The Computer-Aided Design software for Smart Home Device based on Cloud Computing service

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***Abstract*—The "computer-aided design software for smart home device" via cloud computing service helps designer select smart home device and build a smart living space. In the process of design, it offers visual stimulation, builds the smart home device system, and is helpful in budgeting and quotes. As a result, the software is a communicational interface for smart home device industry, designer, and home user. We suggest an integrative structure of "computer-aided design interface for smart home device" based on (1) the theory of intelligent agents, and (2) scenario-oriented design, in order to construct the software interface and therefore build an actual smart living space.**

Keywords- Cloud-client computing, Computer-aided design, Intelligent agent, Scenario-oriented design, Smart home device

I. INTRODUCTION

The development and application of ICT industry allow people to enjoy the convenience and comports brought by smart living. However, the design software for smart home device based on designer's perspective is currently unavailable in the smart living industry. Therefore, companies and home users do not have an effective tool for communication and decision making, making it more difficult to promote the smart living industry. Table 1 shows that, the designer, home user and company have different concerns and perspectives about the "living design." As a result, they need an interface to communicate and cooperate.

TABLE I. DIFFERERNT NEEDS OF THE COMPANY, DESIGNER, AND HOME USER

	Company	Designer	Home user
Objective	To sell the home device	To design and integrate the smart living space	To enjoy smart living
Demand	To promote the distributional channel	To integrate and apply smart home device and the living space	To estimate the progress, participate in discussions and control the budget
Expertise	Technical service and price consulting	Professional construction, indoor design and planning	Habits and situational demands

II. LITERATURE RETROSPECTIVE

A. Cloud Computing

"Cloud Computing: Web-Based Applications That Change the Way You Work and Collaborate Online." [1]

Cloud computing initiates the user-based internet service and offers many on-line platforms for interpersonal communication and teamwork. As a result, it is important to promote the smart living industry by applying internet service, which helps participants contact one another, communicate, and cooperate.

By applying in the concept Software-as-a-service (SaaS) [2] in cloud computing, user interface (UI), applications (AP), and database (DB) no longer have to be on a single computer after "computer-aided design interface for smart home device" is employed. The cooperative relationship is as follows: (1) a home user proposes living demands to the designer on the interface; (2) the designer starts working based on home user's demand; (3) search for suitable smart device on-line; (4) contact smart home device company for relevant product catalog and information, (5, 6) a reference to designers, (7, 8) the designer presents design results to home user on the interface. The infrastructure of cloud computing is provided by the internet company and technology companies. (Fgure 1)

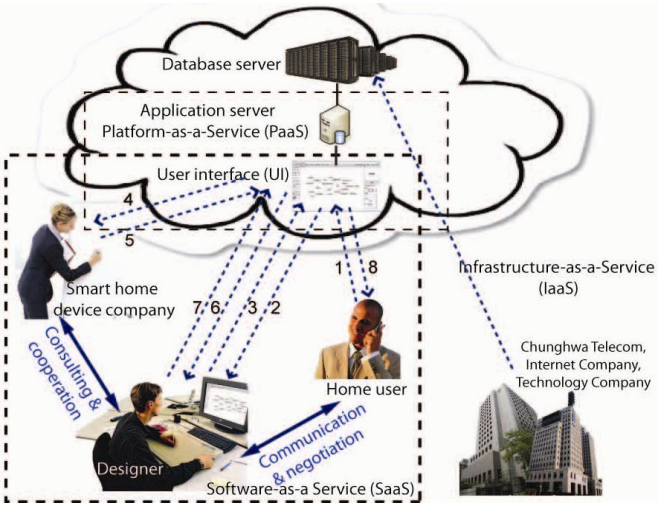

Figure 1. The cooperative relationship of computer-aided design interface for smart home device users.

