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Design of Client Interactive Interface for Exoskeleton Rehabilitation Robot

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Abstract. With the improvement of contemporary biotechnology and the rapid development of exoskeleton robot technology, the demand for exoskeleton rehabilitation robots is constantly increasing, and a large number of movements in daily life require the participation of the limbs. Therefore, it is of profound significance to study limb exoskeleton rehabilitation robots, but there are few products on the market to help customers recover more smoothly. This paper designs an interactive client framework that can help exoskeleton rehabilitation robots to better serve customers. This study mainly for the main purpose of exoskeleton rehabilitation robot, with the support of interaction design theory, through the exoskeleton rehabilitation robot and some medical customers design research and design questionnaire user needs, the analysis of exoskeleton rehabilitation robot client interface interaction, put forward a new exoskeleton rehabilitation robot interaction interface design. By establishing an interactive prediction model for design evaluation, the feasibility and necessity of the client interaction interface of the exoskeleton rehabilitation robot are verified, and the needs of users for such products are summarized. It provides a design idea for the interface interaction design of similar robot products.

Keywords: Human-computer Interaction, Interface Design, Physical Rehabilitation.

1. Introduction

In the context of an aging population, problems such as limb dysfunction are becoming increasingly prominent. Functional neurological disorders of the limbs are a common form of limb dysfunction that is usually caused by stroke, brain injury, muscle injury, spinal injury, neuropathic injury, and orthopedic disorders. In recent years, with the development of medical technology and other technologies, especially artificial intelligence technology, physical rehabilitation has gradually become an important auxiliary tool for patients' physical rehabilitation [1, 2].

At present, the customer interaction interface of exoskeleton rehabilitation robots is operable and supports the theory of interaction design. Through the design research of the exoskeleton rehabilitation robot, the design scheme of the customer interaction interface of the exoskeleton rehabilitation robot was proposed, and the operability of the customer interaction interface was verified through the design evaluation. However, there are still some problems in the field of rehabilitation robots, such as the traditional exoskeleton rehabilitation robots usually lack efficient and concise human-computer interaction methods, and cannot meet the needs of patients for personalized and autonomous rehabilitation. At the same time, many existing clients have problems such as the design of the interactive interface is too rigid and the design of the interaction logic is not clear [3].

In order to solve this problem, meet the rehabilitation needs of more patients, and improve the rehabilitation efficiency of the limb rehabilitation robot. Based on the existing client research, this paper refers to the excellent interface design in other fields on the market, combined with the basic design theory, and aims to optimize the client interface design of the human-computer interaction

system based on the exoskeleton rehabilitation robot, so as to provide the possibility for patients to obtain a more intelligent, convenient and personalized rehabilitation experience.

2. Methods

2.1. Design Research and User needs

In the process of client technology design, this paper refers to the existing medical software on the market, and puts forward the overall design concept based on the needs of this project. After that, the detailed design was carried out by analyzing the results of the questionnaire and various data.

After studying the use of popular medical software, the team members found that patients inevitably experienced negative emotions such as anxiety and anxiety during the use of software. Therefore, the client interactive interface needs reasonable graphic and color design to reduce the psychological burden of users and improve the efficiency of user recovery. In particular, this article takes into account the impact that different colors may have on users or the potential information conveyed when designing colors. For example, blue represents calmness, professionalism, and stability, while red represents warning, danger, attention. For example, the "My Doctor" interface should use blue as the main color to form a positive psychological cue to the user, while the "Emergency Call" interface should be designed to be red to help the user concentrate in an emergency.

In graphic design, the team members believe that the interface graphics should have a certain connotation and generalization, and can use common elements in the user's life as buttons or logos. For example, the icon of the arm is used to represent the upper limb rehabilitation related system, which can make the user understand the role of each function in the memory software more quickly and conveniently, and improve the efficiency of rehabilitation.

The quality of human-computer interface design is directly related to the experience of the designer, and some principles are applicable to almost all good human-computer interface design, and can generally be considered from the aspects of interactivity, information, display, data input 93 art and design, etc., to design a good human-computer interface, rational understanding is primary, followed by creativity, and is effective in analyzing and processing information. Therefore, it is necessary to keep in mind the design principles of the human-machine interface, and in the process of design, always think about whether these principles are observed, and only in this way can the human-machine interface that is loved by the user be designed, such as requirements:

1) Style consistency: in the same user interface, all menu selection, command input, data display and other functions should maintain the consistency of style. A consistent human-machine interface will give people a concise and harmonious aesthetic [4].

