

Experience Optimization of AI-Based Smart Kitchen Dietary Recommendation Systems from a Service Design Perspective

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Abstract: In practical applications, current AI-based smart kitchen dietary recommendation systems still face challenges such as insufficient personalization, inconvenient interaction, and a lack of user trust, making it difficult to effectively meet users' diverse and health-oriented dietary management needs. From a service design perspective, this study adopts questionnaires and semi-structured interviews to identify and analyze user needs and pain points in the usage process. The findings reveal the main obstacles encountered by users and propose targeted optimization strategies. These strategies encompass strategic-level value positioning (clarifying the system's role and positioning in household health management), mid-level process optimization (enhancing the coherence and efficiency of data collection, recommendation generation, and feedback), and presentation-level interface interaction (improving usability and accessibility through voice, image, and visualization design). The study aims to provide theoretical reference and practical insights for the improvement of smart kitchen products and services, and to promote the rational application and dissemination of AI in healthy eating and smart living contexts.

Keywords: Service Design; Smart Kitchen; AI Dietary Recommendation; User Experience; Optimization Strategies

1. Conceptual Clarification of Smart Kitchen AI Dietary Recommendation and Service Design

With the advancement of the Healthy China strategy and rapid progress in artificial intelligence (AI), dietary health has become a central concern of public life, and smart kitchens have emerged as a key component of intelligent households. Among them, AI-based dietary recommendation systems integrate health data, dietary preferences, and nutritional needs to deliver precise and personalized dietary advice.

1.1 Smart Kitchen and AI Dietary Recommendation

Artificial Intelligence (AI) has, in recent years, demonstrated broad potential for application in the fields of dietary health and daily living, with its core capabilities lying in the analysis and modeling of complex, multimodal data. The primary technological approaches include Machine Learning (ML), Deep Learning (DL), Natural Language Processing (NLP), and Computer Vision (CV), all of which can extract features from large-scale datasets and achieve dynamic optimization [1].

In the domain of dietary and nutritional management, AI applications are concentrated in three main areas. First, image recognition and nutritional analysis: by leveraging computer vision, systems can automatically identify food items and meal images, and combined with nutritional databases, output energy and nutrient composition, thereby helping users evaluate dietary structures [2]. Second, personalized modeling and recommendation: machine learning models can integrate users' health data (e.g., weight, blood glucose, allergy history) with dietary preferences to generate differentiated meal plans, which are continuously optimized through user interaction [3]. Third, multimodal and generative applications: the development of large language models and generative AI enables systems to generate recipe instructions from natural language commands and even provide real-time cooking assistance, thereby enhancing interactivity and flexibility [4]. Moreover, the integration of AI with wearable devices, health applications, and IoT terminals facilitates cross-platform data sharing and utilization, gradually forming a closed-loop system of data collection–analysis–recommendation–feedback [5].

1.2 Service Design

Service design focuses on the systematic coordination of people, objects, and information flows to ensure coherent, user-centered service experiences [6]. Its key methods include: (1) user personas, which profile typical groups and their needs; (2) user journey maps, which visualize behavioral and emotional changes across touchpoints; (3) stakeholder analysis, which identifies roles and interactions of different actors; and (4) service system maps, which depict networks of resources, information, and value exchange [7]. By combining these tools, service design links user experience with service processes, enhancing satisfaction and enabling continuous optimization of smart kitchen dietary recommendation systems.

2. Product Architecture and Process Design of AI-Based Smart Kitchen Dietary Recommendation Systems

The product architecture of AI-based smart kitchen dietary recommendation systems can be divided into five components. The data collection layer encompasses health data obtained from wearable devices, records of users' dietary preferences, and ingredient information provided by IoT refrigerators or supermarket APIs. The data processing layer involves data cleaning and integration, combined with a nutritional knowledge base to construct user models that support subsequent recommendations. The AI recommendation layer employs machine learning and deep learning methods to generate personalized dietary plans, while also leveraging generative AI to provide dynamic recipe outputs. The interaction layer covers multimodal interaction formats such as voice commands, mobile applications, and screen interfaces, enabling effective communication between users and the system. Finally, the service layer delivers meal planning and cooking assistance, and incorporates user feedback to achieve continuous optimization, thereby establishing a comprehensive support system for health-oriented dietary management.