B. Case Study

"Computer-aided design software for smart home device" involves the following four fields: cloud-computing, the theorem of intelligent agents, computer-aided design, and scenario-oriented design. We studied requirements for design interface in the following software kits (1) IKEA [3], (2) Sketchup [4], (3) NXT-G [5], and (4) HBE-UBI-Homenet

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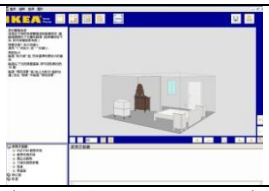
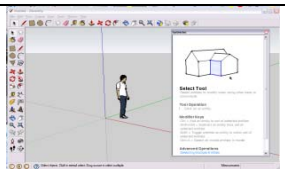
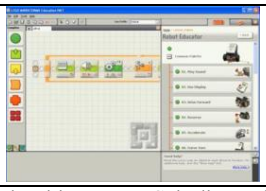
[6]. The case study helps develop a computer-aided design interface for smart home device. The former two are platforms under cloud-computing environment and software service, while the latter two are specific software provided by companies to control agent-based products. The analysis include (1) elements of cloud-computing network environment and software service, (2) spatial design and visual simulation, (3) the mechanism and operation of intelligent agent, and (4) the control mode of smart home device.

TABLE II. CASE STUDY

software	IKEA Indoor Furniture Selection and Design Software	SKETCHUP	NXT Robotics Kit	HBE-UBI-HomeNet
Image				
Introduction	The IKEA program can be downloaded and updated on the internet for free. The software visualizes the allocation of IKEA furniture and space; it also helps budget management. It helps home designers and allows companies to provide latest product information, communicate the design and costs.	SKETCHUP is free 3D design software provided by Google. It visualizes, stimulates the space and is easy to learn. By applying the digital "stretch" and simple "tool kit," computer space design becomes easier. SKETCHUP 6 supports the upload and download of "Google earth," and "3D Warehouse," encourages participants to communicate and design together on the internet. Many countries use it to build "digital cities" on Google earth.	The driver NXT-G is licensed software by LEGO. The object-oriented, modular, and graphic interface is easy to operate, making it easy to control robots. Users do not need professional programming skills. Users select sensors and motors, set conditions for the scenario, and input to the computer of the robot. The robot receives environmental information through sensors; the computer computes and makes judgments, driving the motors to finish the mission.	HBE-UBI-HomeNet is the software to control smart home device. The interface allows users to control device in the home environment and access the status of home device. Remote control is accessible through internet and computer interface. The interface is easy to operate, but the pre-operation phase is complicated. Smart home device are first assembled, then users use custom or original executable files, which is compiled by Cygwin system software and then burn to the operators using AVR Studio.
Application	Simple indoor design, furniture allocation and purchase.	Modeling, project design, collaborative design decision.	To control robots.	To control smart home device.
Goals	Targeting the sales of IKEA furniture and help select furniture and space allocation.	Digital design, collaborative design decision.	The complex programming is replaced by simple graphic interface to promote the robotics industry and education.	Promoting smart living space and its own products
Users	Indoor designer Furniture salesman Home user	Beginners in computer-aided design Architecture or space designer	Beginners in robotics Professional researcher	Users with information or communication background Professional researcher
Steps	1. Draw the floor plan 2. Furniture allocation 3. 3D image 4. Lists of furniture and budget	1. Download the base information of Google earth 2. Tool modeling 3. Select material 4. Search for supporting units in "3D Warehouse" (like trees, cars, or people) 5. Light adjustment 6. Work completion 7. Upload the 3D work through Google earth to the base 8. Decision-making on the internet	1. Outline the script for robot mission (action) 2. Build the physical model 3. Choose the motors and sensors according to the mission script 4. Set the conditions and details for each motor and sensor 5. Input the programs to NXT computer 6. Execute the file, test run 7. Success, or modify the programs or physical model if failed.	1. Assemble the suitable smart device 2. Open and compile the Cygwin system software 3. Link the smart home device, and burn the executable file to the operators using AVR Studio. 4. Link to the Zigbex server, repeat step 1 to 3 (compile and burn the executable file to the server) 5. Open the Homenet interface for operation

