Research On Wearable Technologies And Human-Computer Interaction In The Context Of Augmented Reality To Promote Grid Work

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ABSTRACT

This study focuses on speech recognition, augmented reality, and human-computer interaction to improve power equipment installation, operation, and maintenance. Gestures and head movements are the primary modes of interaction, while voice commands and touch serve as secondary modes. The integration of speech recognition, augmented reality (AR), and human-computer interaction (HCI) represents a cutting-edge approach to enhancing the installation, operation, and maintenance of power equipment. By leveraging these technologies, the study aims to streamline processes and improve overall efficiency. By combining these technologies, the study aims to create a comprehensive system that empowers operators and technicians to work more effectively with power equipment. The seamless integration of speech recognition, AR, and HCI not only enhances productivity but also improves the overall user experience, ultimately leading to better outcomes in terms of installation accuracy, operational efficiency, and maintenance effectiveness.

Keywords: Augmented Reality; Grid Work; Wearable Technologies; Human-Computer Interaction.

1. INTRODUCTION

Research on wearable technologies and human-computer interaction (HCI) in the context of augmented reality (AR) to promote grid work represents a significant advancement in the utility and efficiency of utility workers. Conduct surveys, interviews, and observational studies to understand the specific needs, challenges, and workflows of utility workers involved in grid work. Identify pain points, inefficiencies, and safety concerns associated with current practices. Investigate existing wearable technologies, such as AR glasses or headsets, that could be adapted for grid work applications. Evaluate the technical specifications, ergonomics, and compatibility of different wearable devices with the requirements of utility workers. Design and develop AR applications tailored to the needs of utility workers in grid work scenarios. Incorporate features such as real-time visualization of grid infrastructure, overlay of contextual information (e.g., schematics, maintenance procedures), and interactive troubleshooting guides. Apply HCI principles to ensure that the AR interface is intuitive, user-friendly, and conducive to efficient task execution. Explore interaction modalities such as gesture recognition, voice commands, and touch input to facilitate natural and seamless interaction with the AR system. Address logistical challenges related to the deployment of AR technology in operational environments, including device management, training requirements, and infrastructure support. Evaluate the scalability of the solution to accommodate varying workloads and operational contexts across different regions or utility companies. Explore potential future applications and enhancements of AR technology in grid work, such as integration with IoT sensors for asset monitoring and predictive maintenance. Investigate emerging technologies and research directions that could further enhance the capabilities and effectiveness of wearable AR systems for utility workers.

Wearable device forms have evolved due to advancements in mobile communications technology and low-power CPUs. From idea to commercialization, new wearable gadgets are always emerging. Wearable technology is being explored by major tech firms such as Google, Apple, Microsoft, and Sony. Industry analysts predict that it will be the next big thing after smartphones[1]. Currently, in the grid work, the following challenges exist: This model, which includes standardized work instructions, CARDS, maintenance records, and test reports, is complex and inconvenient for field use. While it is useful for managing daily sheet paper records, it lacks integration with production management systems, is easily lost, and hinders data sharing and statistical analysis. Additionally, it lacks real-time control over the work site. In the production management system, errors and fake entries might lead to increased effort. Substations are many, staff flow quicker, many managers are unfamiliar with the substation route, which affects the actual job; The primary wiring diagram for substations changes regularly, making it cumbersome to reference[2]. The integration of wearable technology into power grid operations is a key industry trend to address the aforementioned issues. Wearable equipment, such as power grids and augmented reality, require research and application of human-computer interaction technology. This includes somatosensory interaction, gestures, physical interaction, eye movement interaction, and integration with the grid. The goal is to liberate people's hands and minds, introduce new work modes, and improve equipment health. Wearable equipment in the electric power industry is expected to drive new managerial innovations[3].

