frequently use their hands to implement human-computer interaction. Many researchers suggest that, in order to strengthen the intuition of a user interface, it is necessary to use a new user interface pattern, which enables users to use natural gestures to choose, operate, and convey a target [19–22]. With the development of the NUI concept, human-computer interactions involving hands are more inclined to the development of easy and natural learning, where complicated memory is not required. Hsieh et al. [23] and Fan et al. [24] advocated the use of a gesture recognition system to detect the actions and directions of users' hands in order to achieve the purpose of complicated human-computer interactions. The study by Bragdon et al. [25] verified that, touch gestures significantly improve the availability of mobile devices; however, not all touch gestures are intuitive and easy to use, as such operation usually requires detailed learning – similar to the hand dexterity training of normal people [26].

With the advance of sensory technology, the development potential of NUI is expected to provide space thinking that involves interactive design [27]. As NUI initially does not frequently provide specific guidance or instruction, Thomas and Lleras [17] found that the participants in a space are unwittingly guided to engage in physical action. Even though NUI endows users with highly instinctive convenience, Norman [28] mentioned that, NUI is different from the GUI used in the past – i.e. all actions can be achieved through a visualization menu. On the contrary, the NUI interface includes so many possibilities that it is difficult to determine all the possibilities and implement their actions. However, this study suggests that, if NUI can be used in combination with suggestive video messaging, this difficulty can be over-come.

2.2 Interactive Devices and Somatosensory Interactive Medicine

Interactive Devices. Interactive devices are mostly applied to human-computer interface systems to complete the objectives of information transfer and communication with users. During the design of an interactive human-computer system, the most important issue is to understand the relationship model between users and system in interactive fields. In addition, from the perspective of an interactive designer, an interactive designer not only has to understand the possibilities to be achieved by technologies, but also properly use suitable technologies to solve problems according to different occasions and environments for designing a good interactive device. In order to use the most suitable technology in a specific field, it is necessary to assess the operating model and procedures adopted by interactive users. Although some technological creations developed using assistive technology can meet need the elderly' for interactions, in terms of users' psychology, the latest idea suggests that it is necessary to assist the elderly in developing socialized self-acceptance [5, 29], and enable users to participate in the creation or use of cultural knowledge to support therapeutic experts in

planning interactive software games [30–32], in order to improve the elderly' self-identity and confidence.

Somatosensory Interactions and Medicine. Ever since the Kinect 3D camera developed by Microsoft Corporation was used as a peripheral of Microsoft Xbox360, after becoming commercially available in 2010, the creations and studies concerning somatosensory technology have increased year by year. Kinect is a webcam that enables users to use NUI, body postures, voice, or image interaction to control a game, and a remote control or body sensor is not required [33, 34]. The Kinect camera has been integrated with the personal computer, and has a potential that even designers cannot predict – from helping children with autism to assisting surgeons in the operating room [35]. Recently, many studies involving this device in academia have focused on the classification of an instant postures and action recognition system [36, 37]. Some studies also investigated the application of somatosensory interactive technology to medicine. For example, Chang, Chen, and Chuang [38] used Kinect to train individuals with past cognitive impairment in order to enable their limbs to complete basic tasks, and then developed a Kinect-based rehabilitation system for adults [39]. Lange et al. used Kinect to develop a game-based recovery tool to provide adults with nerve damage with balance training [40].

3 Research Design

This study attached importance to both theories and practices. In the initial stage of this study, the researcher proactively asked about healing and care facilities willing to participate in the subsequent field survey. After a series of comparisons, the researcher eventually contacted the Suao Branch of the Taipei Veterans General Hospital. In addition to the general outpatient clinics of the general hospital, Suao Branch, Taipei Veterans General Hospital has a nursing home, where many elderly the elderly requiring long-term care are hospitalized. Therefore, opinions from health professionals of this facility could be obtained, and this study could conduct a field survey on elderly the elderly living in a nursing home for a long period of time. This study used the "Double Diamond Design Process (4D)" advocated by the UK Design Council [41]. Firstly, this study reviewed the studies concerning ceramics crafts, NUI, and interactive design, observed the healing facility, had discussions with the caregivers at the facility in order to preliminarily understand the elderly' needs, and applied the summarized principles to the prototype design of an interactive device. Secondly, this study conducted a field survey of the interactive device on professional caregivers and the elderly, and then interviewed users regarding their user experience. Lastly, this study adjusted and summarized the interactive design to meet the needs of users for this research purpose.

