

i-m-Space: Interactive Multimedia-Enhanced Space for Rehabilitation of Breast Cancer Patients

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ABSTRACT

This paper presents i-m-Space, an interactive multimedia rehabilitation space that helps the post-surgery recovery of breast cancer patients. Our goal is to improve patients' physical therapy and psychological relaxation experience through careful applications of multimedia technology. i-m-Space consists of three types of breathing-based relaxation and three types for interactive exercise-based rehabilitation.

Our inter-disciplinary team includes medical professionals, multimedia engineers, designers, and artists. We have implemented i-m-Space in an experimental space in collaboration a local breast cancer foundation. To evaluate i-m-Space, we have recruited several patients who recently recovered from breast cancer to use i-m-Space and to share their first-hand experiences. Our contributions include the following: 1) injecting a sense of fun and playfulness into traditional therapy to attract patients; 2) providing therapists with sufficient flexibility so they can personalize therapy sessions for each patient; 3) maintaining safety of patients.

Categories and Subject Descriptors

J.3 [Life and Medical Sciences]: Health, Medical information systems; H.5.1 [Multimedia Information Systems]: Animations, Audio input/output, Video; H.5.2 [Information Interfaces and Presentation]: User Interfaces – *auditory (non-speech) feedback, screen design, interaction styles*;

General Terms

Design, Experimentation, Human Factors

Keywords

Multimedia Rehabilitation Space, Biofeedback, Computer Vision, Interactive Multimedia, Computer Human Interaction, Human Computer Interface

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1. INTRODUCTION

The i-m-Space project was started from a simple question: “Can multimedia technology assist post-surgery breast cancer patients recover their wellbeing?” Such questions were raised by a few of our team members, who were medical professionals and therapists, who had spent many years on helping breast cancer patients get through their pain and rediscover their normal lives. During their long service on breast cancer meditations and treatments, they discovered a painful fact. Although they could successfully cure a patient and help him or her go home and continue life as usual, still the patient would seem to need to come back to the hospital in a few years, due to suffering from other related ailments like upper limb lymphedema [1][2] or psychological strain [3][4].

The easiest way to prevent it from happening is for them to have rehabilitation exercises about fifteen to thirty minutes per day. This should continue regularly for a year after surgery. However, the incidence of breast cancer is increasing nowadays, the therapists usually get less time for a patient's rehabilitation training. In many cases, patients are only given a paper or a booklet with instructions on various types of exercises. These exercises are often confusing for them, and not quite easy to learn. The lack of sufficient knowledge on psychological relaxation and physiological exercise training will potentially reduce the motivation to do exercises. As a result, physiological and psychological problems combine to create a vicious circle that could increase the possibility of a patient's return to the hospital.

In our opinion, we believe that if we can make the best use of multimedia technology, especially interactive multimedia, and incorporate it into rehabilitations, then it should be easier to attract the patients' attention. Furthermore, it will increase their motivation for doing exercises, and distract them from their feeling of pain during these exercises. Finally, we also want to utilize appealing multimedia content to help them relax their bodies before exercising.

In the i-m-Space project, we have combined not only physical therapies, but also physiological rehabilitations, such as breathing-based relaxation training, and group them into a single-context, multi-session rehabilitation space with interactive multimedia-enhanced technology.

2. RELATED WORKS

In the past, multimedia technology was usually used to assist patients' education, and to help them with gaining necessary information about their diseases [5][6]. There was several technology enhanced rehabilitation project has been developed to persuade patient to do rehabilitation exercises, and to stimulate their ability in paying attention on learning rehabilitations. For example, a computer aided VR simulations for stroke patients to rediscover their motor capabilities [7]. Borren et al. also used haptic user interface with stereo VR-game to help stroke patient recovery [8].

In most studies that we have surveyed [9][10][11][12] has shown the task of learning in a multimedia system can really helps stroke patients recover their physical capabilities, shortens the therapeutic time, and encourages them to do the exercise in a more positive way. However, in the literature survey, it also shows that stroke patients' rehabilitations were more valued by the technical research field than those of other kinds of patients. The urgent need of technology-aided support for breast cancer patient rehabilitation has underestimated by technical research field for a long time compare with we have done for the stroke.