2. THE RESEARCH STATUS AND ABROAD

2.1 The technology for human-computer interaction

Natural interaction patterns in wearable device interaction mostly fall into the following categories: speech, gestures, tactile and visual, etc., in addition to regular engagement.
Voice interaction technology is at its mature stage, with research focusing on voice detection, synthesis, and natural language comprehension. The national 863 initiative supports research on voice interface approaches in computer systems. Domestically, various established commercial apps have been created based on Chinese voice interaction technologies, including xunfei sound at hkust and wormhole voice assistants. Gesture interface technology, particularly vision-based gesture recognition, has received much research[5]. Video collecting equipment captures gesture images, which are subsequently processed using computer vision technologies to detect the motion. Recent years have seen increased interest in human head gesture recognition technologies, as well as the development of several methods for measuring head poses. Wearable devices use various technologies to measure head posture, including mechanical, magnetic, optical, and ultrasonic methods, as well as inertia methods based on two-dimensional graphics, three-dimensional images, and depth image recognition algorithms. Further research is needed in this area.
Wearable devices and human-computer interface technology have been a focus of study both domestically and internationally. As technology matures, it has been commercialized and converged with other technologies.

2.2 The technique of augmented reality
Augmented reality combines reality, interactive technology, sensor technology, and computer graphics to create a virtual environment that blends seamlessly with the user's surroundings. The sensory effects of the virtual environment feel like they are part of the real world[7].
In 2012, Google unveiled the world's first augmented reality Glasses. These Glasses can dock with Google's distributed search engine and developers may utilize Google's software development kit to create their own virtual simulation systems. Magic Leap, an AR business founded in 2011, offers a "Cinematic Reality" experience that adjusts focus to the human eye and automatically converts light field angle and depth, utilizing cutting-edge technology. Domestic augmented reality development has a late start compared to foreign countries, but it focuses on system application technology, scope, and research points. However, some research institutions, colleges, and universities, particularly in augmented reality, have developed larger algorithms and design technology, such as camera calibration and virtual object registration, leading to success.

3. THE KEY TECHNOLOGY

Figure 1 depicts the entire structure for supporting power grid operation in augmented reality wearable devices and human-computer interaction research.

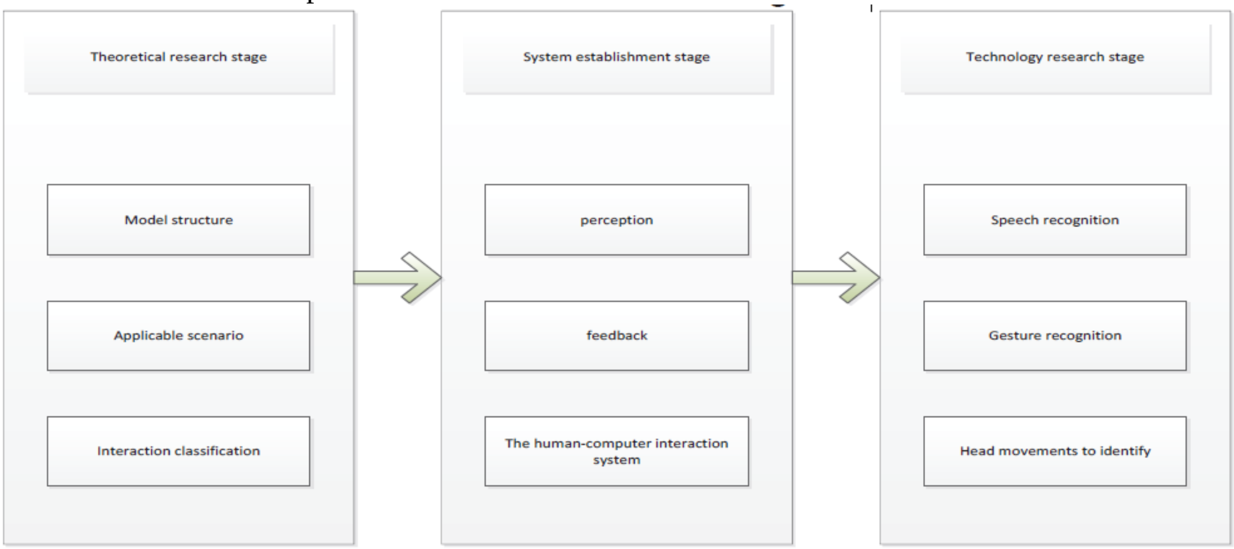

Fig. 1 Technical route structure and research contents

3.1 Studies on the technology of human-computer interaction in the context of power grid operation

The research system focuses on human-computer interaction technology and model design analysis at various levels. This includes analyzing how users interact with computers and analyzing their characteristics to improve system design relevance and adaptability. The study of hierarchical model structures and scene application led to the development of a grid operation environment that includes four parts: system, user, input, output, and human-computer interaction (see figure 2).

