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Research on the Application of Non-contact Sensing Technology in Real-time Emotional Monitoring and Feedback

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Abstract: With the rapid development of information technology, non-contact sensing technology has shown great potential in the field of real-time emotional monitoring and feedback. The purpose of this study is to deeply explore the application of this technology in improving the intelligence of human-computer interaction and realizing personalized service. By synthesizing the experimental results and related literature, a series of important research findings have been formed. First of all, we found that non-contact sensing technology effectively improved the objectivity of emotion monitoring. Secondly, the introduction of real-time feedback mechanism has significantly improved the user experience. However, non-contact sensing technology still faces some challenges in practical application, including privacy issues, cross-cultural adaptability, environmental interference and so on. To solve these problems, technological innovation, the establishment and standardization of privacy policies are needed to ensure the sustainable application of technology in a wider range of fields. This study emphasizes the importance and application prospect of non-contact sensing technology in real-time emotional monitoring and feedback. Future research should focus on the further innovation of technology, the improvement of privacy protection mechanism and the deepening of interdisciplinary cooperation, so as to promote the wider application of this technology in the field of human-computer interaction.

Keywords: Emotional Monitoring; Feedback; Non-contact Sensing Technology.

1. Introduction

In today's digital age, the field of human-computer interaction is undergoing rapid and profound changes. With the continuous progress of science and technology, non-contact sensing technology, as an innovative technical means, has gradually attracted widespread attention. The unique feature of this technology is that it does not need direct physical contact, and realizes seamless monitoring of user behavior and state by sensing changes in the environment [1]. In this field, the application of non-contact sensing technology is increasingly diverse, and one of the most striking is its potential application in real-time emotional monitoring and feedback.

Emotion plays a vital role in human communication and decision-making. Therefore, accurate monitoring and understanding of emotion is of great significance for improving human-computer interaction experience. Traditional emotional monitoring methods mainly rely on subjective reports, questionnaires or physiological signal measurement, however, these methods are often limited by the subject's self-awareness and consciousness level and the experimental environment [2-3]. The rise of non-contact sensing technology provides a new way for real-time emotion monitoring. By collecting nonverbal information such as body language, facial expression and posture, more objective and detailed emotion analysis is realized.

This paper aims to explore the potential application of non-contact sensing technology in real-time emotional monitoring and feedback, and will pay attention to the wide application of non-contact sensing technology in improving the accuracy of emotional monitoring, realizing personalized feedback, and in social robots, virtual reality and other fields. Through in-depth research, we are expected to provide a new perspective for the research and development in this field, and promote the further innovation and application of non-contact sensing technology in the field of real-time emotional monitoring.

2. Basic Principle of Non-contact Sensing Technology

Non-contact sensing technology is a kind of innovative technology, and its basic principle is to realize monitoring and data acquisition of the target object by sensing various changes in the environment without direct physical contact. This technology has shown great application potential in many fields, including real-time emotional monitoring, human-computer interaction, medical care and so on [4-5].

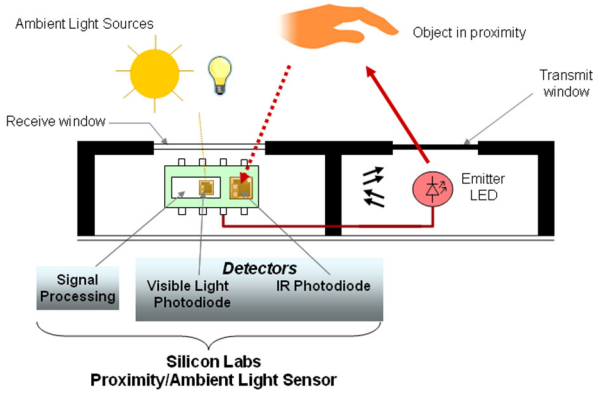

Figure 1. High sensitivity and low power consumption infrared sensor structure

The core of non-contact sensing technology lies in highly sensitive sensors. These sensors can sense and measure electromagnetic, acoustic, optical, or other physical signals emitted by the target object. Taking vision as an example, the camera sensor can capture the image or video of the target object without direct contact [6]. Similarly, sonar sensors,

infrared sensors and so on can achieve effective monitoring without touching the target. Fig. 1 is a structure of an infrared sensor with high sensitivity and low power consumption:

Computer vision technology plays an important role in non-contact sensing technology. Through the processing and analysis of images and videos, the computer can identify the characteristics, shapes, movements and other information of the target object. Deep learning and machine learning algorithms have played an important role in this respect, enabling the system to extract more complex and abstract information from the data collected by sensors, such as facial expressions and gestures.

