www.cadanda.com
Computer-Aided Design AND APPLICATIONS

Application of Artificial Intelligence in Computer Aided Intelligent Home Terminal Interactive Design

Qiaoling Guo[1] and Qingbin Hou[2,*]

[1]School of Art Engineering, Shaanxi Fashion Engineering University, Xi'an, Shaanxi 712046, China, guoqiaoling-16@163.com
[2]College of Fashion Art, Shaanxi Institute of International Trade & Commerce, Xi'an, Shaanxi 712046, China, houqingbin@csiic.edu.cn

Corresponding author: Qingbin Hou, houqingbin@csiic.edu.cn

Abstract: With the maturity and integration of artificial intelligence, big data, Internet of Things, cloud computing, 5G and other computer technologies, our life is becoming more comfortable, convenient and efficient. Artificial intelligence has made incredible changes in many aspects of daily life. Based on artificial intelligence technology, this paper constructs a smart home system architecture that accurately connects consumers and designers to meet consumers' personalized home customization needs. This paper analyzes the three key elements of connection, matching and interaction involved in artificial intelligence technology and home design, reveals the common problems in the current smart home system, and designs a barrier free, accurate connection, matching and interaction smart home terminal system framework assisted by computers, which provides a theoretical basis for the application of artificial intelligence technology in smart home design.

Keywords: artificial intelligence; Smart home; Terminal design; interactive.
DOI: https://doi.org/10.14733/cadaps.2023.S5.22-31

1 INTRODUCTION

The emergence and rapid development of artificial intelligence, big data and Internet of Things technologies have subverted people's lives [1]. With the introduction and popularization of the concept of smart home, more and more artificial intelligence technologies are applied to intelligent devices, such as image recognition, voice recognition, natural language processing and other technologies, which play an important role in smart home scenes [2]. Relying on the artificial intelligence technology, intelligent home devices are constantly innovating. In combination with image recognition, voice recognition and other technical means, smart home can not only realize remote control of equipment, but also interact through voice and other means, or detect abnormalities through video monitoring and timely and automatic warning. Wang et al. [3] concluded that Artificial intelligence technology promotes the systematic development of smart

home. The human-computer interaction mode will develop from the traditional manual control mode to the direction of self-excited induction and self-excited feedback of smart home products. The combination of home space and artificial intelligence technology will become the technological breakthrough and investment growth point of the future home industry development.

At present, the technical support of AI for smart home is still in its infancy. Whether it is an intelligent household product or a smart home platform and system, most of them remain at the level of a single function, have not yet formed an integrated advantage, and still have a gap with the ideal user experience expected by consumers [4]. The comprehensive application of intelligent home has great development potential in China. Researchers have done a lot of research on the integration of artificial intelligence technology and smart home design, and have achieved fruitful results in recent years. On the basis of previous research results, this paper discusses the construction of intelligent home terminal interaction design system based on artificial intelligence, aiming at solving the problems of intelligent docking and interaction in traditional home design, and providing theoretical reference for barrier free and accurate design matching and interaction practice.

2 ARTIFICIAL INTELLIGENCE TECHNOLOGY IN HOME DESIGN

The earliest research on smart home in the world can be traced back to the 1980s, when the United States monitored the air conditioning, elevators, lighting and other equipment of the building during the transformation of some old buildings, providing some simple communication services for the building. Later, Canada, Australia, Singapore and other economically developed countries have also explored the field of smart home design. Smart home is widely used in the United States, Germany, Spain, Japan and other countries. The "House of the Future" built by Bill Gates in 1990 is fully compatible with the concept of smart house. It is not only connected to the Internet, but also has all the doors, windows, lamps, and electrical equipment controlled by computers. It is called Smart home and is the prototype of modern smart house [5].