2) Operational confirmation: Insist on user confirmation for all actions that may cause damage, such as asking "Are you sure?", etc., and allow recovery (UNDO) for most actions, and adopt a tolerant attitude towards user errors [5].

3) timely response: the user interface should be able to make a timely response to the user's decision, improve the efficiency of dialogue, movement and thinking, reduce the number of keystrokes as much as possible, shorten the distance of mouse movement, and avoid making the user feel at a loss [6].

4) Help system: The human-computer interface should provide a context-sensitive help system, so that users can get help in a timely manner, and try to prompt commands with short verbs and verb phrases [7].

5) Interface layout: Reasonably divide and use the display screen efficiently. Only the information related to the above and the following is displayed, allowing the user to perform maintenance of the visual environment: such as zooming in and out of the image; Use windows to separate different kinds of information and display only meaningful error information, so as to avoid user annoyance caused by data that is too difficult to understand [8].

2.2. Design Menu

The main menu of the exoskeleton interface is "Emergency", "My Doctor", "Exclusive Exoskeleton", and "Health" was shown in the Figure 1.

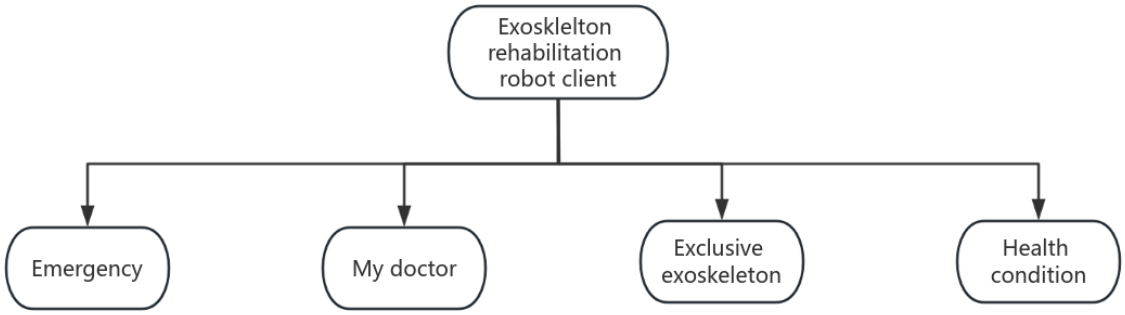

Figure 1. The main body of the interactive interface of exoskeleton rehabilitation robot (Photo credited: Original)

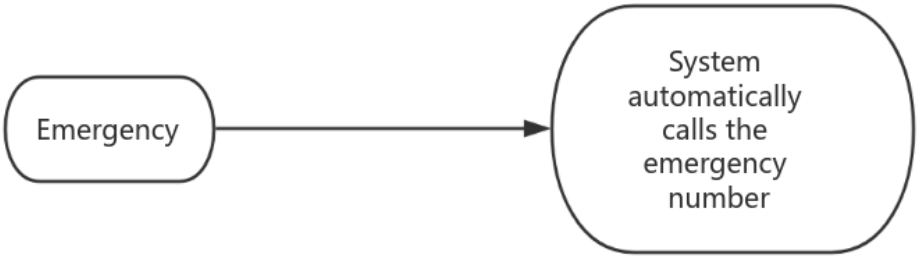

Figure 2. Emergency (Photo credited: Original)

As shown in the Figure 2, the "emergency" interface is used for customers to directly dial the emergency number to save themselves in case of emergency, such as when the exoskeleton robot fails, customers can directly contact the doctor.