In real-time emotional monitoring and other applications, non-contact sensing technology often involves the detection of biological signals. Techniques such as heart rate monitoring, skin electrical response and eye tracking can capture the physiological state of users through sensors, thus indirectly reflecting their emotional state. This method avoids the interference of electrode attachment in traditional physiological signal measurement, and improves the convenience and comfort of monitoring.

Non-contact sensing technology often involves the fusion and analysis of multi-source data. By integrating the data collected by different sensors, the system can understand the state of the target object more comprehensively [7-8]. Complex data analysis algorithms are used to extract meaningful information from massive sensor data, such as the identification of emotional state, so as to achieve more accurate monitoring and feedback.

Generally speaking, the basic principles of non-contact sensing technology include high-sensitivity sensors, advanced computer vision technology, biological signal detection and data fusion and analysis. The synergistic effect of these technologies makes non-contact sensing technology a powerful tool to realize real-time monitoring and feedback, and has shown a wide application prospect in many fields.

3. Application of Non-contact Sensing Technology in Real-Time Emotion Monitoring

3.1. Application of Non-Contact Sensing Technology in Different Emotional Dimension

The application of non-contact sensing technology in different emotional dimension presents many possibilities. Non-contact sensing technology can capture the user's facial expression through the camera, thus identifying pleasant emotions. Expression features such as smile and relaxed eyes can be used for emotion classification by the algorithm. By analyzing phonetic features, including tone, speech speed, emotional color of speech, etc., non-contact sensing technology can distinguish whether users are in a happy state.

The short-term parameters of speech signal are one of the important parameters to characterize the emotional characteristics of speech, such as short-term energy, short-term average amplitude, short-term zero-crossing rate, short-term autocorrelation function and short-term average amplitude difference function [9]. Speech signal is a non-stationary random process with time-varying characteristics. However, its features remain basically unchanged in a short time range. In view of this feature, researchers proposed a short-time analysis method, which segmented the speech signal stream and then derived short-time feature parameters. Fig. 2 shows a time domain waveform diagram of a speech signal.

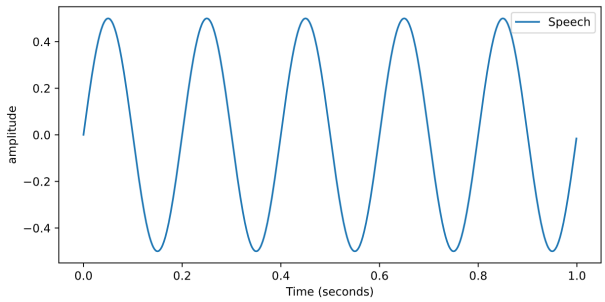

Figure 2. Time domain waveform diagram of speech signal

Anger is usually accompanied by changes in facial expressions and nervousness in body posture. Non-contact sensing technology can detect the tightness of facial muscles and the intensity of gestures, so as to judge whether users feel angry. Physiological signals, such as the change of heart rate, can also be associated with anger, and monitoring physiological signals through non-contact sensing technology can help judge the emotional state of users [10]. Anxiety is usually accompanied by restless eyes. Non-contact sensing technology can detect the user's gaze point and eye movement through eye tracking technology, so as to infer their anxiety level. Non-contact sensing technology can analyze the characteristics of voice tension and speech speed change, and can be used to identify whether users are in an anxious state.

In addition to pleasure, anger and anxiety, non-contact sensing technology can also identify other emotional States, such as sadness and surprise, through the characteristics of tone, speech speed and speech texture in speech. Physiological signals such as blood pressure and skin electrical response can also be used to help distinguish various emotional States. The application of non-contact sensing technology in different emotional dimension provides a more comprehensive and objective means for real-time emotional monitoring through the fusion and analysis of multi-source information. These applications are expected to play a key role in mental health, human-computer interaction and other fields, and bring innovative solutions to improve user experience and humanized feedback of intelligent systems.

