Design strategy research on active interactive system for household appliances based on artificial intelligence

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Abstract—In the era of artificial intelligence, active interaction has become an emerging design and development trend, bringing many opportunities and possibilities to the system innovation and experience upgrade of intelligent household appliances. This research firstly analyzed and sorted out documents in related fields such as human-agent active interaction, interaction design in intelligent household appliances and user-centered interaction design, combined with active interaction cases at home and abroad as well as other smart life fields. According to the system process and operating mode, the interaction stages of "perception-display-control-understanding" were divided. And the connotation, performance, value and opportunity points of design intervention and opportunity points of active interaction in each stage were further analyzed. Finally, this research constructed a smart refrigerator active interaction strategy from the user's perspective, from the four levels of user needs that are knowable, visible, controllable, and predictable, which could realize the trust relationship of man-machine collaboration and an orderly and active interaction system.

1. Introduction

Emerging technologies empower the machine to become an agent, which is capable of assisting or replacing humans in deeper task exploration and resolve through data mining and machine learning. In view of this, the real era of artificial intelligence has kicked off.

The accelerated development of artificial intelligence technology has made the Internet of Things environment brought about by the fifth-generation mobile communication technology gradually take shape. It is thus clear that the trend of intelligent household appliances is irreversible [1]. At the same time, with the emergence of "empty-nest families", "two-child families" and other new family forms that are different from the traditional ones, intelligent household appliances need to adapt to wider distributions among different age groups, more diversified emotional care and higher user experience expectations, which the traditional passive interaction cannot achieve. The degree of interaction in intelligent household appliances and even the entire smart home scene, undoubtedly, will change from weak to strong, and finally evolve to active interaction [2], as shown in Fig.1.
2. Characteristic and manifestation of active interaction

According to different interaction elements, such as purpose, behavior, channel and even scenarios, the active interaction mode will also change accordingly. In order to adapt to the interaction needs of different scenarios, this article classifies and summarizes four active interaction modes, namely, commanded active interaction, auxiliary active interaction, reminder active interaction and predictive active interaction, which are shown in Fig.2.

2.1 Commanded active interaction

Commanded active interaction is an active interaction mode with a low degree of intelligence. In most cases, its decision-making and interaction are initiated by the user. Most of them are used in control functions, often in the form of modular, card and other expressions. It is worth noting that the change of interactive content is often controlled by users.

Control management is the most common functional content for active interaction between smart terminal equipment and digital products. In this function, users can customize frequently used function modules to realize quick operation.
2.2 Auxiliary active interaction
Auxiliary active interaction is initiated by users, among which the machine is responsible for decision-making. It proposes to implement interactive functions such as teaching and planning, which often have slide-style, hierarchical and list-style expressions.

The teaching function often takes the difficulties and confusion that users may encounter into account, gradually guides them to learn, understand as well as master, and finally improves the immersion and ability of the user experience. In addition, through advancing encouragement and effective feedback, the user's positive memory of the scene is optimized.

The planning function presents the function of action interaction in a list-like expression. The advantage of this form is that it provides an interactive way for quick browsing and convenient operation, which can allow users to effectively gather information for search and management.

2.3 Reminder active interaction
Reminder active interaction in the form of red dot, bubble and card, which includes notification, reminder, push and other functions, is initiated by the machine. However, the decision is made by users.

The notification function has two main manifestations in the active interaction of intelligent household appliances based on screen interaction, namely "list" and "red dot". Compared with the former, the “red dot” method has a stronger degree of guidance, which can remind users to jump to an application to view and process information in a timely manner. There are digital red dots, pure red dots and “New” deformation types.

The reminder function is also one of the common functions in the active interaction of intelligent household appliances based on screen interaction. It is used to remind users of entering text or function settings and the current required operation, which often appears in the form of covered pop-up windows. As a more obvious prompt box, the reminder function informs users through this powerful interruption operation that they must confirm or cancel in order to resume or continue the current task.

2.4 Predictive active interaction
The most intelligent active interaction mode is predictive active interaction, which is often reflected in interactive functions such as suggestions and inquiries, and appears in the form of default pages, result pages and embedded guidance.

