Design Innovation Driven by Artificial Intelligence——AI Multifunctional Wheelchair Design Based on the Needs of Patients with ALS

Rong Liyao
Communication University of China, China
cucrly@cuc.edu.cn

Abstract. With the maturity of artificial intelligence technology, the integration of artificial intelligence and the medical and health fields has become more and more closely. The improvement of technology has played an important role in the development of the medical and health industry and has provided more possibilities for the treatment and rehabilitation of rare diseases. In mechanical design, integrated and innovative design methods can better discover the needs of patients, better reflect the advantages of technology and solve practical problems. Under the guidance of design thinking and inclusive design, this article will study the life needs of patients with amyotrophic lateral sclerosis (ALS) and the nursing needs of nursing staff, and integrate artificial intelligence technology to propose innovative solutions to users. Solution-Design an AI multifunctional wheelchair dedicated to ALS patients to provide intelligent methods and paths for the rehabilitation and care of ALS patients.

1. Introduction
ALS generally refers to amyotrophic lateral sclerosis. The early symptoms of the disease are mild, such as weakness, muscle jumping, and easy fatigue. It gradually progresses to general muscle atrophy and dysphagia, and finally respiratory failure. At present, there is still no cure for ALS. The patient will gradually lose language, movement, digestion and even breathing after being conscious. After ALS patients begin to shrink their muscles, they need to use wheelchairs and other tools to assist in their mobility and life.

In the summer of 2014, the "Ice Bucket Challenge" charity event was launched to let the public know about the ALS group. In January 2017, a female doctor of Peking University died of ALS, and she made a will before her death: donating her body for medical research. The deeds that made it possible to break the ALS as quickly as possible have once again aroused public attention to the plight of the ALS group. In the current era of increasing technology and productivity, how to facilitate the lives of patients with ALS through modern technology has become a problem worthy of discussion and research. AI multifunctional wheelchair products will take patients with ALS as the research object, from the perspective of human care, deeply explore the needs of patients with ALS, and design with artificial intelligence related technologies, and are committed to bringing good news to patients with ALS.
2. ALS patient research

2.1. Basic information

ALS is caused by motor nerve disorders. The non-renewable nerve cells responsible for muscle movement in the patient's body die. Irreversible muscle atrophy caused by more than 50% of the damage. The patient will gradually be in a normal mind and clear consciousness. He could not move his limbs until he died.

For patients suffering from ALS, they will face both physical and mental torture. The cruel condition may cause ALS patients to face psychological anxiety while their physical condition deteriorates. Patients who have lost language and motor functions will also face the disruption of social networks, unable to confide their emotions to others, and can only resolve and digest themselves.

Patients with ALS syndrome gradually lose their control over the body-from a healthy person experiencing loss of self-care ability to move, work, and life, the sense of control over the body gradually weakens until it disappears. Therefore, the vast majority of patients have experienced or are going through a stage where life is meaningless, and some have even experienced suicidal tendencies.

In China, the incidence of ALS remains high. The Department of Neurology of Peking University Third Hospital announced that the average annual incidence of ALS from 2010 to 2015 was 2.708 persons per 100,000 persons, and the overall incidence rate was from 2 persons per 100,000 persons. The population increased to 4 people per 100,000, and the main age of onset was concentrated between 30-65 years old. [1]

It can be seen that the design of auxiliary products for patients with ALS syndrome not only needs to take into account the life needs of the patients and help patients to make up for the lack of physical function, but also should focus on the psychological needs of the patients and give the patients spiritual comfort and care. In addition, although the number of patients with ALS is less than that of cancer and other diseases, the increasing incidence rate shows that the market has an urgent demand for auxiliary products for ALS.

2.2. Demand research

2.2.1. Patient needs. Patients with ALS usually face the following problems: difficulty in movement, difficulty in language expression, and difficulty in expressing emotions.

The early symptoms of ALS patients are weakness, leap, and fatigue. At this stage, the limbs and face of ALS patients can still be controlled autonomously. At this time, patients with ALS have low requirements for the fineness of care and hope that they can take care of themselves through certain auxiliary tools and establish their self-esteem.

As the patient's condition deteriorates, the language expression function of patients with ALS disease gradually deteriorates, and the deterioration of language expression function will cause the communication between the patient and the nursing staff to become obstacles, and at the same time gradually lose the social ability. At this time, patients with ALS have higher requirements for the fineness of care, and there is an increased demand for communication with nursing staff through auxiliary tools. After the deterioration of social skills, patients' needs for psychological care have gradually increased [1].