In the residential space, smart home combines architecture, household appliances, network communication and equipment automation, as well as system structure, service and management. Al-Ali et al. [6] utilized generic cabling technology, network communication technology, security prevention technology, automatic control technology, and audio and video technology to integrate facilities related to home life, build an efficient management system for residential facilities and family agenda, and improve home safety, convenience, comfort Artistic, and realize the living environment of environmental protection and energy conservation. Smart connects household appliances or devices through Internet of Things technology and mobile Internet, provides security control, lighting control, water and electricity control, network control, health monitoring and other functions and means, and provides an efficient, comfortable, safe, convenient and environmentally friendly home space environment.

2.1 Intelligent Access Control and Security

The smart door connects with the smart host through voice and iris technology or face recognition, and transmits information to the mobile phone, tablet computer or computer through the network. The smart door identifies the owner through the above recognition technology. The specific performance is as follows:

(1) When the intelligent system recognizes the owner's information, it sends out a command: such as a verbal prompt like "Welcome home", and the door opens immediately to welcome the owner home.

(2) When an outsider or stranger needs to enter the home, the smart door transmits information to the smart host, which transmits information to the mobile phone through the network. The host can make a remote call with the outsider through the mobile phone or tablet computer, and can enter only with permission.

(3) The window is equipped with infrared sensors, sensors and other devices, and connected with the smart host. If the wind and rain come, the window will close automatically.

(4) If strangers or thieves break in forcibly, the system will transmit the information to the mobile phone to remind the owner and give an alarm.

2.2 Intelligent Lighting

Intelligent lighting is the intelligent opening of lamps in the home space by sensing light and capturing people. In the daytime when the light is strong, it will automatically turn off. In case of insufficient light in rainy days, the lamps can be turned on intelligently through infrared induction. When people leave the radiation range of the lamp, the lamp will automatically turn off. Environmental protection, energy conservation and humanization. The lamps in the bedroom and bathroom can be set in multiple modes. When the owner enters sleep, the lamp automatically enters sleep mode. When the owner gets up at night, the lamp slowly turns on the weak and soft light, so as not to make your eyes uncomfortable under the dazzling white light. When normal lighting is required, the owner can switch the lighting mode through voice.

2.3 Intelligent Household Appliances

Home appliances refer to the main appliances in the home, such as televisions, refrigerators, washing machines, air conditioners, etc. Home appliance intelligence is to make home appliances intelligent. The TV can be turned on and off by voice. You can find the channel or program you want to watch by voice. The host can also use gestures, eyes, and distance to interact with the TV. When people leave the TV and no one watches, the TV automatically enters the standby mode or turns off automatically. The owner no longer has to worry about not finding the remote control, and at the same time, it also achieves the goal of energy conservation. The air conditioner can be automatically adjusted by human behavior and the temperature of the overall space, rather than manually adjusted by the remote-control owner. When the owner leaves the space for a period of time, the air conditioner will automatically turn off, without the owner worrying about leaving the home without turning off the air conditioner.

2.4 Intelligent Health System

In the design of home space, the intelligence of health system will be paid more and more attention. People install ultraviolet sterilization equipment in their home space. The device automatically detects harmful germs in the home space through the detection system, and transmits the information to the smart host, which transmits the information to the mobile phone or tablet. After that, the system turns on the UV system through remote control to disinfect the whole space and protect the health of the family. The smart toilet at home is also a detection machine. After detecting and analyzing feces and urine, it sends relevant parameters to the mobile phone to remind the owner to pay attention to health. The floor sweeping robot has already come out. If you equip a floor sweeping robot in your home space, it will save the owner much trouble. On the way to and from work, the owner remotely controls the intelligent sweeping robot to clean the house through mobile phone operation. In case of failure, the information is transmitted to the mobile phone APP, and the owner can realize remote adjustment through home monitoring to complete the cleaning work and maintain the cleanliness of the home.

