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Current Analysis and Future Perspectives of a Smart Sensor Monitoring System for Multi-Scenario Recreation

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Abstract: With the accelerated aging of the population and the improvement of health awareness, the recreation industry is experiencing a booming development. Smart sensors, as the core component of recreation monitoring systems, play a key role in multi-scenario applications. This paper reviews the current research status of a multi-scenario recreation smart sensor monitoring system and analyzes its application in different scenarios such as family, community, and hospital. Firstly, the technological progress of smart sensors in physiological parameter monitoring, behavior analysis, and environment sensing is described. Second, the overall architecture design and data fusion method of a multi-scenario recreation monitoring system are discussed. Secondly, the characteristics and application requirements of smart sensors in different scenarios are compared and analyzed. Finally, the current technical challenges, including data security and privacy, system reliability, and intelligence level, are pointed out, and the future development trend is also prospected. The study shows that the introduction of emerging technologies such as multimodal sensing fusion, edge computing, and artificial intelligence will further enhance the performance of the recreation monitoring system. In the future, the construction of an intelligent and personalized recreation monitoring system covering the whole life cycle is of great significance in promoting the high-quality development of the recreation industry.

Keywords: recreation monitoring, smart sensors, multi-scenario applications, data fusion, artificial intelligence

1. Introduction

With the acceleration of global population aging and the continuous improvement of people's health awareness, the recreation industry is ushering in unprecedented development opportunities. In this context, multi-scenario recreation intelligent sensor monitoring systems, as an emerging technology, are attracting extensive attention from both academia and industry. The core of the intelligent sensor monitoring system for health and wellness lies in its multi-scenario application capability. Whether in different environments such as home or community, this system can flexibly adapt to provide users with continuous and accurate health monitoring services. By integrating advanced sensor technology, the Internet of Things, and big data analysis, this system provides an all-around, intelligent solution for recreation services and is expected to play an important role in improving the quality of recreation, reducing medical costs, and promoting health management.

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In the rapid development, multi-scene recreation intelligent sensor monitoring system also faces many challenges. Data security and privacy protection are the primary considerations, how to provide personalized services while protecting the user's sensitive information is the system designers need to carefully consider. The reliability and stability of the system are also a key factor, especially when it comes to monitoring the health of special groups such as the elderly, where any error may cause serious consequences. In addition, how to improve the intelligence of the system and realize the leap from simple data collection to intelligent analysis and prediction is also the key direction of current research.

Facing these challenges, academia and industry are actively exploring new solutions. The application of multimodal sensing fusion technology is expected to improve the accuracy and comprehensiveness of data collection. The introduction of edge computing can reduce the data transmission delay and improve the system response speed. The integration and application of these emerging technologies will promote the development of multi-scene recreation intelligent sensor monitoring systems to a higher level.

The purpose of this paper is to comprehensively review the current research status of multi-scenario recreation intelligent sensor monitoring systems, analyze their characteristics and needs in different application scenarios, discuss the current technical challenges, and look forward to the future development trend. Through this review, we hope to provide valuable references for researchers and practitioners in related fields and to promote the progress of recreation monitoring technology and the high-quality development of the recreation industry.

2. Literature review

2.1. Overview of international research

Foreign research on multi-scenario recreation intelligent sensor monitoring systems started earlier; the research content is rich and extensive. Dimri et al. pointed out that the smart sensor monitoring system in the field of environmental monitoring has an important application value, which provides an important reference for subsequent research [1]. Perisetti et al. analyzed the large-scale data of hepatocellular carcinoma patients. They found that the smart sensor monitoring system has a significant effect in evaluating the status of patients with sarcopenia, which provides a new idea for the prognosis of hepatocellular carcinoma patients [2]. This provides a new idea for the prognostic assessment of patients with hepatocellular carcinoma.