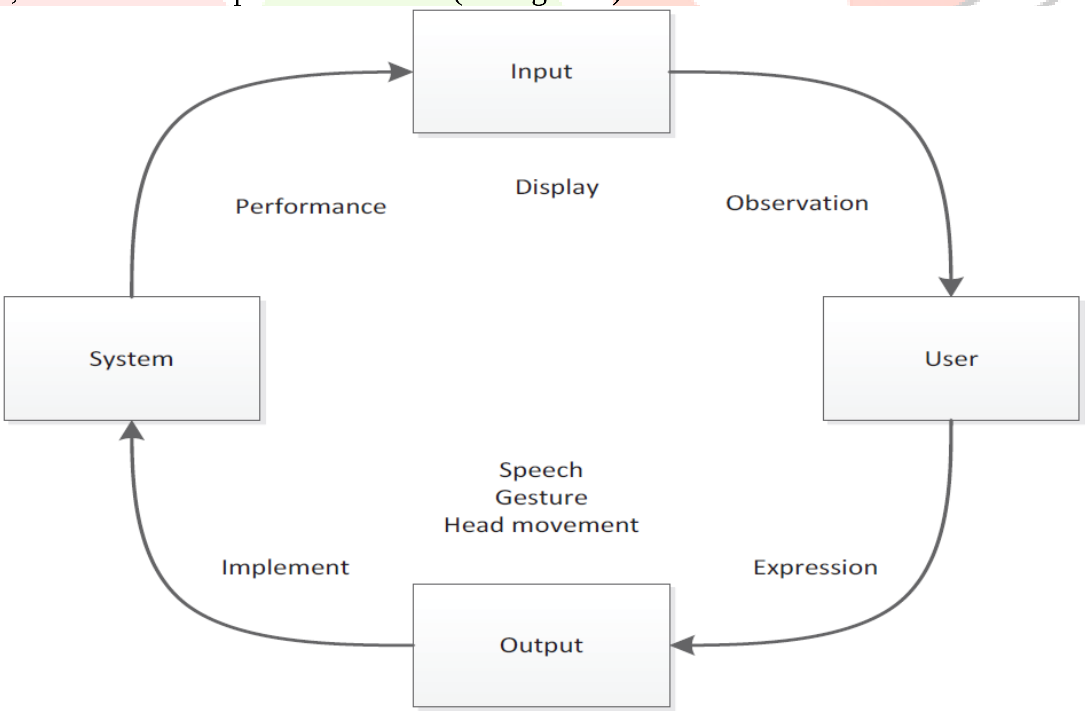

Fig. 2 Framework for human-computer interaction

The user can set objectives and transfer information to the system using voice, gestures, and head movements. The system will generate output in voice, video, text, and display formats based on the description of the operation. Control targets are evaluated during the assessment phase. The interaction process involves expression, performance, and observation of four types of change.

3.2 Study on wearable technologies for human-computer interaction, including gesture and speech

Research on speech recognition and synthesis, as well as semantic comprehension, have led to the development of a voice interaction module shown in figure 3. The mobile intelligent terminal uses a microphone to input speech signals, which are then converted into text and semantics based on the user's intent. The perform module then returns the results, which are then delivered to the speech synthesis module. The text and synthetic speech are then displayed on the screen and spoken by the speaker.

