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Internet of Things Technology in Smart Furniture: An Overview

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Abstract: Advances in IoT technology have made physical devices smarter and more accessible, allowing these devices to be used in a wide range of complex and necessary operations such as agriculture, food supply, smart cities, and health monitoring, while the core concept of the smart home is to use carefully designed management features and integrate the latest information and communication technologies and energy technologies to provide residents with a convenient, safe, entertaining, and comfortable living environment . This study reviews the integration of Internet of Things (IoT) technologies with smart homes, synthesizing the key findings from 20 articles from Web of Science, 2 articles from Google Scholar, and 4 articles from IEEE related literature. It is shown that the integration of IoT technologies with smart furniture systems has significant results in improving connectivity, automation and efficiency in residential and office environments. Although there are some challenges, they can be addressed by taking appropriate measures and have already contributed to the widespread adoption and development of smart furniture technologies. The application of IoT in smart furniture heralds future trends and potential opportunities for smart lifestyles.

1. Introduction

The revolution of Internet of Things (IoT) has helped people to connect and manage physical devices anywhere and anytime, thanks to IoT, physical devices nowadays have become smarter and easier to access, IoT also helps us to utilize these devices in complex and necessary operations. IoT allows physical devices nowadays to communicate with each other, providing human-to-machine communication and machine-to-machine communication [1]. In application areas IoT is also widely distributed such as agriculture, food supply, smart cities, health monitoring etc. By 2025, the financial impact of IoT is expected to be $6.2 trillion per year [2].

The main concept of a smart home is to employ well-designed management functions, as the emergence of a large number of information and communication technologies and energy technologies allows residents to easily integrate technologies and services in their homes and provides residents with the ability to optimally control the maintenance of their homes. Incorporating the latest modern communications and energy technologies into housing will provide a strong impetus for the development of new services and applications. A smart home is "a living environment with information and communication technology that provides residents with convenience, safety and security." Providing appropriate functions for, entertainment uSince the

Internet of Things has been influencing and building our society, such as urban areas, agriculture, transportation, housing environment and healthcare systems, it is natural to apply the Internet of Things to the field of smart homes, and this has also established A unique field of Smart Home Internet of Things (SHIoT). Smart homes and the Internet of Things continue to impact our lives through services that are connected anytime and anywhere. In light of this trend, some scholars believe that smart home [3] is an IoT field because it integrates home automation systems with the IoT. Smart home systems consist of a large number of sensors and switches that are connected to a main gateway, which is the primary control system that users access through digital devices such as smartphones or desktop PCs [4].

This study focuses on the literature review of the union of IoT and smart home, totalling 26 papers, of which 20 were searched by Web of Science, 2 by Google scholar, and 4 by IEEE. The specific structure of the paper is divided into seven parts, the first part is an introduction, the second part is an overview of the IoT technology fundamentals, the third part is an overview of the application areas of smart furniture, the fourth part is the future trends, the sixth part proposes the challenges and solutions, and the seventh part is the conclusion.

2. Basics of IoT Technology

The Internet of Things (IoT) is a rapidly evolving networking paradigm that is fundamentally changing the interactions between things prevalent in the cyber, physical and social domains. In this regard, Ning and Liu construct an innovative Cyber-Physical-Social-Thinking (CPST) framework, from which they propose a technology framework covering scientific aspects. This framework focuses on a series of key enabling technologies, including the key areas of resource management, energy management, data management, session management, security and privacy protection, feedback control, spatio-temporal coherence, nanotechnology and quantum technology. [5].

IoT technology is expected to contribute significantly to the development of smart communities in smart cities, bringing significant benefits by enhancing physical infrastructure and engaging human stakeholders [6]. In order to elaborate on the challenges of IoT, researchers such as Klara and Daniel will first outline the framework of the environment in which IoT resides, followed by a discussion of the challenges faced and the corresponding conclusions and recommendations.

To address the challenges of IoT security, blockchain technology and cybersecurity standards have been proposed to build a decentralized trust and authentication network system. Researchers such as Durand and Gremaud have developed an IoT-centric and scalable decentralized public key infrastructure (PKI) [7]. They also explored how to integrate this system with emerging Web authentication and authorization frameworks to enable it to adapt to resource-constrained environments.