The suggestion functions usually take the form of default page, result page and interactive guidance. When the user operates a certain task, the operation path will go to two final nodes, forward and reverse respectively, one is the final node of the task path, and the other will deviate and enter the default page due to system errors and network abnormalities in the middle.

The most common interactive manifestation of the inquiry function is a pop-up window, such as a dialog box. Because some operations are irreversible, it is necessary to add a confirmation prompt to prevent users from accidentally touching. In addition, similar to the suggestion function, the inquiry function will also take the form of embedded guidance, retaining the original page and embedding visual icons and text on this basis.

3. Human-centered design analysis of active interaction in intelligent household appliances
In order to give users better service experience, artificial intelligence technology re-focuses on the human factor in the process of its commercial application. Design intervenes, mainly from the four stages and levels of perception, display, control and understanding to promote human-machine collaboration, so as to enhance the interactive user experience in smart scenarios [3], as shown in Fig.3.
Fig. 3 User demand levels and interaction design concerns in the active interaction phases

3.1 Perception level: focus on emotional judgment and interaction expression
The ability of machines to perceive and recognize is the prerequisite for the realization of emotional intelligence. The concept of "emotional computing" was the first to be disclosed by Professor Picard of MIT, which gives machines the ability to perceive and express emotions, so that the process of human-machine interaction occurs more naturally. In the future, with the continuous update of software and hardware technologies related to active interaction, smart terminal devices and digital products can have stronger user psychological and physical cognitive mastery as well as better emotional recognition, judgment and control skills, which will be highly valued and emphasized.

3.2 Display level: attach importance to multi-screen display and digital information presentation
The interactive screens of smart terminal devices and digital products are moving towards the trend of continuously expanding their basic parameters and constantly innovating their product forms and materials, in order to be able to adapt to a wider range of applications and cope with more complex and diverse scenarios. To achieve seamless display of information from different electronic devices, more attention should be paid to the sense of continuity. At the same time, in the face of diverse information input, a more perceptual and intuitive display mode can well help users understand information.

3.3 Control level: emphasize the expansion and innovation of channels based on user's five senses
In cutting-edge interaction design research, many researchers have focused on interactions based on the user's five senses in the form of voice, gestures, somatosensory, and physiological signals. At present, due to its superiority in information acquisition and communication, voice interaction has become one of the most natural interaction methods widely accepted and put into use by users. In addition, artificial intelligence technology continues to enhance its own skills in the field of computer vision. After being empowered, the machine becomes an intelligent body. Through accurate identification of perceivable human body information, combined with more detailed calculation and analysis, it is used to realize a reasonable judgment of the user's true intention, and then initiate interaction and decision-making in a timely manner [4].

Due to the addition and empowerment of artificial intelligence technology, the interaction channels and spaces between humans and agents have been continuously innovated and developed. Therefore, the choice of human-computer interaction methods in the future needs to be viewed dialectically: choosing one of them or the integration of multi-dimensional methods, which plays its own advantages and acts in different scenarios with the intention of satisfying the needs of different operating forms.
3.4 Understanding level: highlight human-like interactive metaphors and trust construction
The character setting of the agent mainly revolves around three core elements that can be designed: basic attributes, user relationships and service categories. In the interaction with users, this kind of role image can make the user have a positive or negative emotional experience and usage experience. In the interactive research of smart terminal equipment and digital products in smart home scene, the significance of character setting and maintenance is worthy of attention and reflection. By designing the role image of the agent, it is possible to establish a strong coupling relationship with users from a deeper level of emotion, so as to better promote user's sense of satisfaction, trust and dependence in the continuous interaction, which strives to achieve natural and smooth human-like communication and communication.

4. Construction of human-centered design strategy of active interaction system in intelligent household appliances

4.1 Principles of active interaction design

4.1.1 Follow users
In the actual design of active interaction, it is first necessary to use artificial intelligence technology to fully collect user data information and feedback through data mining and independent learning, to establish a highly related user role and attribute model. Through continuously interacting with users to learn and revise relevant key parameters, the functional services of the agent are becoming more and more sound. Therefore, active interaction places more emphasis on effective two-way interaction by improving the accuracy of predicting user needs.