3.2. Capture and Analysis of Emotional Information by Non-Contact Sensing Technology

Traditional emotional analysis methods usually rely on manual observation, subjective report or data collection based on questionnaire survey. In the emotional analysis of facial expressions, researchers may ask participants to watch some emotional videos or images, and then get their emotional feedback by asking questions or self-reporting. The problems of this method include subjectivity, limited sample size and the possible influence of the subjects on the experimental environment.

Through non-contact sensing technology, especially facial expression analysis, emotional information can be captured and analyzed more objectively and in real time. Taking face recognition technology as an example, the system can capture the user's facial expressions through the camera, and then apply deep learning algorithm to classify the expressions, thus inferring the user's emotional state, such as joy, anger,

surprise and so on.

Non-contact sensing technology provides objective and unbiased data, which avoids the limitations of subjective reports of subjects. In addition, real-time enables the system to capture and respond to users' emotional changes in real time, which improves the timeliness of feedback. Through non-contact sensing technology, large-scale data sets can be processed more easily, thus improving the accuracy of emotion analysis. Deep learning algorithm can learn from a large number of samples, which makes the model better generalized to different situations and individuals. By capturing the user's emotional state in real time, the system can automatically adjust the interface, volume, brightness and other parameters to provide a more personalized experience that meets the user's expectations. This has great potential in the fields of human-computer interaction and virtual reality. Traditional methods may require manual intervention or strict control of experimental conditions, while non-contact sensing technology does not require users to take additional actions, and can monitor users' emotions in their natural state.

It can be seen that non-contact sensing technology has greater advantages than traditional methods, especially in improving objectivity, real-time, large-scale data processing ability and user experience. This makes non-contact sensing technology have a wide application prospect in real-time emotional monitoring and feedback.

4. Personalized Feedback Mechanism

Through non-contact sensing technologies such as facial expression analysis and voice emotion recognition, the system can capture the emotional state of users in real time. Combining the historical data, behavior patterns and personalized characteristics of users, it is possible to establish a personalized emotional model. This model can not only accurately identify emotions, but also better understand the unique responses of different users to specific emotions.

Based on real-time emotional monitoring, personalized feedback mechanism can adjust the user interface and interaction mode of an application or system to better adapt to the current emotional state of users. For example, when users feel happy, the system can choose a more vivid and relaxed color theme; When the user feels anxious, a more relaxed and simplified interface design is adopted, thus improving the user's comfort.

Through the personalized feedback mechanism, the system can adjust the content recommendation strategy according to the user's emotional state. The recommendation of music, video, news and other content can better meet the current emotional needs of users and provide a more pleasant or comforting experience. This emotion-oriented content recommendation not only improves user satisfaction, but also deepens users' stickiness to the system.

In the field of education, personalized feedback mechanism can adjust the learning path and difficulty according to students' emotional state, and provide a learning experience that is more in line with students' personalized needs. In the field of health, the system can adjust health reminders, exercise plans and other services according to the emotional state of users to achieve more personalized health assistance. Privacy and transparency are key factors that cannot be ignored when implementing personalized feedback mechanism. The system should respect users' right to privacy and ensure users' control over their own emotional information. Providing a transparent and clear explanation and explaining the collection and use of emotional data to users will help to enhance users' trust in the system.

5. Challenges and Future Prospects

Non-contact sensing technology involves the acquisition of users' physiological and emotional information, which raises concerns about privacy protection. Ensuring the security, legality and transparency of data and formulating a reasonable privacy policy will be an important challenge. The generality of non-contact sensing technology in different people, cultures and environments is still a problem. The algorithm needs to be general enough to adapt to diverse user groups and application scenarios while maintaining high accuracy. In order to train an accurate emotion recognition model, a large number of labeled data are needed. However, it is a time-consuming and labor-intensive task to obtain emotional tagging data, and tags may be uncertain because of subjectivity. The application of non-contact sensing technology involves many fields such as computer science, psychology and medicine. Interdisciplinary cooperation and communication will be the key to ensure the success of technology in practical application. Facing the challenge of actual environmental interference such as illumination, noise and attitude change, this may affect the accuracy and stability of sensing technology.