Feature	Cloud-computing software service; computer-aided design	Cloud-computing software service, computer-aided design	To control agent-based robots; the robots is capable of sensor, computation, and action, and communication	To control smart home device that is agent-based (including the sensor, microprocessors and motors
Advantage	Accessible operation, offering choices for furniture selection and price which satisfy the basic needs of furniture-purchasing consumers.	Fast modeling, easy operation, the work can be uploaded to the internet by Google earth or 3D Warehouse, encouraging cooperative design	Graphical programming and easy operation; understands the operation of each components including the scenario-oriented design and logical thinking.	Integrated intelligent device, wireless transmission control program.
Limitation	Only provides IKEA furniture catalog, currently not open to other product information of affricated firms.	Compared to other computer-aided software, SKETCHUP is limited in the modeling capacity (often produce squeezed shapes); the light shading is limited to "natural light"	No debugging inspection function, limited situational conditions; the interface is not suitable for complicated actions.	Hard to operate and compile, the operating mode is fixed and not flexible to different scenarios, lack supporting design features.
Trend	Open supporting framework, easy to obtain service information IKEA-affiliated companies with integrated design of smart home device and traditional furniture.	Cloud-computing operating environment, design process, and collaborative design decisions.	Human-computer interaction, scenario-oriented script, detailed settings, multi-robot cooperation model.	Easier to operate, vivid designs targeting user's needs.

According to the case study, under the service of cloud-computing software, renewable "computer-aided design software for smart home device" requires an open supporting framework and standardized communication platform. It will enable the intelligent industry to update product information and expand supports. It is supposed to be easy to operate and have modulated and objected oriented graphical user interface. The goal is to promote the cooperation and decision-making among the designer, industry, and home user. This includes situational needs of home user, the coordination of objects in the space, the technology of home device company, visual stimulation of space settings, and budgeting conditions. "Space designers" can thus provide professions service on smart living space design. As for the objects, the smart device, furniture and architecture elements shall be integrated in the space. As a result, the equipments and objects can coordinate, with the integration of sensor, computing, action, and communication techniques. They will react to environmental changes, the physical and mental changes of a user, and other activity needs.

III. THEORY AND METHODOLOGY

We suggest using the following two as the integrative structure for "computer aided design interface for smart home device": (1) the theory of intelligent agents, and (2) scenario-oriented design.

A. The Theory of Intelligent Agents

"The basic module for intelligent agent consists of the sensor, computing mechanism, and actuators. It includes software and hardware that is autonomous and capable of communication, cooperation, and learning." [7]

Intelligent agent is an important research paradigm in modern "artificial intelligence". Under the distributed intelligent environment, it is a tool of knowledge representation for computing and information communication [8]. It is expected to build a collaborative model for the operation and communication between humans, objects, or human and objects in the industry links, based on the intelligent agent theory.

Smart living space is full of smart home device composed of sensors, calculators, and motors. They are the agents for smart living space. The agent group is in charge of the communication and coordination in order to sustain the operation of living space and satisfy demands of home users.

B. Scenario-Oriented Design

"Scenario-Oriented design is a new design for the product and service in the information era." [9]

As mentioned in the previous session, the theory of intelligent agents has the capacity to describe interactions between "human and human," "human and object," and "object and object." However, it cannot depict or recreate features in a "space." It merely concludes the space function, but information is not sufficient to define a space. Therefore, we employ scenario-oriented design to strengthen the intelligent agent theorem on the function of "space." From top down, the "script" (scenario-oriented design) describes a "story," and the "story" is a combination of related "scenes." The "scenes" include a series of "activities" and the stage for such "activities" (the space and background activities). The stage includes the space and allocation of furniture and objects in such space, both dynamic and static. The intelligent agent drives "events" from bottom up. A series of "events" satisfying the "missions" and "goals" support human and object "activities" on the "stage." Therefore, the "scenario-oriented design" and "intelligent agent theory" work hand in hand. They "recreate knowledge" for the operation, computing and communication of human and objects in the space. (Figure 2)

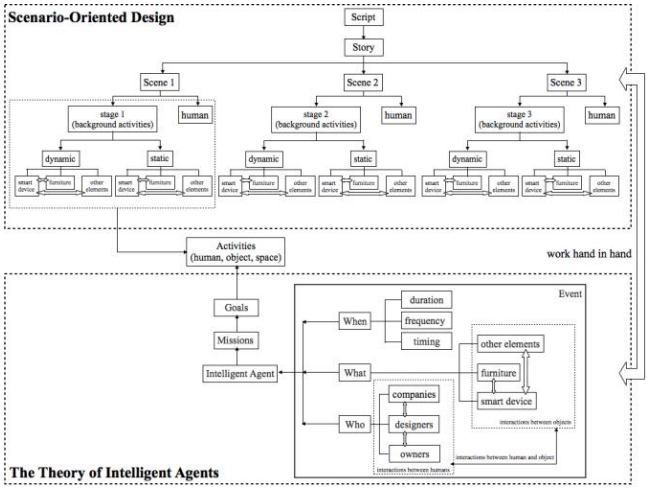


Figure 2. Scenario-Oriented Design and the Theory of Intelligent Agents.