The Industrial Internet of Things (I-IoT) focuses on interconnecting devices in manufacturing systems with the goal of improving productivity, efficiency, safety, and intelligence, and its needs are significantly different from those of consumer IoT. In this regard, researchers such as Hansong and Wei propose a three-dimensional framework for reviewing existing research and analyzing the application of various networking technologies, including 5G, machine-to-machine communications, and software-defined networking. In addition, they propose a second three-dimensional framework that focuses on computing issues in the Industrial Internet of Things (IoT), delving into cloud computing, edge computing, and hybrid cloud and edge computing platforms. These frameworks help to fully understand and address the key technical challenges in I-IoT [8].

Integrating IoT devices with legacy systems can be achieved by employing a security level authentication approach that aims to secure the system. In this regard, Hezam and Konstantas review existing frameworks for IoT security and privacy guidelines, while pointing out the

shortcomings of these frameworks. They also provide a qualitative analysis that argues for the potential application and effectiveness of these frameworks in addressing IoT security challenges. This approach not only strengthens security measures, but also provides theoretical and practical support for the integration of IoT with traditional systems [9].

The combination of blockchain technology and smart cities brings key requirements and challenges for the development of IoT-based smart cities. In this context, researchers such as Umer and Latif U. detail the development of blockchain technology, including compositional techniques, consensus algorithms, and the evolution of blockchain platforms [10]. They also describe the key requirements for the integration of blockchain technology with smart cities, which concern how blockchain can be utilized to enhance data security, transparency, and operational efficiency in smart cities. These studies not only demonstrate the potential of blockchain applications in smart cities, but also point out the technical and strategic challenges to achieve this goal.

As energy supply tightens and demand continues to grow, concerns about energy use and building maintenance are becoming increasingly important. In this context, researchers such as Arun and Sharad have proposed a smart building architecture that is secure and energy efficient. In the field of smart buildings, the application of IoT technology can create such an architecture that enables the building's technological systems to maximize the efficiency of energy use while maintaining security. By precisely controlling the energy consumption and environmental impact of the building, this architecture not only optimizes the energy performance of the building, but also improves the comfort and functionality of the living and working environment [11].

The integration of FIWARE and IoT-NDN (Named Data Networking) provides a comprehensive approach to utilizing IoT devices in a variety of domains such as healthcare, city management, energy, and industry [12]. FIWARE is an open source IoT middleware designed to simplify the transfer of data and the handling of big data tasks. This system has become an ecosystem technology that optimizes the development of various applications and services in IoT. By using FIWARE, organizations can manage and analyze data collected from IoT devices more efficiently, thereby improving operational efficiency and the quality of decision making.

IoT technology is playing a crucial role in the development of smart healthcare systems, especially in the area of bio-cognitive detection through wireless telecommunication technology and artificial intelligence [13]. Manikam and Thangaraju have developed a thin-film based biosensor specifically designed to detect uric acid (UA) in the blood, which is crucial for diagnosing diseases such as arthritis. In addition, the system ensures that data can be securely retrieved from the cloud and supports data visualization across multiple platforms, which provides healthcare professionals with a powerful tool so they can monitor and manage diseases more effectively. This integration of IoT and biosensing technologies not only improves diagnostic accuracy, but also enhances the efficiency of data management and analysis.

By examining the key technologies and frameworks of the IoT, it is clear that IoT technologies can be effectively integrated with smart furniture systems to enhance connectivity, automation and efficiency in a variety of environments. This integration allows smart furniture to not only respond to user needs, but also collect and analyze data in real time, which in turn optimizes the home or office environment. For example, through IoT technology, smart refrigerators can adjust the temperature and humidity based on the food stored, and smart lighting systems can automatically adjust the brightness based on the light in the house and the activity of the occupants. These smart improvements not only enhance the quality of life, but also reduce resource wastage by improving energy efficiency. And these articles can be broadly categorized into four categories as shown in Table 1, which are IoT technologies and frameworks, IoT security and challenges, IoT applications in industrial and urban environments, and practical applications of IoT in specific domains.

Table 1: Article classification for IOT

Category	Covered by study
Internet of Things Technology and Framework	[5], [11]
IoT Security and Challenges	[7], [9]
Internet of Things Applications in Industrial and Urban Environments	[6], [8], [10]
Practical applications of IoT in specific areas	[12], [13]

3. Applications in Smart Furniture

In recent years, the concept of smart furniture has received a lot of attention because of the possibilities it can create and the convenience it can bring. Tokuda and Takashio et al. present the idea of using smart furniture as a platform for context-aware embedded universal applications, highlighting its potential to transform non-smart spaces into smart hotspots with Internet connectivity and personalized services [14]. This innovative approach addresses the cost and time challenges of deploying embedded pervasive applications in various space.