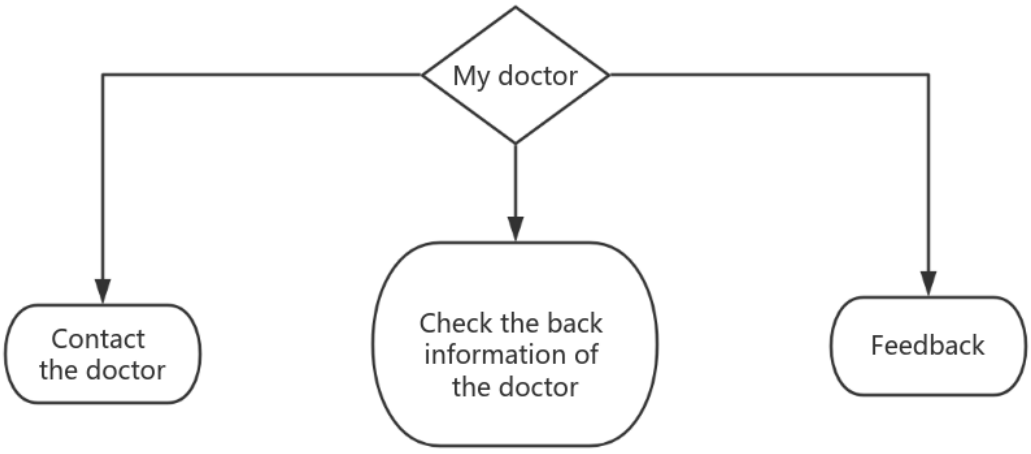

Figure 3. My doctor (Photo credited: Original)

The "My Doctor" interface is used to receive timely feedback from doctors during the recovery process (see Figure 3), making it easier for doctors to exchange information with customers.

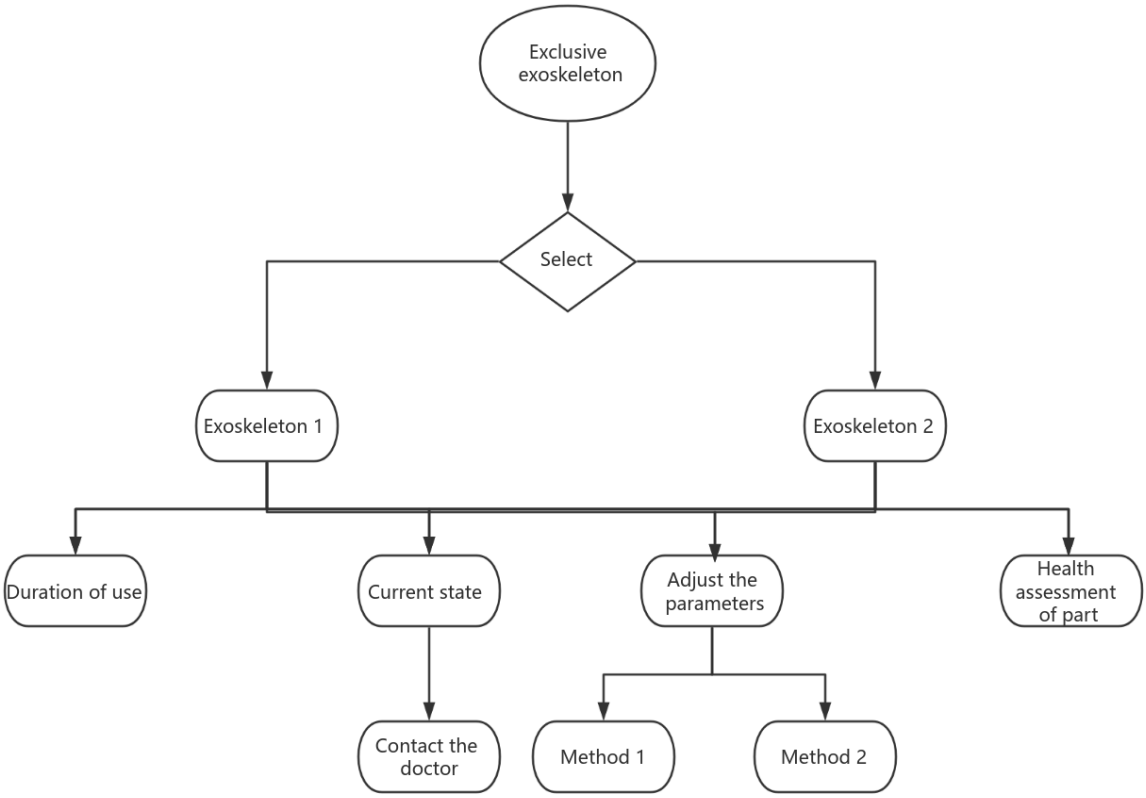

Figure 4. Exclusive exoskeleton (Photo credited: Original)