3.1 Research Process and Method

Research Process. In the research process, and according to the 4D method, the user-centered service design meets users' needs, and includes 4 steps - Discover - > Define - > Develop - > Deliver. The explanations are given, as follows:

Discover – the beginning stage of the double diamond model, and marks the beginning of a project. Initially, ideas and inspirations are obtained from the exploration of the identifiable needs of users. The implementation content includes: environmental research, user research, management information, and a design research group. Upon completion of this stage, a "feasibility review" is applied at the both ends of the diamond in order to explore possible solutions to the issues. Define – stage 2 explains and adjusts the content to meet the needs of the project and its objectives. The critical activities at this stage include: project development, project management, and project approval. Upon completion of this stage, both ends of the diamond converge to a "Brief" to facilitate the precise determination of the details of project, as expected to be implemented at the development stage. Develop – stage 3, at which the design-led solution is developed and retested in an organization, such as visual management, the development method, and project testing. The "Concept review" is used to confirm the final project to be adopted by a service provider. Deliver – the last stage, at which an effective product or a service-related market is confirmed and initiated. The critical activities and objects are: final test, approval, proposal of service project, objective assessment, and feedback reply. Through a series of defining service objects, content, questions, and conversion processes, the interactive effect between a healing provider and a care receiver was gradually revised to further develop the overall healing care service design project, as shown in Fig. 1.

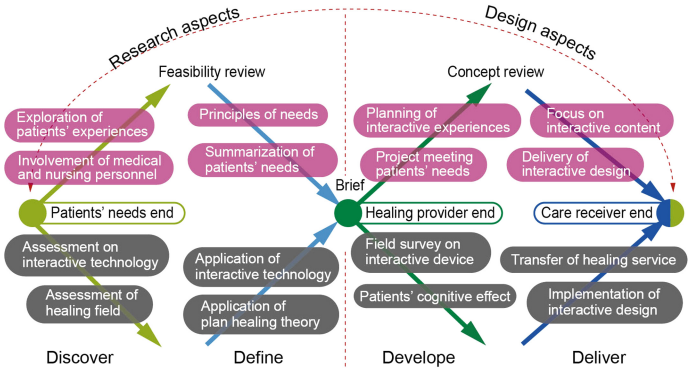

Fig. 1. Double Diamond Design Process (4D) (Source: Design Council, 2005. Compiled by this study).

Research Method. Prior to the formal design being put into practice, this study invited experts in fields of art therapy, video design, interactive engineering, and system design to participate in Stage 1 focus group meetings. The discussions focused on the corresponding estimated lines of art therapy perspectives, as well as the design of interactive content. The reason this study applied this method is that, past studies showed that the purpose of the assembly of these members to engage in group discussions is to reach consensuses on healing environments, facilities, and approaches, through communications and coordination regarding healing procedures and details. Focus groups have long been applied to develop research methodologies and standardized

questionnaire items [42, 43], while open interviews and Q and A sessions can be used to generate subjects' qualitative data, such as attitudes, viewpoints, and opinions. Based on the discussion results of the focus group meetings in Stage 1, this study designed the interactive content, and further developed a semi-structured questionnaire for the subjects to conduct interviews. According to experts, the suggestions of interactive design are as shown in Table 1.

