Evaluation of Rehabilitation Robot through Contextual Interviews based on Usage Scenario

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Abstract

Owing to an increasing number of rehabilitation patients and shortage of professional therapists, various problems associated with ineffective and inadequate care have been occurring at rehabilitation sites. To address this issue, various rehabilitation robots have been developed. However, the development and use of strictly functional and technology centered rehabilitation robots has led to many usage and safety issues at rehabilitation sites (hospitals). Thus, the aim of this study was to determine possible improvements for rehabilitation robots through the opinions and suggestions of the stakeholders via contextual interviews based on usage scenarios as well as to analyze the importance of each recommended improvement through an analytic hierarchy process (AHP).

In this study, the usage scenarios of rehabilitation robots were established through the suggestions of the stakeholders (24 occupational therapists, 2 caregivers, 7 doctors, and 4 robot researchers). In addition, user observations (5 times) and contextual interviews (6 hospitals and 10 therapists had participated) were carried out considering the established usage scenario. The major improvements identified through the interviews and observations were determined on the basis of following category: “support and aid tool for the prevention of compensation actions and range of motion are needed.”

It is expected that rehabilitation robot can be made safe and user friendly by incorporating the improvements suggested in this study.

Keywords: Usability evaluation, Hand rehabilitation robot, Contextual interview, Usage scenario, AHP (Analytic Hierarchy Process)

Introduction

Paralysis of the hand after stroke onset is a concerning disability that leads to serious difficulties for patients in everyday life and activities. Thus, treatment to restore the motor function of the hand and therefore the rehabilitation of patients are important subjects of interest [1]. Recovery rate of the patient’s motor function tends to appear in proportion to the intensity and frequency of the training carried out according to the rehabilitation stage of the patients [2]. Therefore, interest in rehabilitation robots that can provide accurate and consistent training [3] as well as training independent of a therapist [4] is increasing. In addition, there has been a considerable increase in the various rehabilitation treatment methods as well as the development of rehabilitation robots in the last 20 years [5]. However, most of rehabilitation robots are developed considering only clinical effectiveness or technical aspects. Robot development that focus on the therapist, and in particular, the patient, who is the actual user of the robot, are not being properly conducted. Thus, owing to a technical development process that does not focus on the usability aspects of the rehabilitation robot in practice and the lack of consideration for the distinct characteristics of clinic environment and mutual relations between stakeholders in the design process, there happened problems of satisfaction when using rehabilitation robots. And sometimes a number of negligence based accidents occur [6]. A design and technical development process that focusses on the opinions of the stakeholders of such medical devices is a recommended approach referenced in previous studies; effective techniques and products focused on the user and the usage environment have been developed through similar investigative and research methods [7].

To facilitate the development of an effective hand rehabilitation robot that focuses on the end user in a clinical site, this research aimed to identify major problems to be improved and find out the most important ones among them. Interviews with direct stakeholders of the hand rehabilitation robot such as occupational therapists in clinical sites, robot developers, Several improvement points were obtained from analysis of robot usage scenario and thereafter we analyzed the significance of the points by using analytic hierarchy process (AHP) method.
Method

A: 3 Major Motions

- Pronation-Supination of Wrist
- Flexion-Extension of Wrist
- Extension-Abduction of Finger

B: Report of result

Figure 1. Use scene and major training motions of hand rehabilitation robot (A: 3 major motions, B: report of result), Neofact, Korea [8].

Stakeholders’ Survey: In this research, the opinions of the developers of the rehabilitation robot were investigated and the conditions of the actual usage environment in clinical settings were analyzed. Based on this, directly related primary stakeholders [9] were selected for a survey analysis to assist in developing a rehabilitation robot focused on the end user. Interviews and observations were implemented with the stakeholders. Four types of primary stakeholders of the hand rehabilitation robot were selected: therapists in the treatment rooms, medical doctors who decide the treatment method for the patient, the rehabilitation robot developers, and the patients who receive the treatment. For patients, interviews were difficult in many cases owing to cognitive deterioration caused by stroke after effects. Thus, opinions and requirements of patients were gathered through observation and mediators’ user experiences. Through the stakeholders’ interviews, observations, and experiences, usage scenarios based on the rehabilitation robot’s main touch points were identified.