From the clinical aspects of view, the treatment of post-surgery breast cancer patients was met with similar challenges like strokes, even worst. Breast cancer patient need more support for their rehabilitations to avoid possible complications, including physically disorder, attention and memory diminished due to stress, anxiety, fatigue and nausea, mitigate side effects and recover their well-beings. In fact, clinicians and therapists have already asking for immediate help in providing better and more effective treatment and rehabilitation training for breast cancer patients.

3. DESIGN CONSIDERATIONS

Our goal is to try and use interactive multimedia to help post-surgery breast cancer patients learn about their rehabilitation process. To achieve our goal, we not only extracted previous experience from our literature survey, but also gathered opinions through the many discussions with medical professionals and therapists in our team. Several main challenges were revealed after our discussions and survey, showing us few directions that we can take into consideration as our design in developing the i-m-Space project:

1). Educate patients by patients' adequacy: Learning various types of physical rehabilitation exercises is difficult for patients. The therapists could have the same problem, because different training contents should be given to different patients. However, in traditional therapies, both patients and therapists have trouble achieving this. Therefore, to provide interactive rehabilitations, suitably adapted for patients with all kinds of conditions, will be important our design considerations.

2). Persuade patients by injecting playfulness: To effectively teach the patients to do their rehabilitations correctly is just the beginning; the real challenge is to persuade them in doing it everyday for at least one year. Therefore, we try to make rehabilitation task with more playful and fun. If the exercises could be as enjoyable as modern games on Wii, then the patients might be more willing to do them everyday.

3). Relax patients by relaxation trainings: For cancer patients, especially breast cancer patients, physiological rehabilitations are not the only things that would concern the experts. Emotional depression is more important, and a subtle reason that causes the recovery of post-surgery breast cancer patients to be slow and inefficient. Depression could also possibly bring a negative effect on a patient's willingness to do rehabilitation, and resulting in them feeling additional pain. Therefore, the relaxation is important and helpful for the patients prior to the beginning of their rehabilitation exercises.

To summarize, when we design the i-m-Space system and its therapeutic sessions, we have to try and minimize the patients' depression level, bored feelings, and negative thinking, which could potentially occur during rehabilitation. In other words, we should maximize their motivation and willingness to do their personalized rehabilitation, in both body and mind, and in a habitual way too.

4. SYSTEM DESIGN

The i-m-Space system design is composed of six important components. These are: Emotional Multimedia for the patient's first impression, i-m-Server with Database for data storage and communication, i-m-Controller for the therapist to control training progress, PRE-Sessions and Biosensor for providing personal training and the i-m-Training that were all connected to the i-m-Server within local network connection. The system architecture of the i-m-Space with all of the aforementioned components is shown as the following figure:

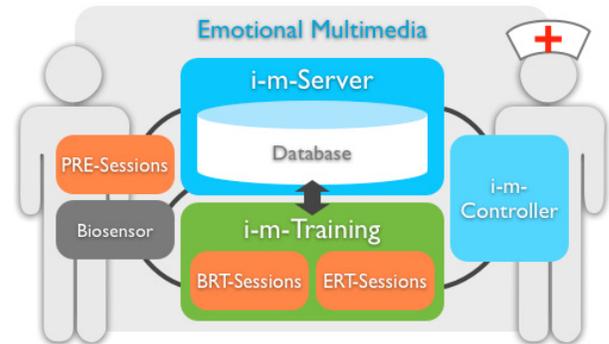


Figure 1. The i-m-Space system architecture.

The Emotional Multimedia is designed for the post-surgery patient who comes to the i-m-Space for the first time and may feel nervous and unfamiliar with the process. Therefore, we want to use computer-controlled light, music and sound, to create a friendly environment, which could help them become more relaxed. The theme of the Emotional Multimedia can be chosen by the patient in PRE-session, and the selection will be saved to the server to provide a personalized context when the same patient comes back next time. In the following, we are going to discuss more about session design in our system; including PRE-sessions and i-m-Training (two sets of session were included.)

