Thera-Network: A Wearable Computing Network to Motivate Exercise in Patients Undergoing Physical Therapy

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Abstract

There is a growing field of smart medical devices for home use. The Thera-Network is designed for patients under the care of a physical therapist. A 2004 survey by the author notes that motivation and regulation are the largest deterrents for patients participating in a course of at home exercise between therapy sessions. With the Thera-Network, motivation is offered through an on-line buddy network, and regulation occurs through distant monitoring by physical therapists between sessions. This device is designed for patients recovering from various types of temporary knee pain and is currently in the prototype phase.

The goal of this technology, is to hasten the healing process through better patient-therapist communication and a networked support system. Insurance companies also stand to benefit from the system. Therapists can easily monitor their patient leading to patients that are more likely to adhere to their home-exercise program; all reducing time from injury to wellness.

1. Introduction

In a survey of individuals who have recently undergone a course of physical therapy, it was discovered that the most common need for this patient group to successfully complete their in home physical therapy, is a motivational tool. The average course of therapy requires patients to visit a therapist 2-3 times a week for an average of 2-3 months. Between office visits, patients are expected to continue with at-home exercises.

The goal of this project is to provide a device and community network to assist in motivating patients to exercise at home.

The device is designed for males and females who defined themselves as "somewhat comfortable" with technology. The design is suited to individuals with a temporary knee injury without cognitive limitations.

2. Justification

In fall, 2004, a survey was conducted to discem the area of greatest need for a device to be used by patients undergoing physical therapy. To understand therapy from alternative viewpoints, both patients and therapists were interviewed. Eleven therapists and 15 patients took part in the surveys.

An overview of respondents to *this* survey, done largely with metropolitan respondents, demonstrates that the demographic undergoing physical therapy are generally well educated (81% are college graduates) living in a major metropolitan area, with a household income of over $60,000 (75%) and non-smokers. The most common age groups to participate in physical therapy, are 35-44 and 55-65. Right-sided injuries occurred three times as often as left.

In the study which led to this project, patients undergoing physical therapy were polled on their comfort with technology. All participants have Internet access at home. Patients (ages 18-65) are at least somewhat comfortable with technology, as are the therapists (ages 23-65).

The question which elicited the most interesting answers, and which this study is focused on, inquired, "What, if anything, would help you stay on schedule with exercises between visits?" [to the therapist]. Although eight individuals had no particular answer, of those who did answer, motivations and reminders were key. Suggestions ranged from getting a personal trainer, to having better self-motivation, joining a health-club and receiving "some kind of reminder." This information is the driving force behind the current Thera-Network design.

3. Prior Work

Related work is currently underway in laboratories across the world. Tünde Kirstein of ETH, in Zurich, Switzerland is designing a system called Motion Aware Clothing in her Wearable Computing lab. Posture and motion training are addressed in this wearable system. Kirstein's ultimate goal is a comfortable garment which incorporates sensors and microprocessors to motivate and give feedback to the wearer. [1]

Timothy Bickmore and Rosalind Pickard authored a study out of Boston University and MIT assessing the usefulness of an electronic workout buddy. [2] The study questions the efficacy of a caring computer agent and whether individuals will respond to a computer that is programmed to interface in a way people associate with caring. Individuals interfaced with Laura (the computer) on their home computers for 10 minutes a day for one month. Laura offered exercise advice and motivation. Although the participants in the "caring" group were more interested in a continued relationship with the computer at the end of the study, in the short paper used as reference, no data was recorded as to whether the caring was more effective in promoting the outcome of increasing or regulating the actual amount of time spent exercising.

At the Rehabilitation Institute of Chicago, Dr. Todd Kuiken created a prototype system for post-surgical use. This device reminds users to exercise the knee throughout the day and was tested with patients still in the hospital. [3] Patients were outfitted with a device that would remind them to exercise their knee every 30 minutes. In this study, it was found that when patients were not reminded to exercise in 30 minute intervals, they were more likely to exercise their knee at various times throughout the day. One hypothesis is that with the reminder to exercise, patients would wait and only do exercises when reminded instead of doing them periodically when they had time or inclination.

With these three projects as a representing new opportunities, it is clear that work in the area of motivational devices and technology which helps us to accurately and continually (on a schedule) participate in an exercise or healing program is of interest to a diverse group of professionals across a range of fields.