2.5 Intelligent Emotional System

Emotional intelligence system is not a single intelligence, but is integrated into various intelligent requirements of home space. In terms of health and hygiene, when the health indicators of the host are abnormal, the emotional intelligence system sends relevant precautions to the host's mobile phone and gives voice prompts. The emotional design of smart home mainly follows the following principles:

(1) Interactive experience is humanized. While people's material life is steadily improving, their emotional demands are also getting higher and higher. Therefore, in the process of smart home design, smart home should combine people's interactive actions and behaviors to awaken people's

emotions. For example, when the owner stands outside the house, the access control intelligence will say to the owner, "The owner is tired, welcome the owner home", and then the door will open automatically. At the weekend, the host will be reminded of "Do you want to get up late tomorrow weekend?" and other warm instructions with emotion.

(2) Naturalization of situation simulation. Smart home designers need to consider users' living habits and individual differences according to different customer groups, reflect the particularity, naturalness and authenticity of the design, and thus enhance users' sense of participation and recognition of the product. For example, in the bedroom, when the host is still up late, the smart home will prompt the host with warm instructions under such natural situations as "It's too late, take a rest early".

(3) Agility of information processing. Smart home uses the effective application of modern technologies such as big data and cloud computing to quickly and accurately collect information and provide users with accurate services.

(4) The system is open and secure. The security design of smart home is particularly important. As smart home provides users with an open communication environment, which is conducive to information sharing and interaction, but also has security risks, it is necessary to further strengthen security design, such as video monitoring, access control, etc., to ensure the safety of users.

(5) Efficient use of space. From the purpose, smart home is mainly to provide people with a comfortable and convenient living environment. Automation technology can effectively improve the use efficiency of space. Users can choose different services according to their own needs to achieve better emotional experience. In the emotional design of smart home, it is necessary to consider the influence of various factors and follow the above five principles to ensure the applicability, scientific nature and rationality of smart home, provide people with better smart home products, and promote the healthy, stable and rapid development of smart home.

3 TEST AND RESULT OF INTERACTIVE DESIGN SYSTEM

3.1 Requirements for Interactive Design System

According to Sepasgozar et al. [7], the smart home system uses artificial intelligence technology to collect voice and image data through end devices, and realizes voice and image recognition and analysis through AI tasks such as cloud model and end side reasoning, thus controlling intelligent devices. According to big data, Figure 1 shows the relationship between the development of artificial intelligence technology and the acquisition of voice and image data in smart home. It can be seen from the Figure that AI technology has greatly promoted the ability of terminal equipment to collect voice and image data. The smart home terminal designed in this paper needs to adapt to a variety of intelligent application scenarios, integrate programming language, voice, vision and deep learning technologies, and have universality, intelligence and the ability to complete complex tasks to achieve the intelligent function of controlling home devices in the home environment. The main application scenarios of smart home terminal design are shown in the Figure 2.

Among them, face unlocking: capture the image or video stream containing a face with a camera or camera, and automatically detect and track the face in the image, so as to carry out face recognition on the detected face, carry out identity verification, and achieve face brushing unlocking.

Electronic fence monitoring: This intelligent function is to monitor the garage, house, bedroom and other places at midnight through the cross ruler or rectangular ruler camera to detect the intrusion of suspicious people. If it reaches the warning line designated by the cross ruler, it will automatically give an early warning or alarm to take corresponding measures.

Intelligent voice: This function module is mainly a combination of offline voice recognition, online voice recognition and App remote control. For offline and online speech recognition functions, the system not only needs to correctly recognize control commands, change the

operating state of corresponding intelligent devices, but also needs to correctly interact with users' non control commands.

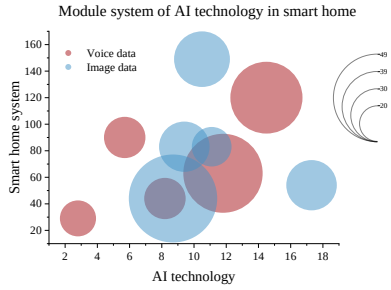

Figure 1: The relationship between the development of artificial intelligence technology and the acquisition of voice and image data.

