

Research on the Application of Artificial Intelligence in Simple Mechanical and Human-Computer Interaction Devices

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Abstract. This paper discusses the application of artificial intelligence (AI) in simple machines and human-computer interaction devices and its revolutionary impact. By combining AI technology with basic mechanical systems such as levers and pulleys, modern interactive devices have achieved automated control, precise feedback, and adaptive optimization, significantly improving user experience and operating efficiency. The study analyzes AI application cases in rehabilitation training equipment, smart homes, games, and sports assistance. For example, intelligent rehabilitation robots provide patients with personalized treatment plans through real-time monitoring and dynamic adjustment of training intensity; smart door locks and curtain systems use AI algorithms to achieve safe and energy-saving automated control. In addition, the application of AI in barrier-free facilities and medical assistance equipment further reflects its social value. In the future, with the development of technologies such as emotion recognition and brain-computer interface, AI will promote the evolution of human-computer interaction in a more natural and intuitive direction. This paper summarizes the potential of AI in improving the intelligence, personalization, and universality of equipment, and looks forward to its broad prospects in smart cities, telemedicine, and other fields.

Keywords: Artificial intelligence; simple machines; human-computer interaction; intelligent rehabilitation.

1. Introduction

With the rapid advancement of science and technology, artificial intelligence has become increasingly integrated into various fields, particularly in human-computer interaction (HCI) and simple machinery. However, these areas have historically faced challenges such as limited intuitiveness, high learning curves, and inefficiencies in operation. Traditional HCI relied heavily on input devices like keyboards and mice, which, while effective, required users to adapt to the machine's logic rather than the other way around. Similarly, simple machinery often demanded significant human intervention, leading to operational inefficiencies and higher risks of errors or breakdowns.

In the early stages of human-computer interaction, users mainly interacted with computers through keyboards and mice. Although effective, this method has a certain learning threshold and operation complexity. With the popularization of touch screen technology, multi-touch technology has become mainstream, and users can interact with devices directly through gestures, which greatly improves the intuitiveness and convenience of the user experience. In addition, advances in sensing technology, such as motion recognition and gesture recognition, allow users to interact with devices through body movements, further expanding the application scenarios of human-computer interaction. For example, devices such as Microsoft's Kinect and Sony's PS Move sense user movements through optical and acceleration sensors, achieving a more natural way of interaction.

In the field of simple machinery, the application of AI technology is also becoming more and more extensive. Through AI algorithms, simple machinery can achieve automated control and intelligent operation, reduce human intervention, and improve work efficiency. For example, AI-driven robotic arms can complete complex assembly tasks through visual recognition and motion planning. In addition, AI can also predict potential failures and perform preventive maintenance by analyzing the operating data of the machinery, thereby extending the service life of the equipment.

The synergy between AI and HCI continues to evolve, with emerging technologies like emotion recognition and brain-computer interfaces pushing the boundaries of how humans interact with

machines. These developments aim to create even more seamless and personalized experiences, where machines can anticipate user needs and adapt accordingly.

The purpose of this discussion is to explore how AI has revolutionized HCI and simple machinery, addressing historical limitations and paving the way for more intelligent, efficient, and user-friendly systems. By examining the mechanisms through which AI enhances these fields, its current applications, and future potential, we aim to highlight the transformative impact of AI on technology and everyday life. The logical progression of this analysis moves from identifying historical challenges to showcasing AI-driven solutions, and finally, envisioning future advancements in the field.

2. Fundamentals of Artificial Intelligence and Simple Mechanics in Human-Machine Interaction

2.1. Basic Principles of Human-Machine Interaction

Kinematics studies motion by analyzing how bones, muscles, and joints work together to control movement. In human-computer interaction, this knowledge helps design systems that respond naturally to gestures. Simple tools like levers, pulleys, and axles enhance physical abilities by amplifying force or changing its direction. For instance, in a system designed for lower limb rehabilitation, the thigh rod is seamlessly connected to the hip joint module through a precise internal transmission shaft, ensuring that it is fixedly connected to the block during the movement of the robot, ensuring the continuity and stability of the leg in movements such as walking and bending [1].

