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Optimizing Augmented Reality Displays for Culinary Guidance: Investigating High-Contrast Effects in Human-Machine Interface

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ABSTRACT

As AR technology advances, it is transforming user interaction by providing hands-free, real-time guidance. In culinary settings, AR enhances cooking efficiency, particularly for individuals with limited experience. This study investigates AR text displays in high-contrast environments for synchronous recipe teaching, focusing on novice users. A quantitative study with 20 participants compared two groups: one using AR glasses for real-time recipe guidance and the other using a tablet-based digital recipe. AR users benefited from hands-free guidance, seamlessly following instructions while handling ingredients, whereas tablet users frequently shifted attention between the screen and their cooking. Usability, user experience, and visual strain were assessed using the System Usability Scale (SUS) and Near Point Accommodation (NPA) tests. Results showed that AR significantly improved cooking performance, efficiency, and confidence. The hands-free interface minimized disruptions, and high-contrast text did not induce visual fatigue. These findings highlight AR's potential in interactive cooking and learning, benefiting both amateur and professional chefs. Integrating AR into culinary education and professional kitchens could enhance training and skill development. Future advancements, including AI-driven personalization and gesture-based controls, could further optimize AR's role in digital culinary assistance and immersive learning.

Keywords: Augmented reality (AR), AR recipe, Human-computer interface, Visual fatigue, Near point accommodation (NPA)

INTRODUCTION

According to a 2020 research report by the Market Intelligence & Consulting Institute (MIC), global digital technology development is advancing in four key directions: environmental experiences, enhanced intelligence, digital ecosystems, and intelligent signaling. The implementation of these trends relies on the integration of various cutting-edge technologies, including the Internet of Things (IoT), artificial intelligence (AI), emotion recognition, blockchain, virtual reality (VR), and augmented reality (AR). In response to the rapid evolution of these technologies, global service industries are undergoing significant transformations to seize emerging

business opportunities. Moreover, the development of AR has attracted increasing public attention, particularly with the growing momentum of the metaverse (Stylianos, 2022). There is a rising interest in understanding core concepts such as digital twins and the integration of virtual and physical environments, reflecting a broader trend toward the convergence of real and digital worlds in the context of digital transformation.In recent years, the restaurant industry has increasingly embraced AR technology in a variety of applications. AR is being used to present detailed information about food, such as ingredients, nutritional content, and promotional offers, with the goal of helping consumers make informed decisions that align with their preferences (Jagtap et al., 2021). Recognizing the potential of AR in the food sector, Google launched Google Food Service in 2019. This service enables users to scan restaurant menus using an app that automatically translates the content into the user's preferred language, streamlining the ordering process.

To overcome the limitations of traditional cooking instruction using paper-based recipes, augmented reality (AR) offers a more interactive and engaging alternative. By presenting a menu of dishes based on specific ingredients, AR technology can guide learners through the cooking process in a visual and intuitive way. This integration not only enhances the overall cooking experience but also promotes greater efficiency and convenience in the kitchen. As a result, cooking becomes more accessible, especially for beginners, allowing them to confidently explore a variety of dishes and recipes. Furthermore, insights gained from this approach can be used to refine and improve the design of AR-based recipe applications.

LITERATURE REVIEW

In recent years, AR has seen increasing diversification within the food and beverage industry. Restaurants, for example, have implemented AR programs that display virtual nutritional information, helping customers make informed decisions about their orders and manage portion sizes, ultimately enhancing the overall dining experience (Crofton et al., 2019). Additionally, AR has been incorporated into promotional materials to allow customers to view dishes in their actual size and appearance from multiple angles, effectively supporting advertising and marketing goals (Stelick et al., 2018).

Overall, current developments indicate that AR applications in the food and beverage sector can be broadly categorized into three main areas. First, navigation-oriented AR applications use virtual text and imagery to present essential information—such as nearby restaurant locations—helping users quickly understand their surroundings (Hashimoto & Cohen, 2021). Second, knowledge-oriented AR applications assist consumers who have food allergies or specific dietary concerns by automatically displaying detailed ingredient compositions, nutritional values, and potential allergens (Fernández del Amo et al., 2018). Finally, experience-oriented AR applications emphasize interactivity and engagement, aiming to create enjoyable and immersive dining experiences (Rauschnabel et al., 2019).

METHODOLOGY

This study aims to develop and evaluate both AR recipe application and a traditional paper-based recipe, with a focus on enhancing user experience and practical usability. To achieve this objective, the research process involves participant recruitment, the use of appropriate measurement tools, systematic data collection, and thorough data analysis. The goal is to ensure the reliability and validity of the findings while generating meaningful insights into the effectiveness of AR technology in the culinary context. In this study, a pilot test was conducted prior to the formal experiment to fulfill several key objectives: assessing the feasibility and practicality of the research procedures, validating the reliability of measurement instruments, and improving the overall efficiency and effectiveness of the main study. 20 participants voluntarily took part in the study and were required to complete an informed consent form before the experiment began. To evaluate visual fatigue, near point of accommodation (NPA) measurements were taken before and after the experiment. NPA, as identified by Ishikawa (1990) and Gunnarsson & Soderberg (1983), serves as a reliable indicator of ocular fatigue. During the experiment, the AR glasses group used augmented reality glasses to access recipe instructions throughout the cooking process, while the recipe group used a tablet device to view electronic recipe content. After completing the tasks, all participants filled out the System Usability Scale (SUS) questionnaire to assess the usability of their respective systems. Finally, the study validated the accuracy and reliability of the collected data through appropriate validation methods. Statistical analysis was conducted using various tools, including SPSS 21.0, as well as data from SUS scores, NPA readings, and culinary completion time.

CONCLUSION

The study found that AR glasses significantly outperformed traditional recipes in terms of usability, efficiency, and user experience. Participants using AR glasses reported higher usability scores, especially in high-contrast environments, while the recipe group scored lower, indicating a need for improvement. AR glasses offer real-time, hands-free guidance, reducing the need to constantly refer back to instructions and making cooking easier and more intuitive—consistent with Derby & Chaparro (2022). In terms of visual fatigue, the recipe group experienced more eye strain due to frequent focus shifts and prolonged screen reading. In contrast, AR glasses displayed instructions directly in the user's view, reducing eye movement and fatigue. High-contrast displays also improved readability, supporting findings from Jeong (2012). The AR glasses group completed cooking tasks faster, particularly among males, likely due to greater familiarity with similar technology. This aligns with Jérémy et al. (2022), who noted improved efficiency with AR support. Lastly, dishes prepared with AR glasses received higher appearance ratings, likely due to precise, step-by-step instructions that improved cooking accuracy and presentation—supported by Majil et al. (2022). Overall, AR technology enhances usability, reduces fatigue, improves efficiency, and results in better cooking outcomes.

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