The "Exclusive Exoskeleton" interface is convenient for customers to directly understand the basic information of their exoskeleton (see Figure 4). If there are a plurality of different exoskeleton robots serving customers at the same time, the interface can also record a number of different sets of data, and customers can learn the basic use and debugging methods of exoskeleton robots in advance, and the interface also supports users to debug their own exclusive exoskeletons, such as customers who wear upper limb and lower limb exoskeleton rehabilitation robots at the same time can debug two kinds of exoskeleton robots respectively to assist their own rehabilitation training. If the user feels that the exoskeleton robot may be faulty, the interface can also provide part health assessment, so that the customer can contact the relevant technician in time if the problem is found.

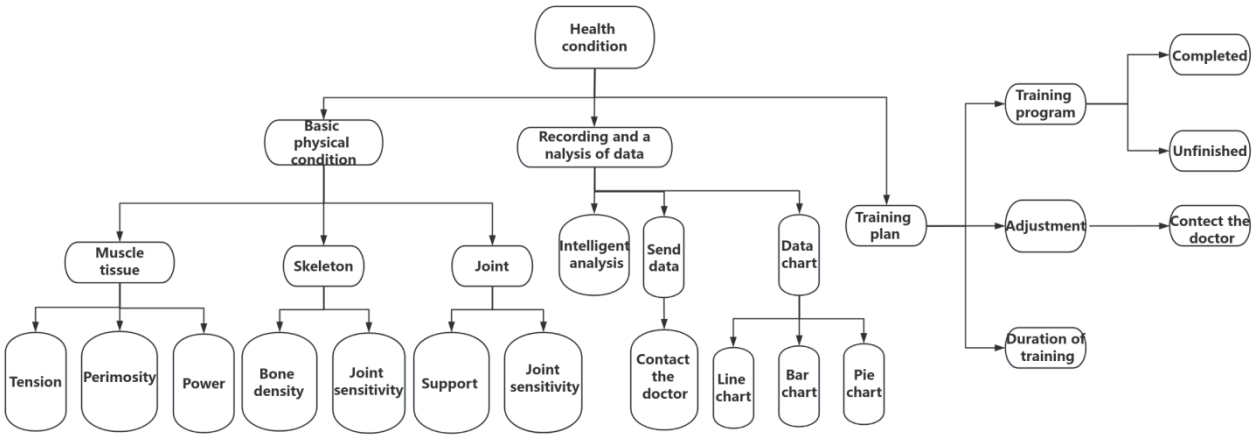

Figure 5. Health condition (Photo credited: Original)

According to the survey results, the "Health Record" interface is the most popular interface among customers (see Figure 5). Through this interface, customers can clearly understand the joints, bones, and muscle tissues related to the limbs during rehabilitation training. Moreover, the interface also

compares the rehabilitation situation at different times through three kinds of charts: line chart, bar chart and pie chart, so that customers can clearly and intuitively understand their recovery situation. These data not only reflect the physical function of the client during the rehabilitation training, but also can be sent directly to the doctor, so that the doctor can improve the next stage of the rehabilitation training plan. Users can also see the completion status and duration of their training plan, and urge themselves to complete the rehabilitation training plan in time.