The mechanical feedback system detects the user's movements and changes in the environment through sensors and transmits this information to the control system. The application of sensors improves the robot's ability to perceive the external environment, enabling it to adapt to complex and changing external environments and broadening the application areas of robots [2]. By combining mechanical feedback and AI computing, human-computer interaction devices can not only respond to user actions more accurately. And make adaptive adjustments based on user habits and needs, thereby improving the overall interactive experience.

2.2. AI-Enhanced Mechanical Interaction Devices

In modern human-computer interaction devices, the combination of sensors, simple machines, and artificial intelligence is the key to achieving efficient and intelligent interaction. Artificial intelligence technology and algorithms play a vital role in mechanical design optimization. These technologies include machine learning, deep learning, neural networks, etc., which can extract useful information from large amounts of data and automatically discover patterns and associations in the data [3]. In a specific system, sensors are responsible for collecting user actions and environmental data, simple machines convert this data into physical feedback through levers, pulleys, and other devices, and AI optimizes the response and performance of the entire system through algorithms.

The intelligently controlled mechanical feedback system monitors and dynamically adjusts the system status in real time through the coordinated work of sensors, controllers, and actuators to ensure stable operation and performance optimization. This technology has the advantages of real-time, precision, adaptability, and intelligence, and is widely used in industrial automation, automobiles, aerospace, and smart home fields. For example, AI enables smart airflow control in subway ventilation. Using machine learning, the system analyzes real-time data (passenger flow, environment, equipment status) to accurately predict and adjust future airflow needs [4].

3. Applications for AI in Simple Mechanical Interaction Devices

3.1. AI-Integrated Lever and Pulley Systems in Rehabilitation Training Equipment

AI combined with levers and axles can provide accurate and efficient training support for rehabilitation patients through intelligent technology. This type of equipment has built-in high-precision sensors that can monitor the distribution of force applied by patients during training in real time, including strength, direction, and balance. AI algorithms analyze this data, identify patients' weaknesses and abnormal patterns, and provide the scientific basis for therapists. Based on patients' historical data and real-time performance, machine learning algorithms continuously optimize training programs, dynamically adjust training intensity, frequency, and action combinations to adapt to patients' rehabilitation progress. Intelligent rehabilitation training robots can significantly improve the treatment effect in rehabilitation treatment. Its personalized rehabilitation training program and intelligent adjustment function make rehabilitation treatment more targeted and precise, which can better meet patients' rehabilitation needs and accelerate the rehabilitation process. Intelligent rehabilitation training robots improve patients' treatment experience. Through intelligent interactive interfaces and personalized training programs, rehabilitation training is made more interesting and interactive, which improves patients' participation and enthusiasm and reduces discomfort and resistance during treatment [5].

This groundbreaking technology demonstrates extensive clinical applications across multiple healthcare domains. In postoperative rehabilitation, it enables precise motion tracking and adaptive resistance training to accelerate recovery while preventing secondary injuries. For neurological rehabilitation, the system's AI-driven analytics can detect subtle motor improvements in stroke or spinal cord injury patients, allowing for real-time protocol optimization. In sports medicine, it provides athletes with data-driven recovery programs that balance rehabilitation intensity with injury prevention. The elderly care sector benefits from its fall-risk assessment capabilities and gentle progressive training modules tailored to age-related mobility decline.

This technological evolution will ultimately create seamless, patient-centric rehabilitation ecosystems that bridge hospital-to-home care transitions while delivering unprecedented recovery outcomes through precision medicine approaches. The integration of 5G connectivity and digital twin technology may further enable real-time virtual supervision by therapists, making high-quality rehabilitation accessible to broader populations.