In terms of emotional expression, as the condition worsens, the patient's psychological and emotional conditions will also deteriorate. Nursing staff need to pay close attention to the patient's condition, so as to reassure the patient in time, and help the patient establish a belief in life. Patients who have lost muscle control may have difficulty expressing and transmitting emotions, so there is a certain demand for tools to help patients express emotions.

2.2.2. Nursing staff needs. Nursing staff of patients with ALS are usually family members or nanny or nurses. This group has not received systematic and professional knowledge about ALS patient care. The high-intensity and professional nursing needs make the caregivers bear huge physical and mental
The pressure. Designing a rehabilitation appliance that can assist patients with ALS syndrome walking can effectively reduce the burden on nursing staff. At the same time, nurses also have a clear need for knowledge about ALS, and they need to receive popular science on knowledge about ALS [2].

3. Analysis of artificial intelligence technology
In the current era of increasing technology and productivity, how to facilitate the lives of patients with ALS through modern technology has become a problem worthy of discussion and research. Although related products have been integrated with artificial intelligence in the rehabilitation field, there are still fewer products developed for the special needs of the gradual cold syndrome group.

This product has selected "brain-computer interface technology", "gesture recognition technology" and other technologies for design.

3.1. Brain-computer interface technology
The research of brain-computer interface technology is the frontier field of artificial intelligence technology. The equipment is divided into two types: invasive and non-invasive. The original intention of the birth of brain-computer interface technology is to provide patients with diseases that interact with the outside world and lose control of the machine. Ability to use alternative operation methods and interactive paths to help patients with neurological rehabilitation, such as patients with ALS disease, bone marrow injury patients, cerebral palsy patients and lock-in syndrome patients.

When a person is stimulated by the outside or engaged in some kind of conscious activity, the brain will produce weak neuroelectric signals and transmit them to the cerebral cortex, thereby producing rhythmic or spatially distributed characteristics. Collecting and combining human brain electrical signals through specific methods and performing feature recognition and feature recognition, and finally encoding human consciousness activities into control instructions through a computer can achieve the purpose of controlling external equipment or feeding the results back to the user [3].

3.2. Gesture recognition technology
Gesture recognition technology is a topic in artificial intelligence and machine learning, and its purpose is to recognize human gestures through mathematical algorithms. The focus in the field of gesture recognition includes facial expression recognition and gesture recognition. Humans can use simple gestures to control or interact with devices, thus building a bridge between machines and humans that is richer than the original user interface interaction.

Regardless of whether the gesture is static or dynamic, its recognition requires image acquisition, hand detection and segmented gesture analysis, and then static or dynamic gesture recognition. Gesture analysis is one of the key technologies to complete the gesture recognition system. Through gesture analysis, the shape feature or motion trajectory of the gesture can be obtained. The shape and trajectory of gestures are important features in dynamic gesture recognition and are directly related to the meaning of gestures.

4. Solution
Based on the physical and mental needs of patients with ALS, the proposed solution is to design an AI multifunctional wheelchair and wheelchair control system that incorporates artificial intelligence technologies such as brain-computer interface technology and gesture recognition technology to assist patients with ALS to take care of themselves. Language expression and emotional comfort.

The wheelchair is equipped with hardware devices such as cameras, controllers, brain-computer interfaces, vital signs detection sensors (as shown in Figure 1), including gesture recognition, automatic driving, intelligent obstacle avoidance, brain-computer interface emotion detection and other modules. The wheelchair control system is controlled by the patient Nursing staff can control the function of the wheelchair. The nursing staff can set the wheelchair function on the wheelchair system control page and understand the emotional state of the patient through the system and realize the communication with the patient. [4]
Figure 1. AI multifunctional wheelchair concept design

During use, patients with ALS can control the movement of the wheelchair through the gesture recognition module to make up for the lack of physical mobility. Nursing staff can control the autonomous movement of the wheelchair through the wheelchair system control page, and the automatic driving module will track the wheelchair status and give feedback for nursing staff, the intelligent obstacle avoidance module protects the wheelchair moving process and improves the safety of the wheelchair [5]. The vital sign detection sensor will detect the patient’s vital sign status, and the brain-computer interface emotion detection will detect the patient’s emotional state. The above detection results will be fed back to the wheelchair control system. The nursing staff can understand the patient’s vital sign status in the wheelchair control system. Patient emotions.

5. Product design

5.1. Design introduction
Design 1: AI multifunctional wheelchair
- Product attributes: smart medical equipment
Design 2: Wheelchair Control APP
- Product attribute: mobile terminal control system

Product concept:
This design includes a multifunctional AI wheelchair and wheelchair control system developed from the perspective of inclusive design and integrated artificial intelligence related technologies based on the needs of patients with gradual frost syndrome, which is used to solve the needs of actions and emotional expression of patients with ALS syndrome, and Auxiliary nursing staff provide intelligent care for patients with ALS.