Furthermore, Jardim-Goncalves and Maria Jose Nunez et al. emphasize the importance of secure e-business services in the furniture industry to meet the demands of the global economy. They pointed out that in the emerging networked digital economy, the adoption of new technologies and practices can stimulate companies to improve the interoperability and efficiency of smart organizations [15].

Krekar and Maresova et al. propose a definition of smart furniture based on an analysis of literature and patents, describing it as connected furniture equipped with intelligent systems or user controls[16]. This definition is in line with the current trends of digitization, smart cities and the Internet of Things, and reflects the evolution of the furniture industry to adapt to modern technological needs.

As technology continues to advance, smart furniture plays a crucial role in the development of smart cities and smart infrastructure.Fraga-Lamas et al. propose an architecture based on LoRaWAN fog computing that provides practical guidance for designers and developers of smart parks. This helps to simplify the deployment and research of LoRaWAN networks in smart parks as well as in other large-scale environments such as smart cities, thus facilitating the implementation and optimization of smart solutions [17].

In addition, as discussed by Georlette and Moeyaert et al, outdoor optical wireless communication technologies have great potential in smart cities, which further emphasizes the importance of incorporating innovative technologies, such as smart furniture, into urban environments to enhance connectivity and efficiency [18]. Such technologies not only enhance data transmission speed and reliability, but also provide critical support for the continuous development of smart cities, making urban spaces smarter and more connected.

These articles focus on the application of smart furniture in smart cities and digital environments and their potential impacts and can be broadly categorized into two groups as shown in Table 2, Smart Furniture Technologies and Applications and Smart Furniture and Global Economic Impacts.

Table 2: Article classification for smart furniture

Category	Covered by study
Smart furniture technology and applications	[14], [17], [18]
Smart furniture and global economic impact	[15], [16]

4. Future Trends

The scope of applications of Internet of Things (IoT) technology has been widely extended to a wide range of fields such as smart grid, smart agriculture, healthcare, building energy management, smart manufacturing and smart maintenance. Yang et al. pointed out that IoT-based systems in smart farms can optimize agricultural production processes through remote monitoring and control technologies, and looked at the core technologies that may be applied to the agricultural sector in the future [19].

Cheng et al. explored the integration of Industrial Internet of Things (IIoT) for smart manufacturing in future 5G environments, emphasizing the key role of 5G technology in driving IIoT adoption[20]. Reddy et al. provide an overview of the trends, applications, and challenges of machine learning in IoT and highlight the important role of machine learning algorithms in optimizing IoT systems[21].

In addition, a smart IoT-based maintenance solution that combines cloud computing and IoT technologies for remote monitoring and control of industrial machines in the future was proposed by Ayad et al. Hong et al. examined the various factors that influence the willingness to use smart home devices and highlighted the growing trend of IoT adoption in residential settings[22-24].

Finally, Degada et al. explore the concept of smart villages and the potential applications of IoT technologies in rural areas to drive economic growth[24], improve agriculture, and enhance health and education services. Taken together, the literature review shows that the use of IoT technology is growing in a number of areas, including smart furniture, which paves the way for future integration and advancement of smart technologies.

5. Challenges and Solutions

The combination of the Internet of Things and smart homes still faces many challenges. Of course, researchers have also provided their answers to these difficulties. Judging from the content of the review, the challenges are roughly technology integration and compatibility, data security and privacy, Cost and resources, technology popularity and acceptance; smart furniture needs to be seamlessly integrated with the existing home environment and other smart devices, which may involve compatibility issues between different devices and systems. Moreover, the widespread use of smart homes also increases the risk of data leakage. The same widespread use also means an increase in economic costs and maintenance costs.

The researchers' solutions include the adoption of open standards and protocols, enhanced security measures, cost-benefit analysis and innovative financing models, user education and participation, etc. Standard protocols can be more easily compatible with most other devices, advanced encryption, use of security protocols, and improved education can help you better protect yourself, conduct detailed cost-benefit analysis, and explore models such as Hardware-as-a-Service (Hardware-as-a-Service) -a-Service) to reduce the user’s upfront costs.

6. Conclusion

By synthesizing these articles, we argue that the integration of IoT technologies with smart furniture systems significantly improves connectivity, automation, and efficiency in residential and office environments. Although there are some challenges, they can be overcome by other measures. These measures have helped drive the widespread adoption and development of smart furniture technology. The application of IoT in smart furniture foreshadows the future trends and potential of smart lifestyles.

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