4. System Design

The prototype for the wearable part of the Thera-Network is comprised of one 12V wall-mount power supply, one 5V voltage regulator, four 10K potentiometers, one op amp, one capacitor, a pre-programmed, animated, electroluminescent (EL) chip from All Electronics, and three EL strips cut to size for the product. EL strips were chosen for their flexibility (they can bend around the leg without damaging the circuit which would have been more difficult with LED's), visibility/glow, low/no profile and the fact that they do not get hot when in use. While creating this device, it was found that EL strips can be successfully sewn into product without damaging the integrity of the strip. The potentiometers are used to gauge leg angle. The joint angle is encased in a semi-rigid plastic (Hytrel by DuPont) and placed parallel to the bend in the knee. The potentiometers in the circuit are set to resist at 1V, 2V and 3.3V. These settings correspond to target angles in the patient's exercise regimen. When the desired angle is reached, a light is lit offering the user immediate feedback that he/she has reached the required flexion.

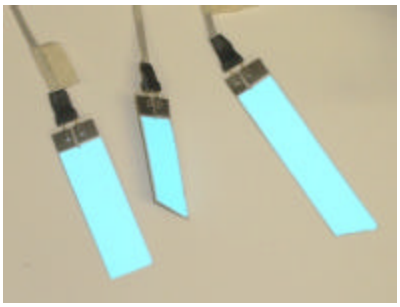

Figure 1 Electroluminescent strips

In the next phase of design, the breadboard with three potentiometers will be replaced with a coded computer interface. This interface will easily allow physical therapists to set desired angles locally or remotely. As the patient progresses the therapist may download new goal angles.

4.1. Networking/Future Work

As previously mentioned, all patients in this survey had home access to a computer and were at least "somewhat comfortable" with technology. Based on that knowledge, a computer based network is suggested for optimizing the therapeutic system.

The network for the system will be set up so that the therapist can be alerted if a patient does not send data (which assumes no exercise) for a pre-determined period of days. The therapist may also send messages of encouragement to the patient through this network.

In addition to patient monitoring, the network will offer an on-line, patient-to-patient buddy system. Many

individuals have a house full of well-intentioned exercise products: a ball, a treadmill, thera-bands and yoga mats. Much of this equipment goes unused. To encourage at home use, the device can be networked so that patients at the same clinic, or patients with similar injuries may share their progress with one another. The buddy system has been shown to encourage individuals to follow an exercise regimen. [4] The computer network can work in a variety of ways. Alert windows (similar to those used in AOL's Instant Messenger program) which fade in and out are gaining in popularity and may be ideal for this purpose. When a user logs on-line, an alert may momentarily appear from the therapist. It may remind the user to exercise or upload data if no information has been recently sent.

Alerts may also tell the patient that new settings have been created or a note if another individual has completed his/her exercises for the day. Knowing a buddy has completed his/her task may be enough motivation to prompt another patient to participate in his/her home therapy.

The network is RF based and uses a home computer to upload information. The wearable device will be able to download information to the computer when it is within 2 feet. A microcontroller houses a counter, controls the EL strips, and receives angle information from the potentiometer. In the next stage, the wireless chip will be approximately 3" and shrinks to 1" in the final product.

4.2. Device Design

Knee injuries automatically bring to mind the image of cumbersome and awkward braces. Braces are made of metal, durable plastic and/or neoprene. This device is designed for healing and to motivate the user, and is therefore designed to appear more aesthetically pleasing than the average brace-device on the market. Because of the function of the device, the final design has roots in a medical device as it requires a functional reading from the bend in the knee.

However, people are more likely to acquire and use a device to which they make an emotional attachment. [5] To move away from a medical product, this device uses more technical colors (black and silver) and opens up the knee space (avoiding the full brace stigma) by using a single sided mechanism. As a final detail, the neoprene is stitched to the Hytrel creating a quilted look, adding a softer, friendlier feel to the product.

5. Future Work

Having completed an initial prototype and received user feedback, a second, wireless prototype is underway. After post-occupancy evaluation of that solution, a third and final prototype will be created. Throughout the process, it is hoped that industry and personal feedback will drive the product towards the most user-friendly design.

Figure 2: Final knee brace design

6. Summary

A need has been defined for a motivational device or system for patients to use when participating in at-home exercises while under the care of a physical therapist. A prototype, analog, wearable device has been created to begin to address this need.

Future work will be done to make the device entirely wireless. The device will then connect to a network allowing therapists, patients and buddies to have access to one another creating a virtual healing community.

7. Acknowledgements

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8. References

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