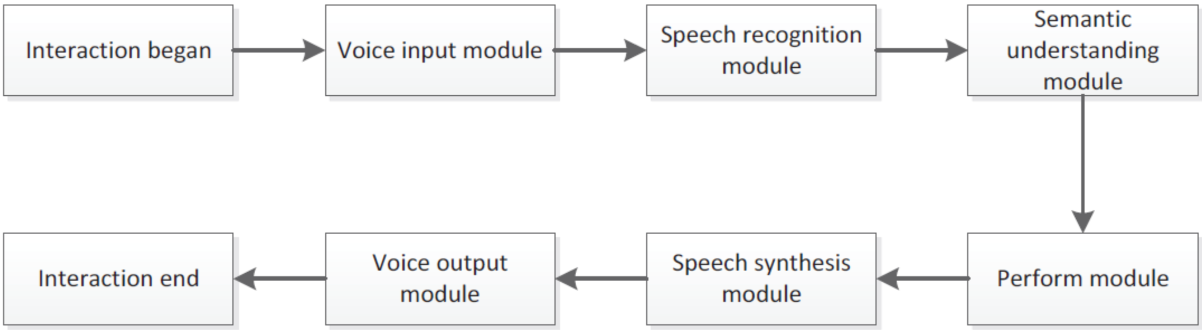

Fig. 3 Module for voice interaction

The study described focuses on the development of somatosensory interaction technology, particularly gesture recognition and head movements. This technology utilizes inertial sensors to detect and interpret hand or head movements for interaction with digital interfaces. Figure 4 depicts the stereo feeling interaction process module, which outlines the various steps involved in this interaction process. Here's a breakdown of the components illustrated in Figure 4:

Data Collection from Inertial Sensors: The process begins with the collection of data from inertial sensors embedded in the wearable device worn by the user. These sensors, which may include accelerometers, gyroscopes, and magnetometers, capture the motion and orientation of the user's hand or head during interaction.

Preprocessing: The raw sensor data collected from the inertial sensors undergoes preprocessing to enhance its quality and prepare it for feature extraction. Preprocessing may involve filtering, noise reduction, and calibration techniques to ensure accurate interpretation of movement signals.

Feature Extraction: Next, features relevant to hand or head movements are extracted from the preprocessed sensor data. These features may include characteristics such as acceleration, angular velocity, orientation, and spatial trajectory, which provide valuable information about the user's gestures and movements.

Movement Classification and Identification: The extracted features are then fed into a classification and identification module, where machine learning algorithms or pattern recognition techniques are employed to classify and identify different types of movements. This step involves training the system with labeled data to recognize specific gestures or head movements accurately.

Stereo Feeling Interaction: Once the movements are classified and identified, the system generates corresponding interaction commands or triggers based on the detected gestures or head movements. These commands can be used to control digital interfaces, navigate through virtual environments, or interact with augmented reality content, providing users with a seamless and intuitive interaction experience.

Overall, the stereo feeling interaction process module depicted in Figure 4 represents a systematic approach to leveraging somatosensory interaction technology for gesture recognition and head movements. By combining data collection, preprocessing, feature extraction, and movement classification, this technology enables natural and immersive interaction between users and digital interfaces, opening up new possibilities for intuitive human-computer interaction in various applications.

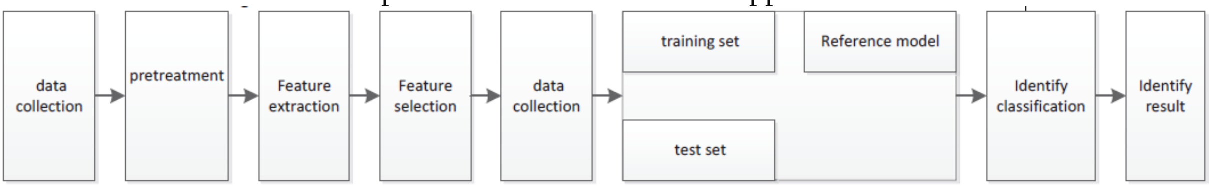

Fig. 4 Module for Somatosensory Interaction

This subject uses light fly time technology for gesture recognition, as opposed to the other three hardware implementation technologies. Depth cameras are used to obtain object depth information and facilitate user gestures. Middleware technology is used to improve data analysis and processing, transform data into gesture instructions, study signal dynamics, track hand movements, identify gestures, and enable user interaction with wearable devices.