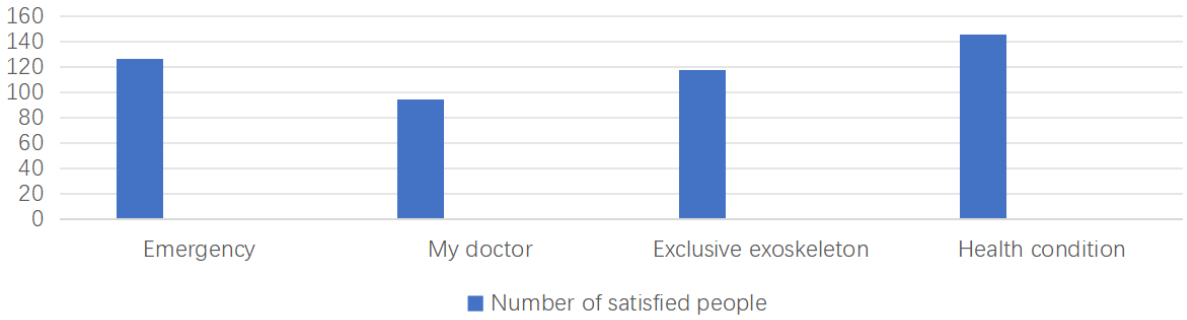

Figure 6. Number of satisfied people (Photo credited: Original)

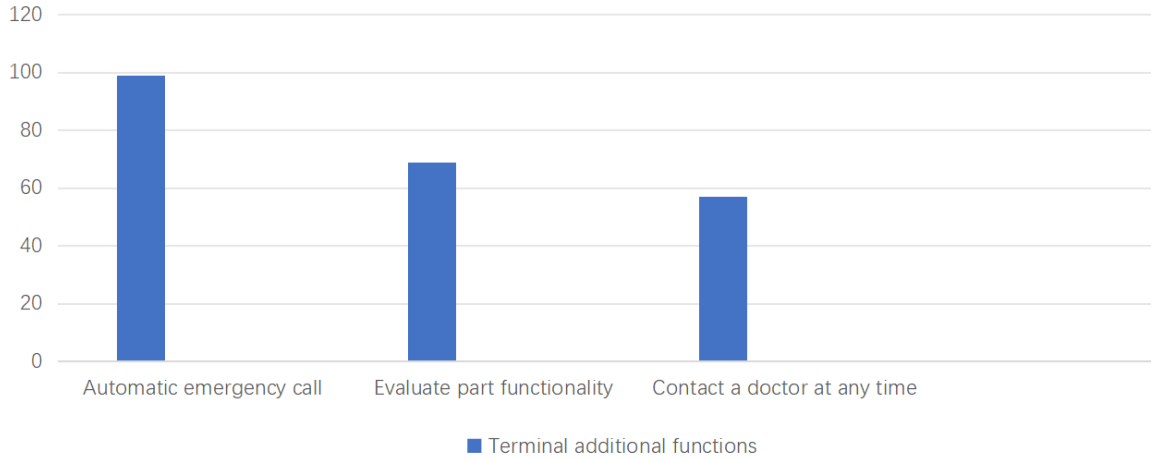

Figure 7. Terminal additional functions (Photo credited: Original)

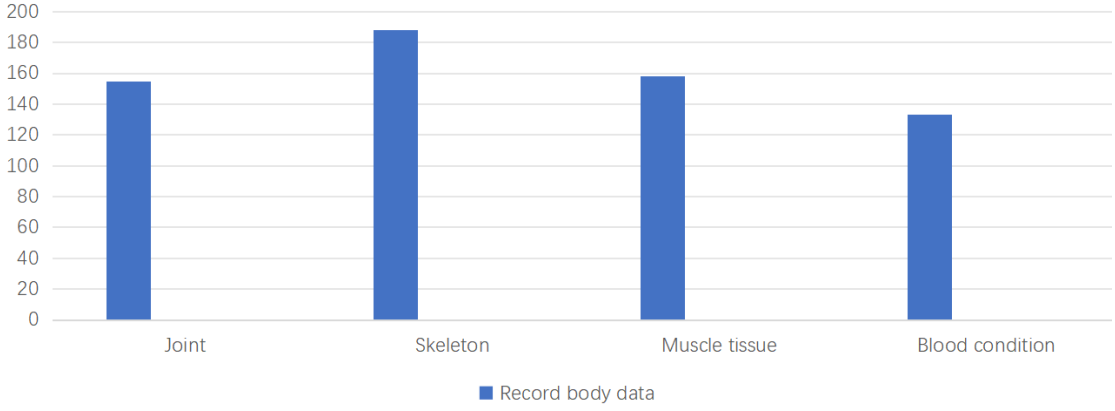

Figure 8. Record body data (Photo credited: Original)