3.2. AI and Simple Mechanics in Smart Home Applications

The combination of AI and simple machinery has brought greater convenience, safety, and energy efficiency to smart homes, significantly improving the quality of modern life. In the field of smart door locks, AI technology is combined with the optimized design of the lever system to achieve efficient door lock control and security protection. Among them, there is a smart door lock system based on LiteOS, which has strong IoT and intelligent functions, meeting the user's convenience needs for smart door locks, including: indoor key unlocking, radio frequency card management, radio frequency card unlocking, password unlocking, WeChat applet remote unlocking, real-time monitoring of door lock status, abnormal alarm, anti-criminal hostage, temperature and humidity display, and intelligent linkage between door locks and indoor lights/air conditioners/humidifiers based on artificial intelligence algorithms[6]. In addition, the optimization of the lever structure makes the door lock operation lighter and more durable, while reducing energy consumption. In terms of curtain control, the pulley mechanism is combined with sensor detection technology, single-chip control technology, and Bluetooth communication technology to design a control system that can automatically control the opening and closing of curtains according to the current ambient temperature, humidity, and light intensity [7]. Through the combination of AI and simple machinery, smart home devices not only achieve automated control. Smart homes improve energy efficiency and user experience, bringing more convenience and comfort to modern life.

3.3. AI Combined with Simple Mechanics in Gaming and Sports Assistance

The combination of artificial intelligence and simple machinery is bringing revolutionary innovation to game interaction and sports assistance. Through classic mechanical structures such as pulleys and levers, AI can achieve dynamic resistance adjustment, real-time motion analysis, and personalized feedback, thereby enhancing the user's immersion and training effect.

In the field of games, the AI + pulley system can create a more realistic force feedback handle. For example, the pulley group controlled by the motor simulates the resistance of actions such as bow pulling and climbing. AI dynamically adjusts the strength according to the game scene and even combines biosensors to detect the player's fatigue state and automatically optimize the operation experience. This technology can enhance the physical interaction of the game. Technology adapts to the operating habits of different players through machine learning, so that both novices and experts can get a smooth challenge experience.

In the field of fitness, the AI+ lever system can optimize training equipment and make it smarter. Computer vision technology breaks the limitations of time and space, allowing people to do sports anytime and anywhere; smart wearable devices can not only help people monitor the scientific and rationality of sports, but also check their physical health; big data technology can provide targeted and personalized fitness guidance, dietary advice and a full range of exercise plans based on personal fitness habits[8]. For example, a smart barbell or rowing machine can correct the user's posture errors in real time through torque sensors and motion capture technology and provide voice or AR visual feedback. AI can also automatically adjust the weight according to the user's strength level or dynamically reduce the load when exhausted, to ensure that the training is both efficient and safe. Combined with the user's historical data, AI can even generate personalized training plans to make each exercise more scientific.

Of course, this type of technology also faces challenges, such as how to ensure the safety of physical systems and how to find a balance between automated assistance and user autonomy. But with the advancement of technologies such as edge computing and multimodal sensing, the combination of AI and simple machinery will surely drive the gaming and fitness fields towards a smarter future.

4. Case Studies of Real-World Applications

4.1. AI in Smart Medical Assistance Devices

Artificial intelligence is bringing revolutionary breakthroughs to medical assistive devices, especially in the fields of prosthetics and rehabilitation. By combining mechanical structures such as levers and pulleys, AI makes these devices smarter, more precise, and personalized. In terms of intelligent prostheses, AI can automatically adjust the position and strength of the lever fulcrum by analyzing the user's electromyographic signals and motion data, making the gait more natural and smoother. This prosthesis can also learn the user's movement habits, whether it is going up and down stairs or running, it can provide just the right support, greatly improving the wearing comfort and user experience.

In the field of rehabilitation therapy, the combination of AI and pulley systems has brought patients a new way of training. Physical therapy equipment can automatically adjust the training resistance according to the patient's real-time status to ensure that the rehabilitation process is both safe and efficient. With the cooperation of virtual reality technology, boring rehabilitation training has become an interesting interactive experience. Patients can complete movements such as grasping and stretching in a gamified environment, which significantly improves treatment compliance. AI will also continue to analyze the patient's recovery progress, provide doctors with accurate data support, and help develop more scientific rehabilitation plans.

Although these innovative technologies have broad prospects, they still face challenges such as security, data privacy, and cost control. With the development of technologies such as flexible

electronics and brain-computer interfaces, future medical assistive devices will achieve a higher level of intelligence and may even interact directly with the user's nervous system, bringing unprecedented improvements in the quality of life for people with disabilities and rehabilitation patients.