IV. COMPUTER-AIDED DESIGN SOFTWARE FOR SMART HOME DEVICE: SOFTWARE STRUCURE AND SYSTEM

Given the theory of intelligent agents, scenario-oriented design, and case study, we build the structure and system of "computer-aided design software for smart home device." The following are the hierarchical structure and design process.

A. Hierarchical Structure of Computer-Aided Design Software Interface for Smart Home Device

"An interface is a hierarchical structure containing high/low-leveled objects and operation." [10]

We apply the hierarchical task analysis (Figure 3) to build a system from designers' perspective, which clarifies the design process of smart living and transfers it into a graphic user interface.

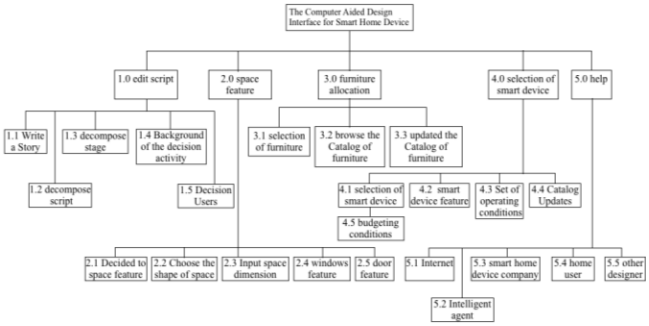


Figure 3. The hierarchical task analysis of the interface.

B. The Design Process of Computer-Aided Design Software Interface for Smart Home Devcie

Based on the scenario-oriented design, proper smart home device are located according to the above analysis to construct the spatial setting and allocate furniture based on the function. After the spatial stimulation is completed, we start selecting smart home device and creating a budget list according to the selected items, which allows home user and designer to make decisions. If the home user is not satisfied with the result, then the designer can go back to scenario-oriented design or the selection of smart home device and repeat the process again. (Figure 4)

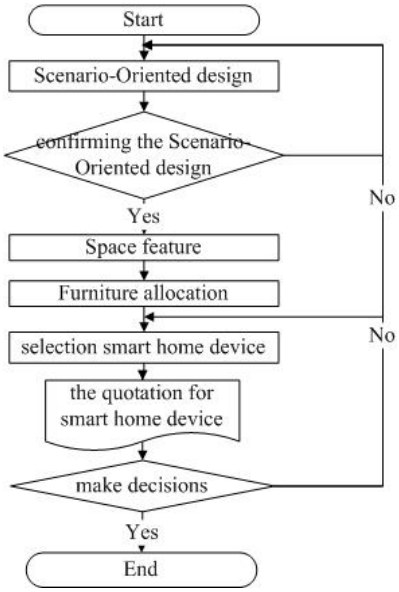


Figure 4. The design process of computer-aided design interface for smart home design.

V. SOFTWARE INTERFACE PROTOTYPE AND REALITY

The study constructs the prototype of computer-aided design interface for smart home device to create the actual smart space and support the theory.

A. The Prototype of Computer-Aided Software Interface for Smart Home Device

To create the prototype of computer-aided interface for smart home device (Figure 5), the designer analyzes the relationship between the players, furniture, other components and the smart home device, according to the stage (dining room) and event derived from the scenario-oriented design script.

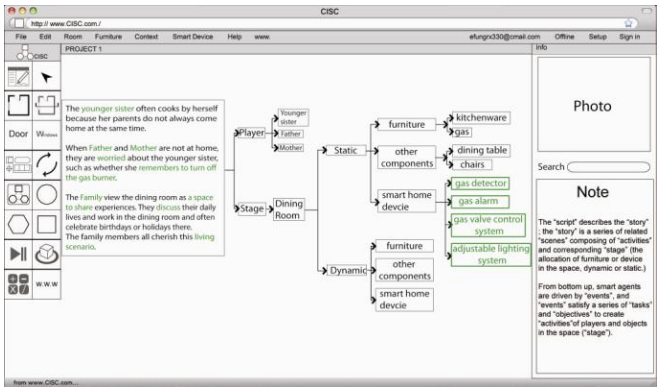


Figure 5. The correspondence between the scenario-oriented script and samrt home device