3.3 Studying wearable technology that uses augmented reality for interaction

The augmented reality system has four steps: gathering real-world information, analyzing it, creating a virtual scene, and displaying it immediately.

In video streaming, markers are used to determine scene location. The graphics system then uses camera position and location information to transform virtual objects to the camera plane using an affine transformation matrix. Finally, depending on the output device, simulated sceneries are shown. The essential enabling technology for implementing an AR system includes output devices, tracking and location technology, interaction technology, and the integration of real and virtual elements.

Tracking research on image registration technology will be integrated into augmented reality systems employing various tracking technologies. Video detection involves pattern recognition technology, template matching, edge detection, and computation of shift and rotation coordinate transformations based on predefined tags or benchmarks. GPS is utilized in an outdoor AR system to monitor and determine the user's location. Ultrasonic technology, similar to GPS, uses a measurement equipment and three known distances of ultrasonic waves to establish a user's location.

The gyroscope measures the user's head rotation angle and converts virtual scene coordinates based on field of vision and content. Using information fusion technology, wearable devices use gyro sensors to detect nakedness. Image tracking equipment records the need to show and connects to a backend server to generate a virtual display screen. The virtual information is then merged with the real image to create an overlay display. The model or operational guidelines for school officials recommend using video recommendations for equipment operation to assist auxiliary workers in precisely identifying faults.

3.4 Switching between modes interactively

Using complimentary operations for a single interaction under multiple conditions allows for dynamic selection based on the working environment. Examples include excessively bright or dark lighting, preferred voice engagement, and secondary signal interaction. Environmental noise is the preferred gesture engagement, followed by voice interaction.

Test the environment and accompanying hardware software for auxiliary judgment.

Later, mutual operation may be used to execute tasks collaboratively in a number of interactive ways inside a single scenario. Examples include distant views, head rotation, amplification of gestures, and limited views.

4. CONCLUSIONS

This system uses real-time computing to determine the position and angle of a camera image, as well as the complexity of power grid equipment and the diversity of information. It uses fusion and 3D registration tracking technology to demonstrate diversity, authenticity, and the flexibility of human-computer interaction. It also provides a virtual overlay on the field with various shapes and rules to identify objects. To improve accuracy and convenience when operating power equipment, field personnel should adjust their head posture, gestures, and voice input based on the specific work scene and module. This includes providing guidance through words and speech output.

5. REFERENCES

[1] Mao Tong, Zhou Kai-yu. Discussion About the Influence of Wearable Device on Mobile Operators' Service, Telecommunications Science,2014

[2] Dong Shi-hai, The progress of the human-computer interaction and the challenge. Journal of computer aided design and graphics; 2004.

[3] Gao Jing-ye, Research of augmented reality, human-computer interaction system, 2004.

[4] Richard V.Cox, Candance A.Kamm. Speech and Language Processing for Next-Millennium Communication Services, Proceedings of the IEEE,2000,Vol.88(8):1314-1335

[5] Cao Chu-qing, Li Rui-feng, Hand Posture Recognition Method Based on Depth Image Technology, Computer Engineering,2012,Vol.38(8):16-21

[6] Li Lei, Head Movement Recognition Technology Research in Augmented Reality Application, North China University of Technology 2014.
[7] Huang Zhen-yu, Research and Application in the Actual Fusion and Human-computer Interaction Technology about Augmented reality, University of Electronic Science and Technology of China, 2012.
[8] Beisbart, Claus. "Are computer simulations experiments? And if not, how are they related to each other?." European Journal for Philosophy of Science 8.2 (2017): 171-204.
[9] Develaki, Maria. "Methodology and epistemology of computer simulations and implications for science education." Journal of Science Education and Technology 28.4 (2019): 353-370.
[10] Goodfellow I, Bengio Y, Courville A. Deep learning. Cambridge: MIT Press; 2016.