3. Design Perspective

3.1 Stakeholder Analysis

Stakeholders are central to the operation and value co-creation of AI-based smart kitchen dietary recommendation systems, shaping user experience through distinct roles and interdependent relationships of needs, responsibilities, and values. They can be grouped into four categories: end

users (households, older adults, patients with chronic diseases), who seek personalization, ease of use, and health management support; service providers (appliance manufacturers, AI developers, platform operators), responsible for technological development, system operation, and interface optimization; resource and support providers (supermarkets, supply chains, nutrition experts), ensuring sustainability and scientific validity through ingredients, logistics, and professional expertise; and policy and regulatory institutions (health authorities, data supervisory bodies), which safeguard promotion and data security through policy and compliance. Despite divergent goals and influence, service design methods integrate these actors within a unified framework, fostering cross-actor value co-creation and user experience optimization (Freeman, 1984). Stakeholder analysis thus serves not only as a tool of identification and classification but also as a lens to understand system logic and guide subsequent design and interaction research.

3.2 User Persona Construction

In the study of AI-based smart kitchen dietary recommendation systems, preliminary investigations were conducted through user interviews and questionnaires, and three representative groups were identified: (A) older adults, (B) adults (parent group), and (C) children and adolescents. Follow-up interviews and observations were carried out to capture behavioral patterns and emotional responses across service stages. Among older adults, over 68% indicated that current devices were overly complex, nearly 60% relied on family assistance, and 52% expressed privacy concerns; more than 70% expected simplified interfaces and voice- or image-based guidance. Among adults, 75% emphasized efficiency in dietary management, with 63% noting insufficient support for multi-member households, and expressed the need for integrated dietary plans linking shopping and storage. Children and adolescents (68%) showed greater interest in novelty and entertainment than in healthy eating, and over 55% preferred recommendations in graphical or gamified formats. These findings suggest that enhancing usability, efficiency, and engagement while ensuring nutritional validity is essential for user-centered system design.

3.3 User Journey Map

Based on preliminary research and the construction of user personas, user behaviors were organized and sequenced to visualize the different stages experienced during system use, along with the corresponding changes in behavior and emotional curves. In the use of the AI-based smart kitchen dietary management system, the user journey can be broadly divided into three stages: “problem discovery and attempts—seeking and receiving assistance—verification and feedback.” Older adult users often feel confused during problem discovery due to complex operations and rely primarily on children or external support to complete tasks; in the feedback stage, they emphasize the need for simplified and automated guidance. The parent group, by contrast, focuses on efficiently formulating and executing meal plans within limited time, often relying on family collaboration or system functions for assistance, and they highlight a stronger demand for personalized and refined suggestions during feedback. Children and adolescent users exhibit a combination of passivity and interest, relying largely on parental guidance during use; in the feedback process, they pay less attention to outcomes but are highly responsive to gamified and motivational design. Drawing from this analysis, the stages, user behaviors, touchpoints, pain points, and opportunity areas involved in exploring the system’s functional platform services are identified, thereby providing support for subsequent comprehensive platform analysis.[8]

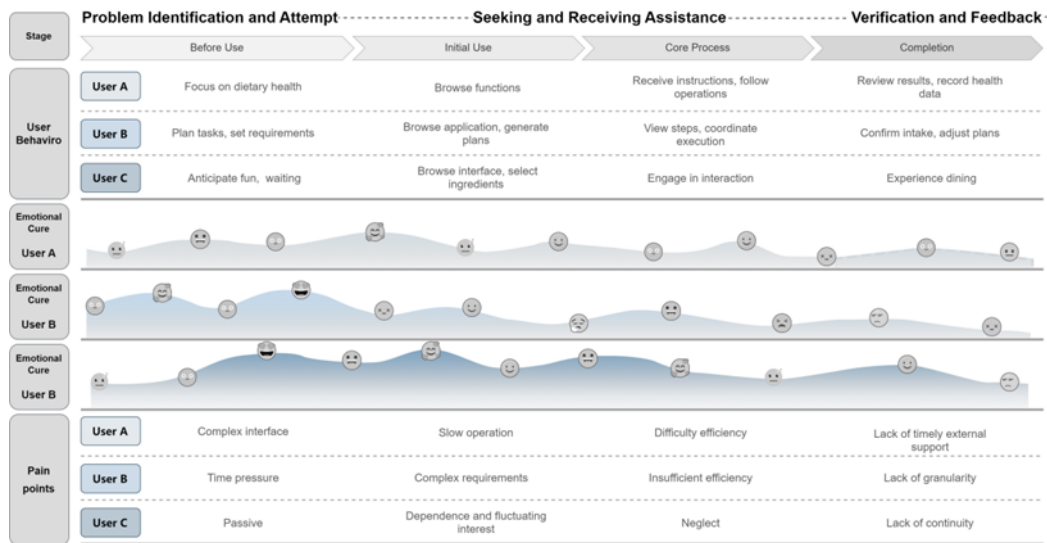


Figure1: User Journey Map.

