Toward Leveraging Augmented Reality (AR) for Enhancing Remote Intergenerational Communication in Cooking Scenarios

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ABSTRACT

The close connection between food culture and family relationship has always been regarded as an important link to maintain family harmony and intergenerational(IG) communication. Through cooking and eating together, family members inherit family customs and culture, and enhance mutual feelings and understanding. However, with the development changes in family structure, there is an urgent need to find new approaches for IG communication between the younger and older generations. In this context, this study will explore how modern technological means such as remote home intelligent control and augmented reality (AR) technology, combined with the characteristics of food culture, can be used to innovate and strengthen IG communication between family members. This study explored the challenges inherent in remote integrated circuits in the context of collaborative cooking. Building on this, we use participatory workshops to explore design proposals to address challenges. Our comprehensive exploratory study consists of two parts, the first of which is an observation of 12 pairs of remote IG participants cooking to summarize the challenges they face. We then had 12 pairs IG participants engage in a participatory workshop, with semi-structured interviews and discussions to summarize the design recommendations. Our findings reveal potential ways to enhance remote integrated circuits through collaborative cooking, suggest the feasibility and versatility of AR in this regard, and outline design recommendations for AR based assistive functions in remote cooking scenarios.

CCS CONCEPTS

• **Human-centered computing** → **Accessibility technologies**; **Empirical studies in HCI**.

KEYWORDS

Intergenerational Communication, AR, Human-food Interaction

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1 INTRODUCTION

Intergenerational(IG) communication refers to the communication and interaction between different age groups. It includes communication between elders and young people, dialogue between traditional and modern values, communication and interaction between different age groups, cultural exchanges, [11, 12, 18]. The importance of IG communication is to promote mutual understanding and inclusion among different age groups. Through intergenerational exchanges, we can continue to learn about historical traditions and culture from the experience and wisdom of the elders; and the elders can also understand the development of modern society and the way of thinking of modern people through communication with modern people. However, despite these benefits, many families face remote IG communication due to factors such as geographical isolation [20], differences in digital technology use [4], and changes in family structure [16]. Thus, there is a need to explore topics that both generations could enjoy and engage in to enhance remote IG communication [10].

In the field of human-computer interaction (HCI), researchers have been studying how to improve remote home interaction and communication. They have explored various methods, including using existing commercial platforms [9, 17], creating customized applications [15], and even integrating traditional cultural elements into virtual reality games [4]. However, there is limited research on the potential role of cooking in promoting IG communication. Relevant studies have shown that food-related discussions can enrich interpersonal communication [6, 21], and older generation usually show greater interest in food-related topics [1, 7]. Young generation are eager to improve their cooking skills, but lack cooking knowledge and effective learning methods [5, 13]. This leads us to the question: whether learning to cook can serve as a scenario that promotes intergenerational exchange, especially when older generations teach cooking skills to younger generations.

One common problem in remote cooking is that people who are cooking could not afford to do many tasks (e.g. answering phone calls, do hand gestures for explanation) with their occupied hands [3]. Augmented reality (AR) has the potential to tackle these problems and enhance user experience. For instance, AR allows users to interact with the interface by voice or gaze [2, 14]. In addition, AR could project the information in the user's view without occluding the real-world settings and it also allows other users to augment on the view of the user to convey their opinions [8]. However, its usage has not been not thoroughly investigated. Our study therefore focuses on the interaction challenges of remote remote IG communication in a cooking scenario.

Motivated by this research gap, we first conducted a survey study (N=200) and an observation study to clarify the difficulties of remote IG communication in remote cooking. Based on the findings, we then conducted a user-centered participatory design study involving 12 parent-child Paris (N=24). As an initial step toward this topic, we have investigated participants' preferences and visions for three key aspects of AR: manipulative steps and gestures, interpersonal interactions, and shared activities, which reflect how they perceive themselves, each other, and the environment they are interacting in. We also explore their perceived barriers to adopting AR as a communication tool.

2 METHOD

We conducted a two-part formative study, inspired by the deep connection between Chinese culture and food, to explore remote IG communication in cooking. This study involved surveys, observations, interviews and workshop. Based on the formative study and literature review findings, we aim to design a prototype incorporating culinary elements and fostering better communication for remote IG communication.