According to the conclusion of the survey results (see Figures 6, 7 and 8), A higher proportion of women in the survey population than in men, And 51 percent had been exposed to exoskeleton products, The majority of respondents supported medical devices interacting with mobile phones, Significantly more people have used health testing clients than have not, 96% of respondents believed

that mobile phone terminals are needed when using exoskeleton medical products, Moreover, the line graphs and bar graphs are the most popular forms of data feedback, For the style of the interactive interface, Most tend to a soft and simple style, And most people prefer to receive rehabilitation training notifications through text, Most people are positive about the colors and fonts for custom interactive client interfaces, Most respondents supported medical devices interacting with mobile phones, And believes that the use of exoskeleton medical products need the assistance of mobile phone terminals. The number of people who have used health testing clients is significantly more than those who have not, which indicates that users have certain needs and cognition for health monitoring and data feedback. In the data feedback form, the line charts and bar charts are the most popular forms, which provide an important reference for the client interface data display. The majority of respondents preferred a soft and simple interactive interface style, and preferred to receive notifications of rehabilitation training through text mode.the most important aspects of the user are to be able to contact the doctor in case of emergency, to give timely feedback to the doctor, the situation of the exoskeleton used by the user, and the user's own body functions. In this paper, we will analyze the interface of the exoskeleton robot client based on these aspects.

3. Analyse the User's Behaviour

As a medical device, the exoskeleton rehabilitation training robot aims to optimize the rehabilitation process of serving patients. Through the analysis of the actual rehabilitation scene and the collection of questionnaire information, we divide the process of using the rehabilitation robot into the following aspects.

Formulation of rehabilitation training plan: The plan can be the recommended option included in the system (the equipment support provider is required to conduct professional medical analysis to formulate the rehabilitation plan that comes with the system), or it can be the rehabilitation plan formulated by the patient according to his actual situation while following the doctor's instructions.

Rehabilitation training notice: After the completion of the formulation of the plan, the application will send a notice of rehabilitation training to the patient according to the plan. Depending on the patient's condition, the patient can choose to proceed with the training, delay the training, or cancel the training session after receiving the notification. However, all unplanned situations need to be recorded by the system and fed back to the doctor to ensure the efficiency of rehabilitation training.

Rehabilitation monitoring: The application will record the data and indicators in the process of rehabilitation training of patients.

Training feedback: The system will send the data of the rehabilitation training robot to the doctor at regular intervals. Doctors can analyze the data to make a follow-up rehabilitation plan. These data may include the unplanned conditions of the rehabilitation data mentioned in (2) and the indicators in the rehabilitation training process mentioned in (3).

4. Design interactive interface

Interface appearance: The application of rehabilitation robots is mainly for patients with physical rehabilitation needs, and a milder color should be selected as the main color of the application in the interface color design. At the same time, the interface graphic design should use more rounded image interfaces to provide users with a softer interface experience

Interface interaction design: Interface interaction design involves the design and combination of more modules, which we will discuss later.

In this part, this work will make some use cases of the UI based on the process we obtained from the previous design and analysis and make a brief prediction of the use of our design based on the principles of the KLM keystroke model and Fitz's law.

Based on the KLM keystroke model and Fitz's law, we can make the following predictions about the action on a touch device

$$T = a + b * \log_2(\frac{A}{W} + 1) \quad (1)$$

The KLM model already includes the prediction of clicking, homing, mentally preparing and responding, but our app is designed based on mobile touch devices, and we also need to predict sliding, which does not exist in the KLM model proposed for PC.

Zhao Xin, Chen Kaixiang al. optimized this model for mobile touch devices [7].

$$T = 0.093 + 0.6657ID\,(R^2 = 0.776) \quad (2)$$

where $ID = log_2(\frac{A}{W} + 1)$

Table 1 showed the operation time of sliding unit, and average operation time of Sliding operation unit is $T = 1500ms$.