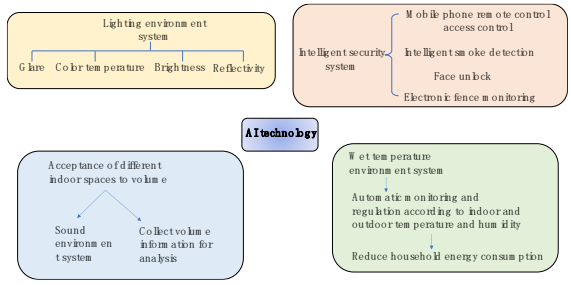

Figure 2: Application module system of AI technology in smart home.

In order to realize the remote control of household devices using App, the system should not only recognize text messages, but also support voice messages.

3.2 Construction of Smart Home Terminal Interaction Design System

In order to highlight the function of system design docking and matching, based on artificial intelligence technology, the article highlights the two main modules of consumers and designers under the household design system architecture, as shown in Figure 3.

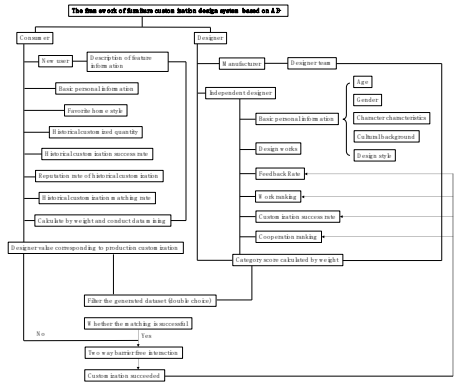

Figure 3: Framework of Home Customization Design System Based on "Artificial Intelligence+".

For active interaction in smart home scenarios, utility and communication are considered to be the basic attributes of active interaction, that is, the premise of realizing the main functions of task execution and user communication, which specifically includes eight functions, including teaching, planning, control, notification, reminder, push, suggestion and inquiry. According to different initiatives, products are generally considered to have strong and weak functional differentiation to meet the needs of different interaction scenarios. Based on this, Shi et al. [8] divided the active interaction of home intelligent products into strong active interaction and weak active interaction. Among them, strong active interaction includes notification, reminder, push, teaching, planning, control, etc. It mainly depends on the product itself to collect and analyze information, make decisions and initiate interaction, so the user's initiative is relatively weak. The weak initiative requires users to exert their subjective initiative to guide system services. Figure 4 shows the relative relationship between strong and weak active interactions in smart home products. It can be seen from the Figure that only when strong and weak active interactions are effectively combined to achieve a relatively balanced state, can they be effective and practical in smart home scenarios.

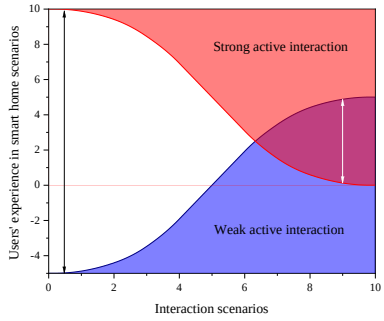

Figure 4: The relative relationship between strong and weak active interactions in Smart Home Scenarios.

As the main party of decision-making and action, users reduce the intelligence of the machine, including suggestions, inquiries, custom settings and other functional content. In the smart home scenario, the active interaction of products is embodied in both the instrumental nature of helping users to handle relevant affairs and the interactive nature of communication with users. Therefore, which party is the main initiator of decision-making and interaction, and how to allocate strong and weak active functions in active interaction systems become the focus of active interaction research. The combination of strong and weak active functions can undoubtedly improve users' experience of products in smart home scenarios. However, excessive strong initiative will also bring privacy invasion and loss of control. In addition, the information overload caused by active interaction will also cause user experience problems such as user cognitive load, while too many weak initiatives will reduce the user's intelligent experience and the efficiency of task execution, without fully playing the advantages of active interaction. In order to meet the needs of different interaction scenarios, the initiators of decisions and interactions need to timely allocate between users and products, that is, the alternation of initiative. And Yan et al. [9] argued that strong active and weak active functions cannot be applied to existing smart home scenarios. Therefore, on this basis, this paper classifies and summarizes four active interaction modes, namely, mandatory active interaction, auxiliary active interaction, reminding active interaction and predictive active interaction, as shown in Figure 5.