4.1 PRE-Sessions

The PRE-Sessions include two sessions that have been made for our system. We have equipped the two sessions with specific ID names. PRE-Session-P1 provides a touch-interface questionnaire with questions for the patients about their emotional status,

including their preferences on Emotional Multimedia. The other session is P2, a small finger-wall-climbing game that tests the ability of the patients' to use their upper limbs. The conditions of patients may be different each time. Factors such as insufficient sleep or tiredness after work could affect their efficiency in doing rehabilitation. Thus, the PRE-Session is crucial in allowing for flexible adaptations to suit each patient.

4.2 Breathing-based Relaxation Training Sessions

In designing BRT-Sessions, we have decided to use a respiratory sensor attached on the abdomen region of the patient, which could make it much easier for both the patient and therapist. They will be able to get a clear view about the status of the relaxation training by visualizing the biofeedback results, thus allowing them to recognize their current relaxation level in real-time during rehabilitations.

Session B1: Instruction of Abdominal Breathing

In this session, we will ask the patient to sit on a chair, and follow the trainer in the video. The patient will also be listening to the guiding voice of the psychologist, and must gradually slow down her breathing and allow her belly to slowly move up and down, through the use of abdominal breathing. In this session, we will not apply respiratory sensor on patient body until next session.

Session B2: Interaction with Chinese painting

We use a digitized Chinese painting to visualize the air being breathed in and out of the patient's body. We will use a sensor attached on the patient's belly to receive bio-feedback, while allowing both the patient and the therapist to monitor current respiration status when practicing abdominal breathing relaxation.

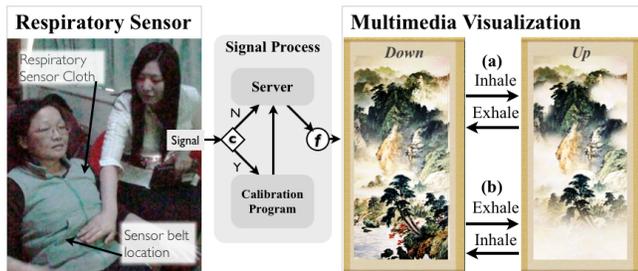


Figure 4. Respiration visualization process in Session B2.

After the signal has been received by the computer that is connected to the sensor, a signal processing program will run a check (component *c* in the middle part of Fig 4.), if there is already a collaboration data for current patient stored in server, If not, the therapist can then build new collaboration data, such as the current patient's maximum/minimum breathing volume, and save it to the server. Once the signal processing program has gotten the collaboration data, it will then use it to do signal transformation by our transformation function (component *f* in the middle part of Fig 4.), which was optimized for our multimedia visualization program, then sends out for visualization, which is, inhalation could drive the clouds into floating upward and exhalation drive them down(Fig 4a.), or in the other way of orientation mapping (Fig 4b.).

Session B3: Journey into The Skylight

At the beginning of this session, the patient will lie down comfortably on the couch, and first hear and see the virtual window (a large LCD display is embedded in the ceiling for this) sliding open vertically, the voice induction will persuade her to imagine that her body and mind have been relaxed enough to flutter out of the couch, and begin an illusive journey into the skylight, starts from bringing her into a spacious opening of treetops touching the blue sky. After flying through the misty clouds, she will enter into a starry cosmic outer-space, which will reflect her breathing in her inner-space.

With the respiration sensor attached on her clothes, the stars will move forward and backward in response to the speed and depth of her exhalation and inhalation. This mini-interactive game is to encourage the patient to relieve all the stress and depressions into the endless cosmic space. After exercising the deep slow abdominal breathing for a certain period of time, the patient will be brought through some beautiful nebula, and then taken back to the sweet home earth eventually and safely grounding back to reality.