4.1.2 Avoid interruptions
In active interaction, the intelligent experience actively provides users with suggestions and prompts that they think are beneficial to users through their own judgment and prediction. However, we must face up to the reality of the gap between artificial intelligence and human intelligence. The information collected by the product cannot be completely consistent with users, and there are also errors in judgment. Therefore, it is necessary to add information management and control to active interaction, and consider the form, content as well as occasions of the interaction.

4.1.3 Continuous experience
The agent, in the past, only responds passively after users’ inquiry, which is used as the only source of information. In active interaction, in addition to responding to user needs and feedback, the agent also needs to make real-time service expansion based on changes in the surrounding environment, and track the progress of content and functional services, thereby forming a continuous and pleasant user experience.

4.1.4 Respect for privacy
In order to realize the active interaction in the ideal state, the agent needs a lot of calculation and analysis of user information. Therefore, in daily interaction, the agent needs to actively collect and update multi-dimensional information related to users, which are stored in smart device terminals and digital products that can access the Internet. There is no denying it: this has a certain risk of data leakage. At the same time, the existing forms of interaction in multiple scenarios are relatively single, and there is no distinction between publicity and privacy. Therefore, it is necessary to pay attention to subjectivity and objectivity, to distinguish between public and private scenarios, so that users are able to complete the active interaction alternately in the decision-making process.

4.1.5 Human-machine collaboration
When facing the exposed or updated interactive path and process, users require different levels of
learning costs. Undoubtedly, the interactive system cannot guarantee that the user will complete the operation correctly each time. Therefore, when designing the project, it should be able to timely send users the corresponding help to enhance the user's interest and curiosity. Invalid help, on the other hand, may cause difficulties for users, affect the completion of response tasks and result in bad user experience for users.

4.2 User-oriented perceptual interaction strategy

4.2.1 Users are deeply involved in personalized content production

In the interaction process between intelligent household appliances and users, users interact with the interaction function of the smart home appliance, which will generate complex and rich interactive behavior data. The use of artificial intelligence and data mining technology can analyze user's interactive behavior, and then obtain valuable data. Using recommendation algorithms, such as collaborative filtering algorithms, the agent is able to discover and measure users' preference through their historical behavior data, and then calculate the relationship between users based on the attitudes and preferences of different users towards the same content and deliver specific information to users, such as real-time prompts or feedback, to restrict or authorize users to use certain functions, so as to achieve effective intervention.

4.2.2 Customized content recommendation based on user portraits

Faced with users seeking to upgrade their experience, customization is one of the best ways to meet their individual needs. From mass production to mass customization, personalized customization, clearly, is a spiraling process with the technological revolution of the mobile Internet and the Internet of Things. By extracting user's historical operations and the quantitative information of user's evaluation of the function, we can analyze features that users is interested in as user's usage tendency, and also carry out the feature extraction of functions, then obtain the recommendation result through the matching degree of user's feature preference to functional features. The final formation of accurate user portraits makes it a reality to customize products and services for each user.

4.3 Display interaction strategy based on information attributes

4.3.1 Create a notification system for the purpose of reducing information overload

Under the background of artificial intelligence and mobile Internet, the sober automatic interaction system discovers and obtains continuously different updated data information. If manual intervention is not performed, it will be notified in the hidden bar system or software information. Therefore, the notification system whose ultimate goal is to reduce information overload is deliberately gentle.

The premise of reducing information overload is to analyze which information is users' inactive state, which should also be notified, and which information can be viewed by users. The system needs to follow certain principles: On the one hand, according to the importance of functions, its intelligent function as the core function should have the highest priority; on the other hand, from the priority of the demand level, the display judgment comes first, and the machine-led judgment ranks behind.

4.3.2 Realize real-time interaction through multi-screen linkage

In the future, the platform for linkage and integration between smart device terminals and digital products will be more open and tolerant. Increasing numbers of household appliances and products in other scenarios will also be empowered to become smart terminals, and ultimately realizing interconnection and intercommunication between various scenes will come true. Through the IGRS protocol, Miracast protocol and so on, a series of operations such as multi-content transmission, display, and control are carried out on different terminals, so that each smart home scene has a terminal that can realize convenient interaction, thus achieving a certain degree of "Decentralization".
4.4 Scenario-oriented control interaction strategy

4.4.1 Use scene presets to reduce cognitive load
Cognitive load refers to the total amount of energy that users consume in order to achieve their interaction goals in the process of interacting with the system. The causes of cognitive load can be roughly summarized as excessive options and thinking, or unclear expression. Once the cognitive load is formed, it will have a negative impact on user's understanding of tasks or operations, resulting in difficulties in control and management [5].