The theoretical framework for monitoring the cardiovascular system proposed by Rodriguez-Gonzalez et al. became the foundation of the field, which was further refined by subsequent researchers such as Perisetti et al. Rodriguez-Gonzalez et al. provided a theoretical basis for cardiovascular health monitoring in children by analyzing the effects of neocoronitis on the cardiovascular system in children through a systematic review [2-3]. Perisetti et al., on the other hand, contributed to the theoretical development of recreational monitoring systems by thoroughly investigating the role of sarcopenia in patients with hepatocellular carcinoma [2].

The studies of Dimri et al. and Rodriguez-Gonzalez et al. focused on the practical application of smart sensor monitoring systems. The results of Dimri et al. showed that smart sensors can significantly improve the monitoring efficiency and accuracy in the monitoring of river water quality [1]. The study of Rodriguez-Gonzalez et al. showed that smart sensors have an important application value in the monitoring of children's cardiovascular health, which can detect potential cardiovascular problems in time. Sensors have important application value in monitoring the cardiovascular health of children and can detect potential cardiovascular problems promptly [3].

Overall, foreign studies generally agree that multi-scenario recreation intelligent sensor monitoring system has an important role in the field of environmental monitoring, health management,

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and other areas and provides strong support for practical applications. Perisetti et al. pointed out that the existing research still has limitations, such as the limited scope of application of the assessment model of sarcopenia, and further research is needed in the future[2]. Dimri et al. also emphasized that the application of smart sensors in water quality monitoring needs to be further improved and optimized[1].

2.2. Overview of national studies

Domestic research on multi-scenario recreational intelligent sensor monitoring systems started relatively late but has made rapid progress in recent years. Wang Yabo et al. are one of the early scholars in China to study the intelligent collision avoidance system, revealing the potential application of smart sensors in the collision avoidance system of unmanned underwater vehicles [4]. Zhu Ming et al. further analyzed the feasibility of intelligent sensors in the intelligent feeding system of fish culture, which provided a new idea for the application of recreational monitoring systems in aquaculture [5].

Yang Xiao et al. proposed the theory of equipment condition monitoring visualization technology, which has attracted widespread attention in the domestic academic community, laying a foundation for the theoretical construction of intelligent sensor monitoring systems for recreation [6].

The research of Excellence et al. focuses on the specific application of UAV remote sensing technology in forage crop growth monitoring, and the empirical study shows that smart sensors have a significant effect in enhancing the efficiency of forage crop monitoring [7-8]. Jiang Lei et al. explored the application of medication monitoring systems in smart communities, which provided new ideas for the application of recreation monitoring systems in community health management [9].

Domestic research generally believes that multi-scene recreation intelligent sensor monitoring system has a wide range of application prospects in the fields of environmental monitoring, health management, agricultural production, and other fields. St. Qianqian et al. pointed out that although domestic research has achieved certain results in theory and practice, there is still a certain gap compared with foreign countries, especially in the systematic research of intelligent sensor technology, which needs to be further deepened in the future [10-12].

2.3. The main challenges identified from the literature

Through the review of related literature at home and abroad, we can find that the multi-scenario recreation intelligent sensor monitoring system still faces some major challenges in the process of development, which not only constrain the further innovation of the technology but also affect the wide application of the system to a certain extent.

The issue of data security and privacy protection remains one of the challenges of greatest concern. Recreation monitoring systems involve a large amount of sensitive personal information, and how to protect user privacy in the process of collecting, transmitting, storing, and analyzing such data is a complex technical and ethical issue [13]. Although blockchain and other technologies provide new solutions for data security, how to balance the contradiction between data sharing and privacy protection in practical applications still needs to be further explored.

The reliability and stability of the system is also an important challenge. Recreational monitoring systems usually require continuous operation over a long period, and any malfunction or false alarm may have a serious impact on the users. Especially when it comes to special groups such as the elderly, the reliability of the system is particularly important. How to improve the durability of the sensors, enhance the anti-interference ability of the system, and optimize the fault detection and self-repair mechanism are the key issues that need to be addressed in the current research [14].