When a designer allocates the smart home device, he/she must master the system and structure of smart home device, in order to allow interactions between players and objects according to the feature of smart home device. According to the theory of intellectual agents, the smart home device includes sensors, calculators, and motors. The "sensor-computation-operation-communication" mechanism sets the operational criteria and cooperation model for smart home device. The system design of smart home device is completed through shared internet transmission and protocol. (Figure 6)

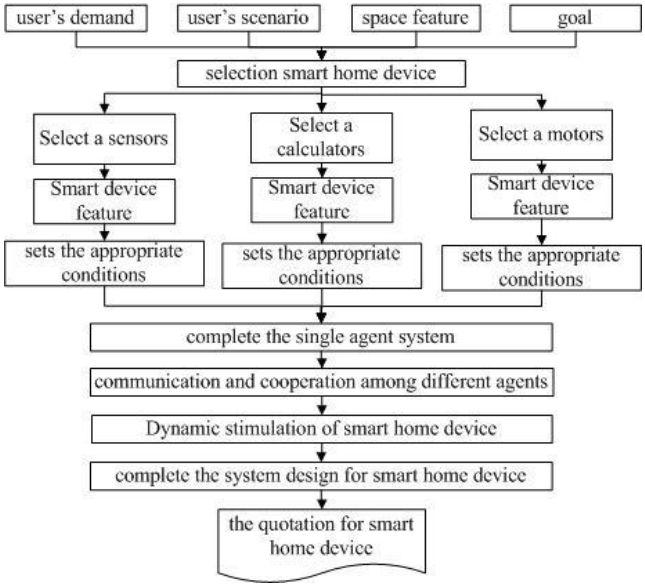


Figure 6. The flow chart fo the selectin of smart home device

After the smart home device system is completed, the designer reviews the cooperation and operational process of smart home devices; then the operation of various smart home devices in the spatial scenario is stimulated for designers to make decisions. (Figure 7)

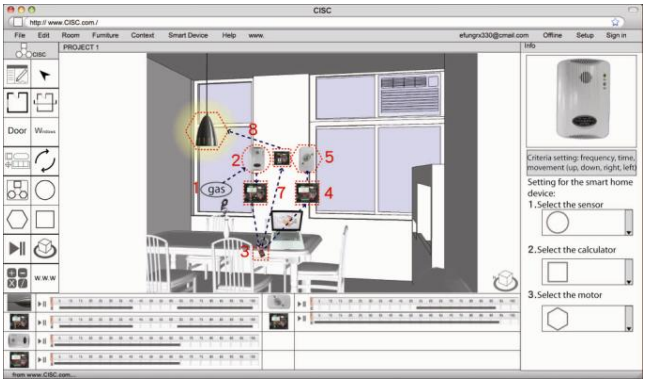


Figure 7. Dynamic simulation of smart home device.

Budget estimation of smart home device (Figure 8) provides product information, specification, quantity, and price to help the designer and home user make decisions and search for specific smart home device companies.

Item	Photo	Product	Technical specification	quantity	price	Total
1		natural gas blocking valve module (calculators)	Calculator for the gas valve control system, must combine with the motor of the gas valve control system	1	15000	15000
2		Adjustable lighting module (calculators)	calculator for the adjustable lighting module,works with ordinary lighting devices, can adjust the brightness of lighting devices.	1	15000	15000
3		natural gas detector module (calculators)	Calculator for the gas detector module, must work with the gas detector. If gas emission is detected, it will send a message to the user interface.	1	15000	15000
4		natural gas detector	Sensor for the gas detector module, can detect gas and send alarms.	1	5000	5000
5		A ceiling lamp	ordinary ceiling lamp.	1	500	500
6		natural gas blocking valve module (motor)	The rotating motor on installed on the gas valve.	1	5000	5000
All				6		55500

Figure 8. Price estimation for smart home devices in the smart dining room

B. *Reality Construction: Smart Dining Room*

In building the smart living space, our major tool is "HBE-UBI-Homenet Smart Home Option." It is equipped with the wireless transmission and unit-modulated smart device to test the theorem of intellectual agents. Homenet is a smart living system composed of various sensors, calculators and motors. Users can make adjustments according to needs and react or transmit user information on the interface to notebooks or other modules, which completes the interaction between players and objects.