In order to give users a higher quality service experience, AI technology pays more attention to human factors in the process of its commercial application. Design is involved in it, mainly from the four aspects of perception, display, control and understanding, to promote the orderly and active interaction design centered on people, so as to enhance people's experience in the intelligent scene.

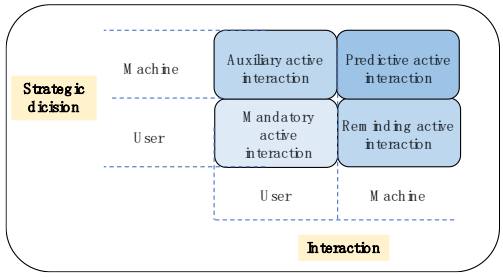

Figure 5: Content and Mode of Active Interaction Function in Smart Home Scenarios.

This paper builds an information architecture model from four levels: knowable, visible, controllable and predictable. Through the design expression of decision-making and interaction, it builds a sense of trust between people and smart home products, so as to achieve orderly and active interaction centered on people, as shown in Figure 6. It can be seen from the Figure that the information architecture model built from the four levels of perception, display, control and understanding can give users a higher quality service experience, and can play a more important role in building a sense of trust between people and smart home products.

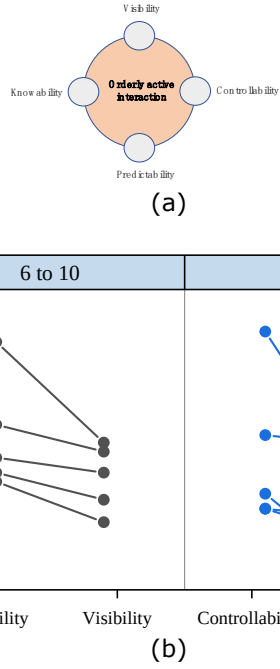

Figure 6: Schematic diagram of orderly and active human centered interaction.

3.2.1. Actively create personalized interactive content recommendation:
designers help predict the needs of different users in different scenarios through active interaction at the perception level, with the intention of realizing the humanization of emotion and personality. On the one hand, we can use AI technology to effectively carry out personalized content recommendation for users' individual interests. Under the background of big data, we collect rich individual interest samples. Through the application of machine learning and AI technology, products pay more and more attention to personalized recommendation; On the other hand,

mobile terminal devices can perceive the characteristics of different scenes, and designers can accurately design for the occasion by sensing and analyzing the user needs of the current scene, so as to enhance the user's comfort and pleasure.

3.2.2. Actively provide multiple forms of interaction based on mobile Internet:
designers can help provide situational and diversified presentation of information in a design way according to the specific needs of users and scenarios. Moreover, through the alternate guidance of the above four active interaction modes, the visual effect and interaction experience can be optimized while meeting the user's needs, so as to simplify the operation steps and conform to the user's usage habits, making the interaction more efficient and smoother. Multi-screen linkage extends to the mobile terminal. At the same time, the information sharing between smart home products and smart terminals enables the transmission and interconnection of broadcast content between multiple screens through screen operation, realizes the interconnection of multiple systems and terminals, and builds the ubiquitous connectivity.

3.2.3. Actively establish multi-channel integration paths to expand more interaction space:
designers can meet the needs of users in different situations by establishing interaction models to integrate voice, face, gesture, physiological signals and other ways, so as to more conveniently and accurately judge the true intentions and needs of users, and provide timely and accurate responses and services. In addition, in the specific design, the designer can facilitate the connection and switching of multiple scenes by presetting interaction scenes and using multi-channel integrated interaction paths.