Table 1. Operation time of Sliding operation unit

Action	Time consumed
Clicking（C）	200ms
Sliding(S)	1500ms
Homing(H)	400ms
Mentally preparing(M)	1350ms
Responding(R)	100ms

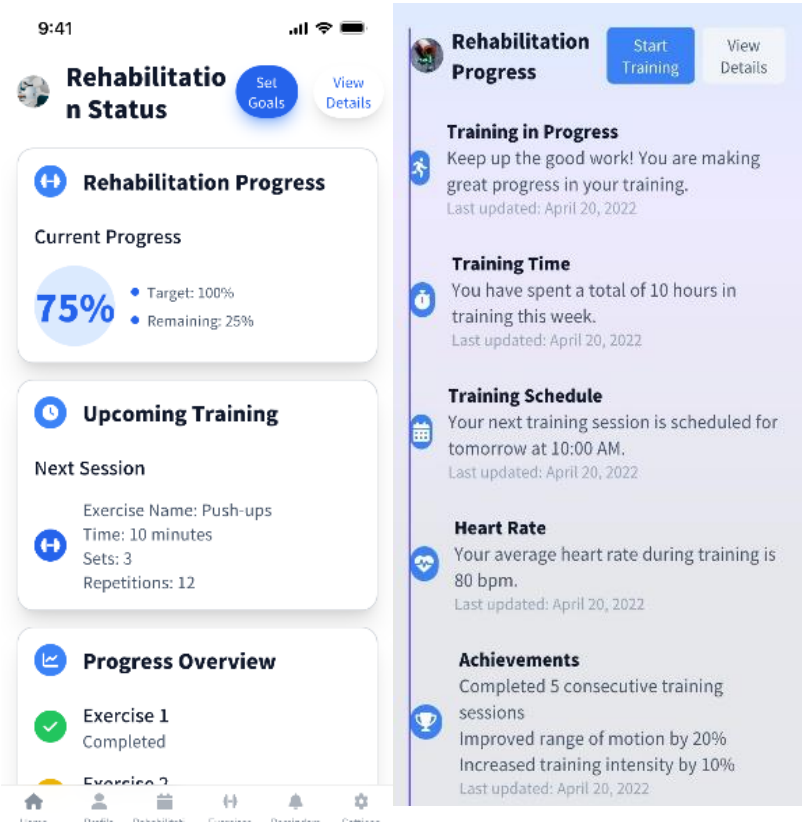

Figure 9. Rehabilitation status and process (Photo credited: Original)

Based on the approximate time required for these actions, combined with our design, this work will predict the time it will take for the software to perform various major operations. Figure 9 showed the **r**ehabilitation status and process.

Example: Create a autonomous plan: Open the app(CR)—Prepare to operate(M)—Click and enter the training plan interface(CHR)—Select to make a training plan(MCR)—Mentally preparing for a plan(M)—Enter Training Plan(22s) *—Save Training Plan and Exit (MHR)

*The training plan that is entered includes information such as the start and end time and date of the training, and is estimated to be 22s after the test.It takes about 28.8 seconds to calculate this action. Table 2 showed the estimated time for the main operations.

Table 2. Estimated time for the main operations

Action	Time consumed
Create a autonomous plan	28800ms
Use your doctor's plan	18200ms
Execute the training plan	12600ms
Emergency contact	600ms
View training feedback	14400ms
Check the mechanical condition	8800ms

5. Conclusion

Our project focuses on researching the client interface design of exoskeleton rehabilitation robots, aiming to enhance user experience and rehabilitation effectiveness. Through in-depth research on the background and significance of exoskeleton rehabilitation robot technology, this paper focuses on its interdisciplinary applications in rehabilitation engineering, biomedical engineering, and robotics. By optimizing the client interface design, we aim to distribute survey questionnaires to the elderly population and patients with mobility difficulties as the main target group, and understand user needs through survey results, in order to improve user experience, enhance rehabilitation efficacy, promote clinical applications, and provide patients with more personalized and effective rehabilitation plans. Throughout the design process, key considerations include color design, Icon design with common things in life as the theme, user friendliness, functionality, and safety to develop an interface that not only meets user needs but is also aesthetically pleasing and user-friendly. Our ultimate goal is to create a customer interface that not only meets functional requirements but also enhances the overall rehabilitation experience. Our ultimate goal is to create a customer interface that not only meets functional requirements, but also provides personalized modifications based on the user's own ideas, enhancing the overall rehabilitation experience and ultimately helping to improve rehabilitation outcomes and nursing quality.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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