5.2. Function introduction
Patient's gesture control wheelchair. With the help of the nursing staff, the patient can input and set the gestures for controlling the movement of the wheelchair through the APP. For example, the patient can choose to raise the thumb to represent the wheelchair to move forward, and to raise the index finger to represent the wheelchair to stop. After the setting is completed, patients and nursing staff can choose the installation position of the camera for image capture of gestures. After the installation is completed, gestures can be implemented to control the movement of the wheelchair. [6]

5.2.1. Remote control wheelchair automatic driving. The wheelchair has a GPS positioning system. The nursing staff can view the location of the wheelchair in the APP and can also remotely control the
wheelchair through the APP, or set the wheelchair driving destination to realize the remote control of the wheelchair and automatic driving.

5.2.2. Patient vital signs detection, emotion detection. The AI wheelchair is equipped with a head-mounted wearable device (non-invasive brain-computer interface, vital sign detection sensor), and the device will detect the patient's vital signs and brain state.

In the information collection stage, the electrical signal on the scalp surface is obtained by the electrode sheet and amplified to achieve real-time detection. In the artificial intelligence recognition and processing stage, the device inputs the patient's brain electricity and vibration signals into the comparison library and model library for processing and learning.

In the information presentation stage, the cartoon facial expressions of the patient's emotional state, the patient's emotional data, and the patient's vital signs data will be displayed in the APP, and the nursing staff can understand the patient's vital sign state and emotional state through the APP. The APP will notify the nursing staff when the patient's vital signs are abnormal or the mood fluctuates greatly. [7]

5.3. Technical realization

5.3.1. Gesture recognition module (as shown in Figure 2).

Figure 2. Technical realization of gesture recognition module
5.3.2. Emotion detection module (as shown in Figure 3).

![Emotion detection module diagram]

Figure 3. Technical realization of emotion detection module

6. Design thinking
In the era of interdisciplinary integration and innovation, the research of science and technology and the transformation of results are inseparable. At present, there are a large number of scientific research results and design innovations in the medical and health field, but the information between scientific research results is independent, and there are certain difficulties in putting it into practice. It is more necessary to participate in inclusive design thinking based on human care to help scientific research results be transformed into benefiting mankind Medical health equipment [8]. The involvement of the design discipline can better extend the artificial intelligence platform and promote the further development of technical prototypes and the landing in the form of products. At the same time, inclusive design pays more attention to the real needs of users, and products researched with user needs as the design starting point will be more practical and easy to use, reflecting the human care of technical products in various fields, especially in the field of medical and health.

7. Conclusion
With the development of modern technology, scientific and technological research and design transformation are inseparable. Today, when human care is getting more and more attention, designers should also focus on people with special needs such as patients with ALS. This design hopes that through the integrated application and design of artificial intelligence technology, it can effectively solve the needs of patients with ALS for life and action. At the same time, it also hopes that the emotional detection design of human care will help patients with ALS overcome the disease psychologically.
Reflect the scientific temperature.

At the same time, we also look forward to the emergence of more scientific and technological products designed based on the physical and mental needs of patients in the future development of medical and health, so as to provide better methods and approaches for solving patients’ pain and promoting disease treatment.

Reference

[1] Zhang Peiyuan. *Research on the needs of patients with ALS from the perspective of social support.*

[2] Wang Lili, Liu Li, Liu Shumei, et al. *Research on the correlation between social support and self-efficacy of patients with chronic diseases in the community.* Chinese Nursing Management, 2011(8): 34-40.

[3] Wolpaw JR. *Brain-computer interface as new brain output path.* The Journal of Physiology, 2007, 579(3): 613-619.

[4] Bai Feifei, Lu Li, Cao Xiaohong. *The design of multi-sensor smart wheelchair.* Computer Products and Circulation, 2019(05): 119.

[5] Li Jiadong, Zou Cunzhi, Sun Yuanao, et al. *Multifunctional service smart wheelchair for the elderly.* Science and Technology Innovation, 2020(16): 15-16.

[6] Pan Lu. *Research on Intelligent Wheelchair Design Based on Human-Computer Interaction.* (Doctoral dissertation).

[7] The editorial department of this journal. *Smart hospitals can be expected in the future. When traditional methods and digital models meet, subvert or rebirth?* Smart buildings and smart cities, 2020(9).

[8] Clarkson J. Cleman. *Inclusive design: design the whole population.* Vienna: Springer, 2003.