3.2.4. Actively assume interactive roles to build and strengthen trust relationship:
designers can actively design the so-called "artificial design" of agents through insight into users' emotional needs, that is, to form a role image composed of personality characteristics, human-computer relationship and basic attributes in the interaction process between users and agents to cater to different types of users. By constantly enriching the expression dimensions of the artificial design, we can establish a strong coupling relationship with users in the interaction. By integrating emotional factors into the interaction design, we can better promote users to generate positive emotions and happy memories in the use process, and further improve users' product use intentions and trust tolerance. At the same time, users' concerns about privacy invasion, cognitive load and other issues are fully considered to avoid excessive hierarchy in interaction design. In the long run, the establishment of trust relationship can finally build a human centered orderly active interaction system at the four levels of perception, display, control and understanding.

3.3 Hardware Design of Smart Home System

The hardware of the smart home control system mainly uses the Nano development board as the core processor to detect the environmental parameters through various sensors [10]. The system accesses the electrical signal output by the sensor to the A/D conversion module of the development board and converts it into a digital signal that the development board can process. The system interfaces with intelligent devices such as electric curtains, adjustable lighting, sensor components, etc. through the WiFi gateway, and also interfaces with human-computer interaction devices such as microphones, cameras, speakers, displays, etc. Then, the system sends to the ECS through the WiFi module, and sends some important parameter values to the mobile app for display. As illustrated in Figure 7, the core hardware modules include the following:

(1) Development board selection: The Jetson Nano is a powerful minicomputer of NVIDIA, which can support entry-level edge AI applications and devices. It has 5W low power consumption, and can be externally connected with HDMI and network cable, 64G memory card and a variety of IO interfaces, which can meet the requirements as the core processor of the system.

(2) Camera: The system adopts Haikang webcam DS-IPC-B12V2-I, with 2 million pixels and 8mm focal length, and supports infrared camera, meeting the camera requirements of the electronic fence case.

(3) Voice system: The system can use a microphone array or a cheaper USB drive free starting microphone, which can meet the requirements.

(4) Access control system: The system adopts an access control power controller of model KT-P101, which supports charging overload protection. As well as the electric mortise lock of model KT-L606, the starting current is 110mA, the magnetic induction locking mode is adopted, and the door opening mode of power on locking and power off unlocking is supported.

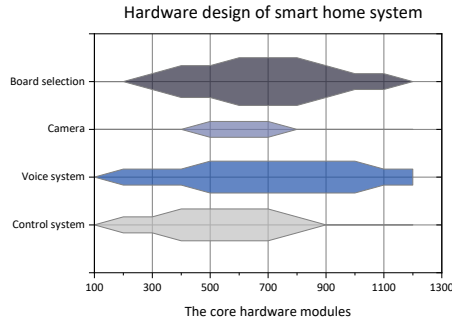

Figure 7：Diagram of hardware design of smart home system.

3.4 System Software Design

In the design, the system uses the gateway to realize the communication link between various devices and the Internet of Things platform, which integrates device management, data communication, message subscription and other functions. Downward support for connecting intelligent terminal devices and collecting device data to the cloud. The cloud API is provided upward, and the mobile app can send instructions to the device by calling the cloud API to achieve remote control.

After the equipment is connected to the Internet of Things platform, the equipment data can be reported to the cloud. Through the integration of other cloud products related to the Internet of Things platform, the message communication between devices and servers, as well as the processing and storage of device data can be realized. The system can also realize the AI function of voice recognition or image recognition through the AI service on the cloud, or directly deploy the model to the JetsonNano development board to complete the AI model reasoning of local voice recognition or image recognition.