4.2. AI in Augmented Reality and Virtual Reality Devices

Artificial intelligence is pushing the interaction mode of Augmented Reality (AR) and Virtual Reality (VR) devices to a new level, especially in combination with mechanical structures such as levers and pulleys, achieving more realistic force feedback and immersive experience. In terms of force feedback systems, AI analyzes the physical characteristics of the virtual environment and dynamically adjusts the resistance of pulleys and levers, allowing users to obtain accurate tactile feedback when grabbing, pushing, and pulling virtual objects. For example, when users draw bows and shoot arrows in VR, the AI-controlled pulley system can simulate different bowstring tensions and combine handle vibrations to create a nearly real memory training experience.

In interactive mechanical design, AI gives devices more intelligent response capabilities. Through machine learning algorithms, the system can identify the user's operating habits and automatically optimize the motion trajectory and feedback strength of the mechanical structure. For example, in power maintenance, AI can simulate the real environment and scenes on the power demand side. This includes using virtual reality equipment and software for data visualization, model display, and interactive operations. Through virtual reality technology, researchers can more intuitively observe and analyze the behavior and changing trends on the power demand side [9].

4.3. AI and Simple Mechanics in Accessibility Facilities

Artificial intelligence is also used in barrier-free facilities. By combining simple mechanical structures such as levers and pulleys, it creates a smarter and more humane living environment for people with limited mobility. In terms of wheelchair control, the AI visual recognition system can analyze user gestures, head movements, and even eye movements in real time, and cooperate with the intelligent lever transmission device to achieve precise direction and speed control. For example, when it is detected that the user wants to turn, AI will automatically adjust the torque distribution of the wheel hubs on both sides to make steering more labor-saving and smoother. The ARM Cortex-M3 main control chip enriches the interface of the smart wheelchair, uses radar and laser sensors combined with obstacle avoidance algorithms to build the wheelchair's active perception of the working environment, and builds an electronic fence to achieve active safety for the wheelchair during movement [10].

In the field of barrier-free facilities in buildings, AI has given new life to traditional automatic doors and elevators. Through deep learning algorithms, pulley-driven automatic doors can identify the approach speed and distance of wheelchair users, intelligently adjust the timing and amplitude of door opening, and avoid the risk of sudden closing. The elevator system uses AI to analyze real-time passenger flow data, optimize the operating efficiency of the pulley group, and give priority to responding to barrier-free needs. When a wheelchair is detected entering, AI will automatically extend the door holding time and adjust the height of the car to be flush with the ground.

5. Conclusion

The application of artificial intelligence in simple machinery and human-computer interaction equipment provides a revolutionary solution to the problems of low operating efficiency, high learning threshold, and single interaction mode in traditional technologies. By combining AI with basic mechanical systems such as levers, pulleys, and shafts, modern interactive devices have achieved automated control, precise feedback, and adaptive optimization, significantly improving the user experience. For example, in rehabilitation training equipment, AI dynamically adjusts the training intensity by monitoring the patient's motion data in real time to provide personalized treatment plans; in the field of smart homes, AI-driven door locks and curtain systems are combined

with mechanical structures to achieve safe, energy-saving, and convenient automated control. These applications not only improve the performance of the equipment but also reduce the need for manual intervention, making the technology more humane.

In the future, AI will have great potential for development in intelligent interactive devices. On the one hand, the maturity of technologies such as emotion recognition and brain-computer interface will promote human-computer interaction to develop in a more natural and intuitive direction, enabling devices to actively understand and respond to user needs. On the other hand, the integration of AI with emerging technologies such as 5G, digital twins, and edge computing will further improve the real-time and intelligent level of equipment and expand its application scenarios in telemedicine, smart cities, and other fields. In addition, as the cost of technology decreases and becomes more popular, AI-driven interactive devices will benefit more groups, especially the elderly and people with disabilities, and promote the intelligent upgrade of barrier-free facilities.

In general, the combination of AI and simple mechanical systems is reshaping the way of human-computer interaction, turning devices from passive response to active service. Future intelligent interactive technology will pay more attention to personalization, real-time, and universality, bringing more convenience and possibilities to human life. Continuous innovation in this field will not only promote scientific and technological progress but also have a profound impact on the sustainable development of society.

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