In the future, non-contact sensing technology is expected to realize the fusion of multi-modal data, and combine visual, sound, physiological signals and other information to improve the accuracy and comprehensiveness of emotion recognition. With the continuous development of deep learning technology, it will become a development trend to train the model of non-contact sensing technology more deeply and effectively. The optimization of the model and the improvement of generalization ability will help to adapt to diverse users and scenarios. Combine real-time emotion monitoring with instant personalized feedback to provide users with more intelligent and personalized services, such as adaptive user interface and emotion-oriented content recommendation. Non-contact sensing technology will play a role in a wider range of applications, including medical care, smart home, virtual reality, social robots, etc., to provide users with a richer experience. The industry needs to work together to formulate standards and norms to ensure the sustainable development of non-contact sensing technology in different fields, and at the same time, pay more attention to privacy and ethics. Strengthen the interpretability and transparency of non-contact sensing technology model, help users understand the working principle of the system, and increase users' trust in technology.

Generally speaking, although non-contact sensing technology faces some challenges in practical application, it still has great potential in improving user experience and promoting intelligent development. Through continuous research and innovation, it is expected to overcome the current technical problems and promote the non-contact sensing technology to make greater progress in the future.

6. Conclusion

Non-contact sensing technology shows great potential in real-time emotional monitoring and feedback, which provides a new way to improve the intelligence and personalized service level of human-computer interaction. However, we should also realize that some key problems need to be solved

in the process of technology development and application to ensure the successful application of this technology in a wider range. The future research direction should focus on further innovation of technology, improvement of privacy protection mechanism and deepening of interdisciplinary cooperation.

References

[1] Zhang Jitao, Xu Zhiqiang, Yuan Chao, Zhang Qingfang, Wang Xiaolei, &Cao Lingzhi. (2018). Study on contactless differential gmi current sensor for DC transmission and its sensing characteristics. Journal of Henan Agricultural University, 52(2), 5.

[2] Sima Wenxia, Zheng Rongfeng, Yang Ming, Wang Yang, Wang Jing, & Wilson. (2020). Development and sensing performance of non-contact current sensor based on rare earth magneto-optical glass. High voltage technology, 46(6), 10.

[3] Shang Yunfei, Xia Xinxin, Hao Shuwei, Zhu Chongqiang, Lei Zuotao, & Yang Chunhui. (2022). Experimental design of non-contact temperature sensing based on up-conversion nanocrystals. Experimental Technology and Management, 39 (12), 143-147.

[4] Bi Chao, Bao Chenxing, Lei Wenming, & liuyong. (2018). Construction and implementation of non-contact nozzle swirl groove measurement system. Journal of Sensing Technology, 31(9), 6.

[5] Chengzhang. (2017). Non-contact laser measurement system of artificial intelligence. Laser Journal, 38(9), 4.

[6] Luo Dan, Qing Yang, Huang Lingyu, & Dong Funing. (2021). Contactless current sensor based on micro-ring resonator. Acta Optics, 41(12), 9.

[7] Vilen. (2019). Design of Absolute Magnetic Encoder and Its Application in Servo System. Journal of Sensing Technology, 32(4), 6.

[8] Yang Yilong, Liang Chenhua, Feng Yifei, Liu Guangsheng, &He Ying. (2023). Research status and prospect of non-contact vital signs monitoring technology. China Medical Equipment, 38(6), 151-156.

[9] Kang Lai, Wei Yingmei, Jiang Jie,& Xie Yuxiang. (2020). Non-contact object size acquisition method based on visual inertial sensing data. Journal of System Simulation, 32(5), 9.

[10] Zhen Fang, Chen Xianxiang, Jian Pu, Zhang Hao, Yao Yicheng, & Geng Fanglin, et al. (2022). Overview of non-contact medical health monitoring technology based on fmcw radar. Journal of Radar (003), 011.