4 CONCLUSION

AI technology plays an important role in the innovation and development of smart home system design. How to deal with the compatibility of smart home system construction and AI technology is also a problem that the current home design industry and AI technology industry need to face together. The computer aided intelligent home system based on artificial intelligence technology has changed the design mode of traditional home by using intelligent algorithms. With "customer orientation" as the core idea, it has changed the problem of difficult connection, matching and interaction between consumers and designers caused by the information island phenomenon of traditional home. Relevant industries should establish the operation standards and specifications for integrating AI technology into the home furnishing industry as soon as possible, simplify the user's mobile phone operator interface and steps, increase the research and development and investment in the smart home AI cloud platform, and gradually promote the market promotion of AI technology in the smart home system. The era of real smart home has come, which will help

the smart home market at the start-up stage to develop steadily and enable users to obtain more personalized and situational enhanced experience.

5 ACKNOWLEDGEMENTS

This work was supported by Scientific research and innovation team construction project of Shaanxi Fashion Engineering University (No.2022XT02); Scientific research platform project of Shaanxi Institute of Fashion Engineering (No.2022XP03).

Qiaoling Guo, https://orcid.org/0000-0002-5400-7836
Qingbin Hou, https://orcid.org/0000-0001-9129-1170

REFERENCES

[1] Vourganas, I.; Stankovic, V.; Stankovic, L.: Individualized responsible artificial intelligence for home-based rehabilitation, Sensors, 21(1), 2020, 2. https://doi.org/10.3390/s21010002
[2] Lee, D.; Tsai, F.-P.: Air conditioning energy saving from cloud-based artificial intelligence: case study of a split-type air conditioner, Energies, 13(8), 2020, 2001. https://doi.org/10.3390/en13082001
[3] Wang, C.-X.; Di Renzo, M.; Stanczak, S.; Wang, S.; Larsson, E.-G.: Artificial intelligence enabled wireless networking for 5G and beyond: recent advances and future challenges, IEEE Wireless Communications, 27(1), 2020, 16-23. https://doi.org/10.1109/MWC.001.1900292
[4] Woniak, M.; Poap, D.: Intelligent home systems for ubiquitous user support by using neural networks and rule-based approach, IEEE Transactions on Industrial Informatics, 16(4), 2020, 2651-2658. https://doi.org/10.1109/TII.2019.2951089
[5] Cui, Y.; Zhang, L.; Hou, Y.; Tian, G.: Design of intelligent home pension service platform based on machine learning and wireless sensor network, Journal of Intelligent and Fuzzy Systems, 40(2), 2021, 2529-2540. https://doi.org/10.3233/JIFS-189246
[6] Al-Ali, A.-R.; Zualkernan, I.-A.; Rashid, M.; Gupta, R.; AliKarar, M.: A smart home energy management system using IoT and big data analytics approach, IEEE Transactions on Consumer Electronics, 63(4), 2018, 426-434. https://doi.org/10.1109/TCE.2017.015014
[7] Sepasgozar, S.; Karimi, R.; Farahzadi, L.; Moezzi, F.; Shirowzhan, S.; Ebrahimzadeh, S.-M.; Hui, F.; Aye, L.: A systematic content review of artificial intelligence and the internet of things applications in smart home, Applied Sciences, 10(9), 2020, 3074. https://doi.org/10.3390/app10093074
[8] Shi, Q.; Zhang, Z.; Yang, Y.; Shan, X.-C.; Salam, B.; Lee, C.-K.: Artificial intelligence of things (AIoT) enabled floor monitoring system for smart home applications, ACS nano, 2021, 15(11): 18312-18326. https://doi.org/10.1021/acsnano.1c07579
[9] Yan, W.; Wang, Z.; Wang, H.; Wang, W.-D.; Li, J.-H.; Gui, X.-L.: Survey on recent smart gateways for smart home: Systems, technologies, and challenges, Transactions on Emerging Telecommunications Technologies, 33(6), 2022, e4067. https://doi.org/10.1002/ett.4067
[10] Zaidan, A.-A.; Zaidan, B.-B.: A review on intelligent process for smart home applications based on IoT: coherent taxonomy, motivation, open challenges, and recommendations, Artificial Intelligence Review, 53(1), 2020, 141-165. https://doi.org/10.1007/s10462-018-9648-9