3.4 Pain Points and Opportunities

As shown in Figure 3, the pain points encountered by users at different stages can be mapped to corresponding opportunities: **Integration of Professional Guidance and Personalization:** The design of AI-based smart kitchen dietary management systems should focus on integrating professional nutritional guidance with personalized recommendations to ensure that dietary plans are both scientifically sound and tailored to individual needs. **Efficient Interaction and Multimodal Support:** Users often experience difficulties due to complex interfaces or redundant information, particularly among older adults and multi-tasking parents. The system should incorporate more efficient interaction mechanisms and multimodal support (e.g., voice, visual guidance, automated prompts) to lower the barriers to use and enhance operational efficiency. **Dynamic Generation of Personalized Diet Plans:** The user journey highlights the diversity and dynamic nature of dietary needs, which cannot be adequately addressed by fixed meal recommendations. AI-based smart kitchen dietary management systems should generate dynamically adjustable personalized dietary plans based on users' health data, dietary preferences, and lifestyle habits, thereby improving applicability and long-term value.

These conclusions provide clear directions for the formulation and implementation of relevant design strategies. Specifically, they can be reflected in the design strategies of smart kitchen product-service systems as follows: first, service providers should focus on developing recommendation modules that integrate nutritional knowledge bases with user health data, improving guidance systems to provide real-time feedback and corrective suggestions. Second, interaction processes should be optimized by reducing operational steps and introducing multimodal methods such as voice commands, image recognition, and visualized interfaces to improve efficiency, accessibility, and user engagement, thereby enhancing enjoyment and sustainability. Finally, an AI-driven continuous learning mechanism should be established to dynamically generate and update dietary plans in accordance with users' personal goals, preferences, and physical conditions, ensuring long-term adaptability and optimization.

3.4 Service System Diagram

Household users are the core stakeholders of the system, and their use process involves multi-level support and collaboration. When older adults or parent groups encounter difficulties during operation, they often seek assistance from children, relatives, or technical support teams, who provide solutions through remote guidance or system assistance functions. In this process, the flow of information and services among family members constitutes a crucial link in the system's operation. At the same time, the technical support team and the software development team continuously optimize system performance and interaction experience through feedback and maintenance mechanisms, thereby forming a cyclical connection between front-end services and back-end support.

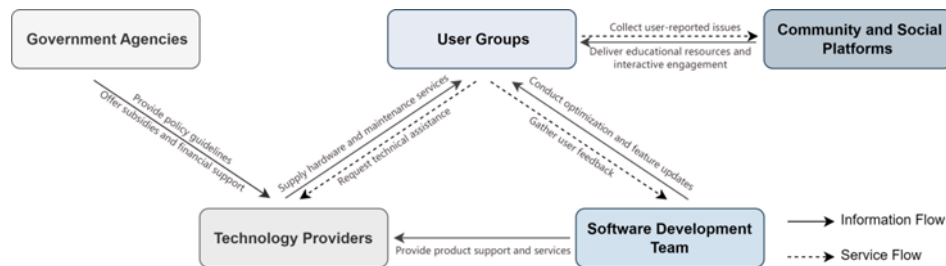


Figure 2: Service System Diagram.

5. Conclusion

This study explores the service design of AI-based smart kitchen dietary management systems by integrating service design theory with qualitative research methods. It systematically analyzes the characteristics and needs of older adults, parent groups, and children/adolescents during system use. Through the construction of user personas and user journey maps, the study reveals differentiated pain points across the three stages of “problem discovery and attempts—seeking and receiving assistance—verification and feedback,” and identifies corresponding opportunity points. Building on this, it proposes multidimensional design strategies encompassing the integration of personalization and professional guidance, efficient interaction with multimodal support, and the dynamic generation of personalized dietary plans. The AI-based smart kitchen dietary recommendation system is not only a technological tool but also a service medium for multi-role family collaboration. Its design optimization should balance scientific rigor with personalization, efficiency with accessibility, and dynamism with sustainability, thereby enhancing the overall user experience in dietary management. This research provides both theoretical support and practical references for interaction design and service system optimization in the smart kitchen domain, while also offering directions for future interdisciplinary research and product iteration.

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Disclosure statement

The author declares no conflict of interest.

Author contributions

Jiaying Li was solely responsible for the conceptualization and design of the study, the data collection and analysis, as well as the drafting and revision of the manuscript.

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