Interview contents

- Method, Procedure, Menu configuration, User interface, Error rate
- 3 Major motions, Sensors feedback
- Interests, Effectiveness, Difficulty
- Understanding, Reliability, Score

Figure 2. Contextual interview and interview’s contents on the touch points of use scenario

Hand Rehabilitation Robot: The purpose of the robot used in this research is rehabilitation treatment of the hand of a patient suffering from a disease of the central nervous system. The glove-form device is placed on the affected hand and through a game content that draws the patient’s interest and directs his/her required training motion. The patient performs the following exercises: pronation-supination of forearm, flexion-extension of wrist and flexion-extension of finger. By repetitive training in the three main exercises, the rehabilitation robot aids in ROM: Range of Motion enhancement and muscle strength improvement. (Figure 1(A)). In the process of performing the game, the angular movements of the joints are analyzed to evaluate the accomplishments of the training (AROM (Active)/PROM (Passive)). (Figure 1 (B)).

Interviews were conducted with the following stakeholders of the hand rehabilitation robot: occupational therapists (24), rehabilitation robot developers (2), and rehabilitation medical specialists (7); observation for two patients was also conducted.

Usage Scenario and Contextual Interview: In this research, touch point [10] based scenarios [11] were identified based on the interviews and observations of the stakeholders. Contextual interviews [12] were conducted on patients receiving treatment for each touch point at five treatment rooms in the rehabilitation medical centers of five general hospitals. At the same time, observations of the patients’ treatments were also conducted (Figure 2).
importance of the improvements was derived as percentages.

Six items were selected from among the main improvements for the hand rehabilitation robot identified through the contextual interviews mentioned above as the evaluation items of the AHP surveys. In order to secure the reliability of the importance of the improvements for the hand rehabilitation robot, the AHP survey was implemented on five specialists, each with more than 10 years of experience (rehabilitation robot specialist, consumer investigation specialist, rehabilitation treatment specialist, usability engineering specialist, and medical equipment developer).

### Results

**Composition of Usage Scenario:** The following 10 touch points were identified from the stakeholders’ survey (interviews, observations, and experience): 1. Approach, 2. Detailed explanation about the rehabilitation, 3. Wearing the glove, 4. Setting content, 5. Calibration, 6. Rehabilitation, 7. Posture, 8. Content of rehabilitation, 9. Display (monitor and visualization), 10. Reporting of result (score) (Figure 2).

**Results of Major Improvements:** The following major improvements, as listed in Table 1, were identified from the contextual interviews conducted for each touch point.

### Analysis of the Importance of Each Improvement

Major improvements identified from the contextual interview results were organized into six different evaluation items. The AHP was implemented on these items to determine each item’s comparative importance (Table 1). When the improvements are observed as per their importance ranking, “support and aid tool for the prevention of compensation actions and range of motion are needed” appeared as the most important one and its importance percentage was 24.3%. The second was “additional content and improvement of content are needed for patients at various rehabilitation levels,” with an importance percentage of 16.8%. Next was “adjustability of the glove size is needed,” with a 10.7% importance level. “Additional content and improvement of content that can induce interest and motivation from senior citizens is needed,” was at 9.4%; “training for the motor based resistance mode and assist mode,” was at 7.3%; and “table that can be adjusted for height and adjustable distance with the screen is needed,” was at 6.1% importance.

### Discussion

In this study, observation and contextual interviews related to the use of the rehabilitation robot were conducted with direct stakeholders in order to identify improvements for the robot. This method was used because the rehabilitation robot is a device that must accommodate the opinions and requirements of many different stakeholders. The robot developer must take various situations and environments into consideration when developing the robot. Specialists who influence the purchase of the device and select the patients to

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**Table 1. Result of major improvements and analysis of the importance of each improvement**

| Touch points of Use scenario | Detailed explanation about the rehabilitation | Setting content | Rehabilitation | Content of rehabilitation | Reporting of result |
|-----------------------------|-----------------------------------------------|----------------|---------------|--------------------------|---------------------|
| Approach                    |                                               |                |               |                          |                     |
| Wearing the glove           |                                               |                |               |                          |                     |
| Calibration                 |                                               |                |               |                          |                     |
| Posture                     |                                               |                |               |                          |                     |
| Display                     |                                               |                |               |                          |                     |

| Usage Problems               | Adjustable table and chair | Glove size | Wearing time is long | Support of therapist is needed | Assist mode is needed | Subjects pool is less | Boring, low concentration |
|-----------------------------|----------------------------|------------|---------------------|-----------------------------|----------------------|-------------------------|---------------------------|
| Improvements                | Adjustable distance with the screen and height of table | Adjustable size of the glove size | Training for the motor based resistance mode and assist mode | Support and aid tool for the prevention of compensation actions and range of motion are needed | Additional and improvement of content for various rehabilitation levels | Additional and improvement of content for interest and motivation |
| Importance (%)              | 8.1                         | 10.7       | 7.3                 | 24.3                        | 16.8                 | 9.4                     |
| Importance (ranking)        | 6                            | 3          | 5                   | 1**                         | 2                    | 4                       |