4.3 Exercise-based Rehabilitation Training Sessions

In **ERT-Sessions** design, we try to merge interaction into multimedia, and to use its interactive-ness to attract patients. The goal is for them to actively want to commit to therapy or rehabilitation exercises. Moreover, we are using interactive feedback to represents the patients' participation, and trying to bring an additional playfulness and novel experience to them. Before ERT-Sessions begin, the therapist will help the patient in selecting loose clothes, allowing them more comfort in doing exercises.

Session E1: Bubble Coach

The Attention Bubble in this session was designed to draw attention of the patient to concentrate on the posture during rehabilitation exercise, a software mirror with a camera, which can capture the patient's current image, and directly shows both her self image and the coaching video in front of the patient. As a result, the patient can easily do a comparison of two postures, and correct her own posture to match the coach in the rehabilitation instructions. The overlaid transparent bubble on the patient's body will always move in sync with and change its size according to the coach's body. This is done to draw the patient's attention on the important area where the coach was exercising. The exercises menu will be adaptively provided to the patient, taking into account the various conditions among the different patients.

Session E2: Nemo Waving

For the postoperative patient, the lost of upper limb function, like hands squeezing and arms raising, can be significantly improved by regularly rehabilitations. Therefore, in this session, we want to encourage the patient to raise her arms and wave horizontally. We designed this exercise training as an interactive game, composed by emotional lights around the main space, which can then reenact the respiration from the patient by a wide-angle IR camera on the ceiling. The patient's posture will be detected by the camera and the light can be controlled by the user waving movement.

Session E3: Block Breaking



Figure. 8 Subject is happily playing Block Breaking arcade game.

Session E3 is an interactive rehabilitation arcade game with the goal to break targets again and again to in a native 3D view. The patient can bounce a ball to break bottles from a distance, within the rear plane of virtual space. Two special features were designed in this game. First of all, in the first round, the "auto-aiming" system is automatically on by default, to ensure every hit must cause a block to break. This will enable the patient to feel happy because there will be no chance of a miss. Secondly, a restricted area will be set in the top of the screen, to prevent the patient from hurting herself, with an identical height to the highest level checked in PRE-session P2 by finger wall-climbing (of current patient's).

5. RESULT AND DISCUSSION

Through the design and implementation processes, we have done a compacted structural documentary in this paper to present our i-m-Space. Moreover, we have everything setup in a real site and ready to run. The user study was held from February to March in 2010, running several times for a total of 18 subject experiences. All subjects including 11 experts who have an average age of 35, 7 female patients with an average age of 49; among them 6 had healed as a result of surgery, after having gone through recovery for at least two years, were asked to finish a Satisfaction Questionnaire, after taking a tour of i-m-Space with two specially recruited full-time therapists accompanying them, without project team member to avoid bias.

The semantic differential scale was used in the Satisfaction Questionnaire we provided; the overall relaxation level and satisfaction level were rated for the purpose of gaining more comprehensive knowledge on their impression of the whole procedure. A remarkably positive feedback was granted by the patients; with an average score of 4.1 in overall relaxation level, and 4.5 in overall satisfaction level, indicating that they were very satisfied. There were also other comments given by the subjects in mostly positive. They had noted the novelty, the playfulness and fun in E3 block breaking, as well as the relaxation aspect of B2 journey into skylight. However, there are few negatives given for session B2 interaction with Chinese painting. Looking at this objectively, perhaps the session could give the patients additional pressure due to the over-expectation in seeing the reward.

6. CONCLUSION

This paper presents a carefully designed environment, i-m-space, as an attractive and useful aid to prevent breast cancer patients from possible complications.

In this work, we addressed the potential ways to make therapies be attractive and persuasive, as well as playful and safe. According to the preliminary test of our system, overall high rating from all subjects shows strong support to our work, we

have also learnt several improvements can be applied from design to implementation. We are going to run a longer evaluation for the i-m-space. We believe that interactive multimedia-enhanced therapies can help breast cancer patients in their post-surgery rehabilitation, and effectively aid them in the recovery of their quality life.

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