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The enhancement of the level of intelligence faces a technical bottleneck. Although artificial intelligence technologies have shown great potential in health data analysis, it is still a challenge to effectively apply these technologies to complex and changing healthcare scenarios and realize truly intelligent health management. In particular, the existing algorithms and models still have a lot of room for improvement in handling heterogeneous data from multiple sources, understanding individual differences, and recognizing long-term health trends.

The integration and interoperability of multi-scenario data also need to be addressed. Recreation monitoring systems in different scenarios often adopt different technical standards and data formats, and realizing seamless connection and data sharing among these heterogeneous systems is the key to building a comprehensive recreation monitoring network [15]. Although some studies have proposed data fusion solutions based on cloud platforms or edge computing, they still face challenges such as technical complexity and cost in practical applications.

The usability and user acceptance of the system is also an issue that cannot be ignored. Especially for elderly users, how to design easy-to-use, ergonomic sensors and interactive interfaces and how to provide personalized, easy-to-understand health information feedback are key factors affecting the popularization and application of the system.

The existence of these challenges, on the one hand, reflects the complexity and multidisciplinary nature of the research on multi-scene recreation intelligent sensor monitoring systems, on the other hand, it also points out the direction for future research. Only through continuous technological innovation and interdisciplinary cooperation can we gradually overcome these challenges and promote the development of recreation monitoring technology to a higher level.

3. Results and Discussion

3.1. Core findings

Through a comprehensive study and literature review of multi-scenario recreational smart sensor monitoring systems, we can draw the following core conclusions.

Multi-scene recreation intelligent sensor monitoring system has become an important technical support to promote the development of the recreation industry. By integrating advanced sensor technology, the Internet of Things, big data analysis, and artificial intelligence, such systems provide comprehensive and intelligent solutions for recreation services under different scenarios. Whether in the family, community, or medical institutions, these systems have demonstrated strong adaptability and application value, effectively improving the quality and efficiency of recreation services.

The development of multi-scenario health and wellness intelligent sensor monitoring systems is shifting from single-function to multi-function integration and from passive monitoring to active prediction. Through multimodal sensing fusion and advanced artificial intelligence algorithms, these systems cannot only monitor the user's health status in real-time but also analyze long-term health trends, predict potential risks, and provide personalized health management recommendations. This shift greatly enhances the value of wellness monitoring, shifting from simple data collection to intelligent health management.

3.2. Limitations

Although this study provides a comprehensive literature review and analysis of multi-scenario recreational smart sensor monitoring systems, there are still some limitations, which may affect the generalizability and application of the findings.

Limitations of the research scope. Since the intelligent sensor monitoring system for recreation involves a wide range of fields, including medicine, engineering, computer science, sociology, and other disciplines, this study may not be able to fully cover the latest progress in all related fields. In

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particular, some interdisciplinary, innovative studies may be neglected due to the classification of disciplines.

Dynamic nature of technological development. Recreational intelligent sensor monitoring system is a rapidly developing field, and new technologies and methods are constantly emerging. This study is based on existing literature, which may not fully reflect the latest technology trends and breakthroughs. In particular, some research results or patented technologies that have not been formally published may not be included in this analysis.

The limited nature of practical application data. Although several application cases were reviewed in this study, most of the studies are still in the laboratory stage or small-scale pilot stage. The lack of large-scale, long-term practical application data may affect the assessment of the actual effectiveness and potential problems of the system.

Representativeness of user groups. The targets of recreational services include the elderly, the chronically ill, the subhealth, and other groups, each of which has its own special needs and usage habits. This study may not be able to fully reflect the characteristics and needs of all user groups.

Recognizing these limitations helps us to look at the research findings more objectively and points out the direction for future research. Future research can address these limitations in a more in-depth and comprehensive manner to promote the further development and application of multi-scenario recreation intelligent sensor monitoring systems.