Table 1. Summary of focuses from art therapy expert meeting

Interactive content of plant images	Perspectives of art therapy
Garden interactive environment (a certain tree)	Garden environments are featured by higher accessibility and tolerance. Open spaces and bright lines create more safety, as well as the willingness and possibility of exploration. In addition, interactors' acceptance of visual colors, object abundance, and psychological control over environment is higher.
Leaves "falling from top to bottom" or "rolled up from bottom"	1. Leaves falling from "top to bottom" represent that people change from head to toe and throw away troubles.
	2. Leaves "rolled up from the bottom:" represent an upward force, obtainment of assistance, recall, memory, and re-obtainment of the lost.
Leaves "falling" or "bouncing"	1. Leaves "falling:" convey the meanings of loss, missing, and separation, and is the passage and change of time.
	2. Leaves "bouncing" enable viewers or interactors to perceive the signs of timing of self-maturation, to throw away everything that is old, shabby, negative, and inappropriate, and accept new things.
Leaves "shining or changing their color" when touched	"Leaves shining or changing their color" when touched signifies the energy of warmth and softness, enabling interactors to be covered by energy, perceive support, empower themselves, heal themselves, and purify themselves.
"Waving" of the elderly during interaction	"Waving" is the expectation towards attention from other people and environmental interaction, as well as the need for assistance or help.
Leaves "sounding" when touched	Touch, in combination with visual image stimulation and audio stimulation (sounds), can better deepen and internalize individual external experiences and trigger deep emotions and feelings.
A sprouting tree or fallen leaves returning to a tree	Represents self-recovery, rebirth, gradual exuberance, and recovery of existing vigor and feelings of regeneration

(Compiled by this study)

3.2 Design Case- Design of Interactive Rehabilitation Device

According to the preliminary testing of medical and nursing professionals, as well as the above mentioned literature review, this study initiated the advanced corrections and development of the design of interactive devices, including three parts: (1) image design; (2) sound design; (3) sensing design. The design process is briefly described, as follows:

(1) *Image design:* Based on the aforementioned studies investigating the positive effects of plants on users' cognition, this study mainly used a common arbor as the material. According to the survey, this study chose the tree shape of the birch, as it is featured by gentility and tenderness [44]. Moreover, relevant studies on tree shapes indicated that, users' visual preference is round shaped leaves. Therefore, this study mainly referred to the tree shape drawn by Booth [45] to select the shape display. Moreover, according to existing studies on preference for the visual shape of a tree, this study further simplified the shape to the final shape for the case according to the visual subject of interactive design, as shown in Figs. 2 and 3.

(2) *Sound design*: As humans rely on all things in nature to earn a living, when faced with natural elements, such as plants, water, and rocks, they usually develop positive responses, as well as naturally peaceful behaviors in their emotions [46, 47]. Throughout time, people have used natural elements to obtain actual effects. The sounds in the nature enable listeners to imagine that they are in a natural environment. The preset garden environment in this study was integrated with pure birdsong.

(3) *Sensing design:* This study mainly used computers in combination with Kinect somatosensory devices, as well as the program syntax of processing software, to form the content of movement and spatial depth framework of users for detection. As the principle for the use of NUI mainly focuses on limbs (especially gestures), many researchers advised some changes to guide users to use specific gestures to implement human-computer interactions, and priority should be given to such changes during the initial system design [48]. This study developed a type of interactive designs according to the elderly undergoing physical rehabilitation, as shown in Fig. 4.

3.3 Subjects and Limitations

The subjects were divided into two types. Upon completion of the initial interactive prototype design, this study performed testing on caregiving professionals at a healing

Fig. 2. The shape of tree in the case

Fig. 3 The shape of leaf in the case

Fig. 4. Interactive design proposals for three types of patients (From A to C: patients undergoing rehabilitation, bedridden patients, and patients with acute illness).

and care facility, as well as ordinary people, in order to provide professional assessment and assessments of various needs. The prototype design was corrected and adjusted according to professional opinions from various fields. Afterwards, the design was installed in a healing and care environment for the three types of the elderly that were the expected targets to use the design. The researcher observed the elderly, maintained records, and interviewed them about their feelings.

3.4 Experimental Process

As stated above, this experimental study was divided into two parts: Firstly, this study invited occupational therapist, head nurses, and medical administrative personnel to try out the design on their own (Fig. 5). Secondly, this study encouraged the elderly at the healing and care facility to try out the design (Fig. 6). Upon termination of the trial, the subjects were interviewed one by one (Fig. 7).