Through the card design, pre-setting user's possible operations in each scene based on their behavior data to form corresponding scene cards, users can quickly perform desired operations, which can reduce possible cognitive load and unnecessary repeated interactions. The process, undoubtedly, realizes fast and one-button scene control, and also helps to reduce the computing load of intelligent household appliances.

4.4.2 Manage task interruption combining scenario factors
Scenario factors revolve around the user, including time, location, behavior, and other key content. It is worth noting that there are two enhanced contents of location in the context of the mobile Internet: online locations of smart terminals and offline locations of real-time position.

Through active interactive intervention in the control phase, it is possible to actively judge and predict users' interaction target by actively combining the update of the status and the change steps of the specific interactive scene, so that the efficiency of user control management can be improved through the design of quick operations.

At the same time, problems such as interruption can be avoided, and then the pleasant interactive experience, surprised as well as moved, can be sent to users.

4.5 Build understanding interaction strategy relying on trust relationship

4.5.1 Respect user privacy to avoid infringement and loss of control
Based on artificial intelligence technology, the active interaction system after continuous perceptual computing and analysis can continuously learn and update and iterate itself. According to the changes of information attributes and user status, the agent can actively initiate interaction and make decisions, thereby reducing the cost of user interaction and decision-making. To a certain extent, it also brings users a smooth and efficient interactive experience. However, while giving the interactive system a higher degree of intelligence and more proactive behavior, users often lose control of the interactive system, and instinctively have a sense of distrust of the machine and the interactive system, then refuse to participate in the interaction and decision-making of the interactive system when violated. Therefore, the active interaction system needs to respect the privacy of the user in the process of interaction, and avoid privacy violation and loss of control from it.

4.5.2 Determine the degree of privacy by information attributes and user status
Support user-defined Do Not Disturb mode: In the process of interaction, except for the initial use, the system defaults to users’ informed consent for the system's perception and collection of relevant data. In order to achieve an orderly and active interaction in terms of privacy rights, users should be involved in the autonomous interaction of the system, which should implement information classification authorization, and gradually obtain consent for the personal information involved in the interaction process. Also, the system ought to support users to modify the authorization according to real-time demand changes.

In the design of active interaction systems for intelligent household appliances, it is necessary to consider injecting emotional factors into the logic of human-computer communication, which could give users strong or weak emotional links from a natural and smooth point of view. For example, when the user needs effective assistance, the interactive system appears as an "assistant" and assists
the user in completing the interactive task quickly. When the user is biased toward the interactive goal of receiving emotional reminders, the interactive system needs to appear as a "partner" to remind and care for the user in time, and even predict and respond to the user's potential needs in advance.

Through the exploration of the human-machine collaborative work mode of the perception layer, the display layer and the control layer, and then through the metaphors of the assistant-type and companion-type interactive roles at the understanding level, a strong emotional link between the user and the active interactive system is gradually formed. As users have a strong sense of substitution and resonance, and find an outlet for emotional catharsis, emotional barriers will also be touched. As a result, the positive effects of the so-called interaction system such as favorability, loyalty, and trust are also coming, and the trust relationship between the user and the active interaction system of intelligent household appliances is finally constructed, as shown in fig.4.
5. Conclusion

Different from the machine perspective in the past, the active interaction design strategy of intelligent household appliances with human-machine collaboration is developed from the user's perspective. Therefore, the strategy needs to emphasize human factors in all aspects of active interaction. The user-centric active interaction design strategy should be gradually established, based on the principles of focusing on users, avoiding interruptions, continuous experience, respecting privacy, and human-machine collaboration, and step by step through key stages such as contextual calculation and analysis, information display and notification, contextual control and management, and emotional linking and trust [6]. The active interactive system of smart home appliances can be deployed in an orderly manner, and humans have become the focus of interaction research again.

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