According to the scenario-oriented design analysis, the smart dining room must satisfy the following two objectives: (1) to secure and monitor the gas switch, and (2) to satisfy user's demand driven by environmental changes. As a result, smart home devices in the dining room most cooperate to achieve the objectives together. (Figure 9)

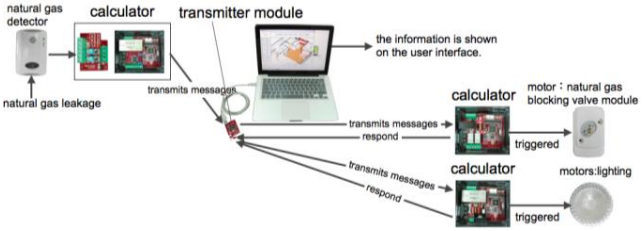


Figure 9. The operational strucutre for smart home devices in the smart dining room.

1) *Security monitoring of the gas switch.*

For user's safety, it detects and monitors gas emission, so that the environmental information unrealized by users can be sent to the user interface and helps create a safe and secure care. (Figure 10)

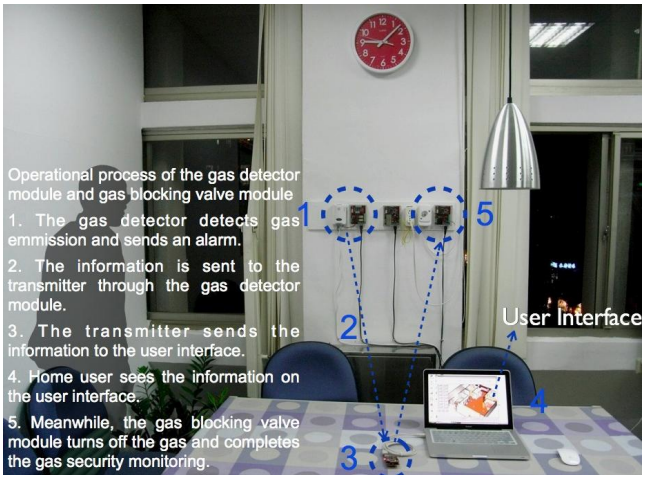


Figure 10. Operational process of the gas detector module and gas blocking valve module.

2) User's demands driven by environmental changes.

Home users can control the brightness of lighting devices according to the number of people, events, and mood, in order to create proper atmosphere and fun for dining. It facilitates flexible uses and allows different activities in the once monotonous dining room. (Figure 11)

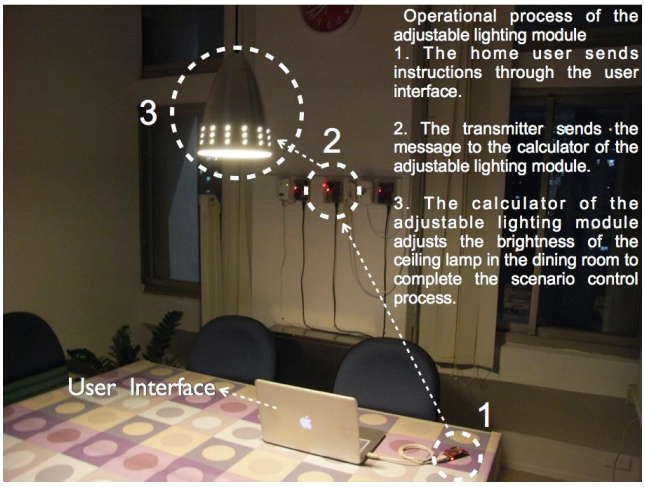


Figure 11. Operational process of the adjustable lighting module.

VI. CONCLUSIONS

The study employs (1) the theory of intelligent agents and (2) scenario-oriented design to integrate and build the software of "computer-aided design software for smart home device." We apply the interface to construct a real smart living space and verify the feasibility of the theory. The result shows that the operation of smart home devices has four smart modes: passive, responsive, active, and interactive. Even the study is mainly based on active smart home device, we also factor in the different scenarios, home user's demands, timing, and spatial function. In the design process, designers must communicate with home users repeatedly to select an appropriate smart home device model according to user's specification. The objective is to truly satisfy home user's demands and complete the smart living design.

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