**Importance of Improvements:** The AHP was conducted using pairwise comparison of the 9-point Likert scale for the improvements drawn from this research. (ICR: inconsistency ratio < 0.1)[13] Through this, the importance of the improvements was derived as percentages.
receive treatment, therapists who carry out the treatment using the rehabilitation robot, and patients who receive treatment must all be taken into consideration. Aside from this, family members of the patient, caregivers, and the environment (treatment room, home, rehabilitation hospitals, general hospitals, etc.) and conditions in which the rehabilitation robot is used must all be considered together. Thus, this research aimed to reflect the opinions of the major stakeholders and the opinions voiced at the treatment site in the development of the rehabilitation robot.

The most important improvement that resulted from this research and that first improvement point was the “need a support and aid tool for the prevention of compensation actions and space availability for range of motion.” Of course, there were individual differences in the opinions of the experts regarding the main improvements according to the AHP results. However, most of the survey results (Stakeholders’ survey, Contextual interview, Observation of rehabilitation) stated it as the most important. The importance percentage of this improvement was 24.3%, which is higher than the other items. In this research, compensation [14] refers to the error where in the process of the robot performing its main rehabilitation movements (Figure 1(A)), it will recognize that a correct movement was made and move on to the next training process although the movement required by the patient was not performed owing to the structural limitations of the robot. Therapists and doctors are aware of the hand rehabilitation robot as a treatment equipment option. This means that they anticipate that there will be clinical effects from using the rehabilitation robot as a treatment device. A treatment device’s most important functional objective is implementing accurate treatment movements and providing desirable rehabilitation effects. However, this research showed that the hand rehabilitation robot cannot provide effective rehabilitation training because of the compensation actions that occurred during rehabilitation. Six hospital therapists who participated in the survey brought up compensation problem. They stated that this compensation needs to be prevented and an aid tool to induce accurate rehabilitation movements is required.

The second most important improvement was: “additional content and improvement of content is needed for patients at various rehabilitation levels” with a 16.8% importance level. This item is an improvement to expand the range of rehabilitation patients affected by stroke that can use the device. Treatment that actually occurs in general hospitals is mostly for stroke patients [15]. For stroke patients, to reach the rehabilitation level of the treatment (hand rehabilitation), it takes at least 2 weeks And it usually takes about 6 to 8 weeks for the hand to reach an active state after which the patient is able to use the robot. Currently, however, the hospitalization period in Korean general hospitals is about 2 to 4 weeks, which means that patients are unable to use the rehabilitation robot during hospitalization. In addition, both outpatients, those who are discharged from the hospital, and inpatients, those who are able to receive treatment because their rehabilitation stage are good enough, are unable to recognize the content of the rehabilitation robot used in this research. Thus, the opinion of therapists to improve on-site treatment is that instead of increasing content for the sake of arousing interest, content that takes into consideration the patients state (rehabilitation level, length) and situation (out or in patient) and allows the robot to be used for a wide range of rehabilitation levels is required. “The need for glove size adjustment” was also an important point that allows the robot to be used regardless of the patient’s hand size.

With regard to the survey method that focused on a clinical setting and user analysis for identifying improvements for the hand rehabilitation robot, specialists and consultants who participated in research mostly agreed that all of the improvements identified from this research are important points of consideration for improving the effectiveness of the hand rehabilitation robot [16]. The improvements derived from this research are expected to contribute to the enhancement of various stakeholders’ satisfaction levels and improve usage convenience. If the robot is improved with regard to clinical effectiveness, suitability, safety, and other aspects of usability, it will help to increase the effectiveness of patients’ rehabilitation treatments in clinical settings and at the same time spread the use of rehabilitation robots.

**Conclusion**

In this study, instead of using the typical research method, contextual interviews were implemented based on touch points in rehabilitation situations in order to identify the problems naturally that occurred during rehabilitation. In these methods, which interview, observation and research the convenience of usability were very effective and importance in the medical equipment field as they take into consideration the opinions of various stakeholders in general hospitals and treatment rooms; moreover, these methods are expected to be used in various fields in the future. Furthermore, the improvements were identified from this research for the engineer of rehabilitation robots, and importance levels items for improvement were compared simply as well as this research would be important as reference and guidelines for rehabilitation robots development directions through identifying users, patients, etc., and establishing a sales strategy clearly.

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