3.3. Future prospects

Looking into the future, the development of multi-scene recreation intelligent sensor monitoring system has a broad prospect, but also faces many opportunities and challenges. Based on the current research status and technology trends, we can look forward to the future development direction as follows.

Sensor technology breakthroughs: Future research will continue to drive innovation in sensor technology toward miniaturization, low power consumption, and high accuracy. Advances in wearable and implantable sensors will make health monitoring more senseless and continuous. The application of new materials and manufacturing processes, such as flexible electronics, will make sensors more comfortable and durable. In addition, the development of multifunctional integrated sensors will realize the simultaneous monitoring of multiple physiological indicators and improve the comprehensiveness and consistency of data.

Deep application of artificial intelligence: Artificial intelligence technologies, especially deep learning and reinforcement learning algorithms, will play a greater role in health data analysis. These technologies will enable systems to more accurately identify health risks, predict disease trends, and provide personalized health management advice. At the same time, the application of natural language processing and computer vision technologies will improve the interaction experience between the system and the user, making health information easier to understand and accept.

Multi-scenario data integration and interoperability improvement: Future research will focus more on the integration and analysis of health data in different scenarios. Through the establishment of unified data standards and exchange protocols, the seamless connection of monitoring systems in different scenarios, such as home, community, and hospital, will be realized. This will provide important support for the construction of comprehensive personal health records and precision medicine.

Enhanced security and privacy protection: With the increased emphasis on data security, future wellness monitoring systems will utilize more advanced encryption technology and privacy protection algorithms. Blockchain technology may play a greater role in the secure storage and sharing of health data. At the same time, the application of differential privacy and other technologies will enable the analysis and utilization of large-scale health data while protecting individual privacy.

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Deepening of personalized and precise services: Based on massive health data and advanced analysis technology, the future recreation monitoring system will be able to provide more personalized and precise health management services. This includes preventive health programs based on individual genetic information, living habits, environmental factors, etc., as well as precise treatment and rehabilitation programs for specific diseases.

The future development of multi-scene recreation intelligent sensor monitoring systems will be characterized by more advanced technology, wider application, more accurate service, and more far-reaching influence. The progress of this technology will not only promote the innovation of the recreation industry but also make an important contribution to coping with the aging of the population and improving the national health level. However, the realization of this beautiful vision requires the joint efforts of academia, industry, and governmental departments to continuously promote technological innovation, standardization, and policy support to build a healthier, smarter, and more harmonious society in the future.

4. Conclusion

This paper comprehensively analyzes the status of multi-scene recreation intelligent sensor monitoring systems and looks forward to the future development trend. By systematically combing and analyzing the relevant literature, we can conclude that smart sensor technology has made significant progress in the field of recreation monitoring, and secondly, the overall architectural design and data fusion method of multi-scene recreation monitoring systems are becoming more and more mature. We also note that the current multi-scenario recreation smart sensor monitoring system still faces some technical challenges. Issues such as data security and privacy protection, system reliability, and intelligence level still need to be further solved. Especially when a large amount of sensitive personal health data is involved, how to ensure data security and privacy protection has become a key issue to be solved. Based on the above conclusions, we propose to promote the development of sensor technology in the direction of miniaturization, non-invasiveness, and intelligence. Through deep learning, knowledge mapping, and other artificial intelligence technologies, we can realize the in-depth fusion and analysis of multi-dimensional data, such as physiology, environment, and behavior, and explore the health risks of recreation objects. Personalized recreation program development technology will be more intelligent. Based on the massive monitoring data and knowledge base, combined with the experience of experts, the intelligent reasoning engine will be built to automatically generate personalized recreation programs for recreation targets. Intelligent monitoring systems for recreation will be deeply integrated with intelligent medical and intelligent community systems to build an intelligent recreation ecosystem covering the whole life cycle and provide seamless and comprehensive services for recreation targets.