Fig. 5. Pre-test

Fig. 6. Test on a patient

Fig. 7. Interview

Table 2. Experimental results of the subjects using the interactive design

Samples	M07601	F08401	M08901	F05701	F09001	F07101	F08701	F08402
Gender	M	F	M	F	F	F	F	F
Age	76	84	89	57	90	71	87	84
Status	b	c	c	c	a	a	c	c
Number of days of hospitalization	180	365	1095	210	60	365	30	730
Emotion	e	e	e	e	e	e	e	f
Plants have a healing effect	Y	Y	NA	Y	N	Y	N	Y
Virtual plants can replace actual plants	N	Y	NA	NA	NA	NA	NA	NA
Aware of technological art	N	N	N	Y	N	N	N	N
Music in the interaction	e	e	e	i	i	i	i	i
Feeling after the interactive experience	e	i	e	e	e	e	e	e
Functions to be added	Dancing	Flower planting						

Gender: F: Female M: Male
Status: a: normal/b: crutch/c: wheelchair/d: others
Emotion: e: pleasant/f: sad/g: relaxed/h: Others/i: no feeling
Yes: Y /No: N /No idea: NA

4 Results and Discussion

This study used the participant observation method, and 8 subjects were enrolled (2 male and 6 female the elderly). The oldest subject was 90 years old, while the youngest one was 57 years old; 2 of the subjects were mobile, 5 were in wheelchairs, and 1 used crutches. The experimental results are as shown in Table 2: Among the 8 subjects trying out the interactive design, although none were aware of professional terms, such as interactive technology or art therapy, most of them agreed that the interactive experience of the interactive design created a pleasant feeling, and only 1 claimed not to feel anything. In terms of plant healing, as many as 5 subjects believed that plants have a healing effect, and only 1 agreed that virtual plants can replace actual plants and have a healing effect. Moreover, the music in the interactive design was usually ignored by the subjects, and only 3 of them had a vague impression of background music.

5 Conclusion

5.1 Interactive Design and the Elderly' Rehabilitation

This study used the interactive device planned and developed in this study to perform testing. The interactive device design provided by this study won the recognition of most of the elderly, as well as the healing and care facility. Most of the elderly participated in the test with an attitude of attempting a game or taking exercise. In addition, caregivers had to remind most of them to move their hands and feet to enable them to continue implementing dynamic video interactions. Therefore, it is important to build an initial sense of trust when the elderly are exposed to the interactive device interface. Some of the elderly that were older and could walk autonomously could better focus on the operational procedures of the interactive device. Apparently, healthy and mobile the elderly are more interested in, and are more willing to engage in, interactive behaviors. Moreover, this study found that, because the study site is located in a remote area and the hospital scale is small, it only has several outpatient clinics. During the test, this study found that some of the wards were not used, suggesting that there were only a few the elderly in the facility. In addition, medical and nursing staffing was more simplified, and most of the elderly were not those with critical illness. Therefore, the device developed in this study may meet the needs of this type of healing and care facility in the future.

5.2 Interactive Design and Rehabilitation Healing

Rehabilitation healing focuses on the recovery of past physical and psychological health and functions. Therefore, it is necessary to use a device that has been verified as effective by professionals and experiments. The focus of this study was not on the effectiveness of the developed aids or healing device, but on the use of visual and psychological healing of the plant images themselves, in combination with NUI, which has no particular learned requirements. This study intended to use a more simple and effective method to popularize professional interactive devices to assist in improving

medical devices. Firstly, this study designed the interactive device based on the observations of the needs of elderly the elderly. According to the tests of healing professionals and the elderly, several principles for corrections of the interactive design were summarized. Although this creation is not a medical aid or device, it is not a pure video game. However, from the perspective of the elderly, the healing effect of this device still can be expected.

The development direction of subsequent devices should be intricate and abundant interactive forms. Future devices should better grasp the healing needs of the elderly of different levels of healing needs. Interactive devices or systems of various levels of difficulties should be designed through closer cooperation with professional scientists, anthropologists, professional doctors, therapists, and rehabilitation units. Moreover, it is necessary to develop a mechanism for testing the healing effect of the interactive device, integrated with plant images, in order to precisely grasp the healing effect of the elderly and develop a database of actual application cases. In this way, the seemingly simple but versatile interactive device, when integrated with humanity and patient-centered design, can be used as equipment for analyzing and determining the mechanism of people facing physical and psychological disability.

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