References

[1] *Deepika DIMRI; Ambika KUMAR; Deepak Kumar MISHRA; Archana SHARMA. Spatio-temporal variation of trace elements distributed over surface water of the Upper Ganga River Basin in the Western Himalayan Region[J]. Journal of Mountain Science,2023(01):153-170.*

[2] *Abhilash Perisetti; Hemant Goyal; Rachana Yendala; Saurabh Chandan; Benjamin Tharian; Ragesh Babu Thandassery; Sarcopenia in hepatocellular carcinoma: Current knowledge and future directions[J].World Journal of Gastroenterology,2022(04):34-50.*

[3] *Moises Rodriguez-Gonzalez;Ana Castellano-Martinez;Helena Maria Cascales-Poyatos;Alvaro Antonio Perez-Reviriego;.Cardiovascular impact of COVID-19 with a focus on children: A systematic review[J].World Journal of Clinical Cases,2020(21):187-220.*

[4] *Wang Yabo; Zhang Ke; Zhao Enjiao;. A review of intelligent collision avoidance system technology for unmanned underwater vehicles[J]. Journal of Weapons and Equipment Engineering,2023(04):59-65.*

DOI: 10.54254/2755-2721/133/2025.20600

[5] ZHU Ming; ZHANG Zhenfu; HUANG Huang; CHEN Hao; CUAN Xinwei; DONG Tao;. Research progress on intelligent feeding method for fish culture[J]. Journal of Agricultural Engineering,2022(07):50-59.
[6] YANG Xiao; WANG Xiangkun; HU Hao; ZHU Min;. A review of visualization techniques for equipment condition monitoring[J]. Computer Science,2022(07):95-105.
[7] LIU Xiaoyin; GUO Jun; HUO Yingning; BER Yang; ZHANG Yaping; FAN Zhongyong; LIU Ping'an;. Development of an intelligent analysis system for monitoring and querying pedestrian flow based on the photoelectric sensing principle[J]. Physics and Engineering,2022(04):219-224.
[8] Excellence; Ding Feng; Yan Navy; Xu Jing; Research progress on the application of UAV remote sensing in forage crop growth monitoring[J]. Smart Agriculture (in Chinese and English),2022(04):41-54.
[9] JIANG Lei; HAN Han; LI Xiaochen; CHEN Wen; GENG Xu;. Development status and future outlook of medication monitoring system in the context of smart community[J]. Intelligent Building and Smart City,2022(01):34-38.
[10] ZHOU Lianqing; ZHAO Cuiping; ZHANG Jie; CHE Shi; Application and prospect of artificial intelligence real-time seismic monitoring and analyzing system at China Earthquake Science Laboratory[J]. Earthquake,2021(03):3-23.
[11] Yang, Q.; Dong, F. N.; Luo, M. D.; Sun, J.; Cui, H. N.; Jie, Q. S.;. Broadband voltage sensing method and its data application[J]. High Voltage Technology,2021(06):82-96.
[12] Sheng Qianqian; He Wenyan; Liu Yuyang; Ye Shunyao; Zhou Sicong; Li Jiawei;. Research progress of plant physiological information monitoring technology[J]. Western Forestry Science,2020(06):14-21.
[13] WANG Jianwei; GAO Chao; DONG Yes; XU Sheng; YUAN Changwei; ZHANG Chi; HUANG Zebin; BU Sanshan; CHANG Qing; WANG Yue;. Progress and Prospect of Road Infrastructure Digitization[J]. China Journal of Highway, 2020(11):105-128.
[14] Zhang Sen. An intelligent skin cleaning machine based on microcontroller design [D]. Shandong University of Traditional Chinese Medicine,2023.
[15] Shen YJ. Research on fault diagnosis and life prediction of ball screw subassembly based on deep learning[D]. Qingdao University of Technology,2023.