2.1 Formative Study

2.1.1 Survey Study. To gather general information on the users' needs and attitudes about IG communication through remote cooking, we conducted an online survey study following ethical guidelines through the Tencent Questionnaire platform [19] in March 2023. The survey consists of five sections: demographics, general remote IG communication experience, remote cooking experience, expectations for new technologies to support remote IG communication, and attitudes toward remote cooking. We posted the survey on mainstream social media platforms commonly used in the locally. The eligibility criteria for recruitment included: 1) age between 18 and 45, and 2) maintaining communication with old generation. Finally, we collected a 218 responses in total. After applying our eligibility criteria, we obtained 177 valid responses, including 88 from males and 89 from females, ranging in age from 18 to 45. We then conducted descriptive statistical analysis for all questions.

2.1.2 Observational Study. The study aimed to understand the challenges and user experiences of IG communication in a remote cooking context. The researchers conducted observational studies and follow-up semi-structured interviews with 24 participants, including 12 pairs of parents and children (Table1). The younger participants ranged from 25 to 30, while the older participants were between 60 and 65. The participants had diverse backgrounds, lived at varying distances from each other (40 km to 1,600 km), and used mainstream communication apps for remote cooking.

For the observational study, a simulated kitchen with a camera was set up to observe the remote cooking process. The younger participants used their mobile devices with communication apps to interact with their parents. After cooking, the participants were interviewed to gather more insights.

2.2 Participatory Study

2.2.1 Workshop Design. To avoid unclear and ambiguous communication, we conducted a participatory design workshop based on the findings derived from the formative study to enhance the user experience of remote cooking. Specifically, the participants were asked to design some Augmented Reality (AR) features to aid communication during cooking.

2.2.2 Participants. We recalled the previous 24 participants (12 pairs of parents and children) on another day for a continual participatory design workshop. The age (M= 25, SD= 1.29) range of the young participants was 22 to 30, with 5 females and 7 males. The

Table 1: Participants' demographic information.

	Parent (12)	Children (12)
Sex	Female (8), Male (4)	Female (7), Male (5)
Age	50-59 (6), 60-69 (6)	20-29 (8), 30-39 (4)
Cooking Proficiency	Novice (1), Intermediate (3), Advanced (4), Expert (4)	Novice (4), Intermediate (3), Advanced (4), Expert (1)
Online Communication Frequency	less than once a month (1), about once a month (2), about twice a month (1), once a week (3), more often (5)	
In-person Communication Frequency	less than once a year (0), about once a year (4), about twice a year (4), about once in two months (4), about once a month (0), more often (3)	

Table 2: Participants' demographic information.

	Parent (12)	Children (12)
Sex	Female (10), Male (2)	Female (5), Male (7)
Age	50-59 (5), 60-69 (7)	20-29 (8), 30-39 (4)
Cooking Proficiency	Novice (0), Intermediate (2), Advanced (7), Expert (3)	Novice (7), Intermediate (1), Advanced (4), Expert (0)
Online Communication Frequency	less than once a month (0), about once a month (2), about twice a month (0), once a week (3), more often (7)	
In-person Communication Frequency	less than once a year (0), about once a year (1), about twice a year (4), about once in two months (3), about once a month (2), more often (2)	

age (M= 61, SD= 1.2) range of the older participants was 55 to 62 (Table 2) . In our study, we organized participatory design workshops in a laboratory setting, involving one child participant from each group. The parent participant from the same group joined the session online through WeChat. We supplied the participants with design materials such as sticky notes, cardstock, pens, and scissors to facilitate the design process. To ensure comprehensive documentation of the entire design process, we obtained participants' consent and utilized a video camera to record the proceedings.

2.2.3 Procedure. Our participatory design process consists of the following steps: 1) We show participants a 30-second AR introduction video to give them a basic understanding of the AR interface. 2) Participants watch a recorded observation experiment playback to review the challenges encountered during the cooking process. 3) We provide participants with the necessary design materials and briefly explain the purpose of each material. Throughout the process, two researchers stand beside participants to answer questions and ensure their complete understanding. Afterward, participants begin the design work and can refer to pain points discovered in the formative research if uncertainty arises during the design process. The duration of the design phase varies, usually between 40 minutes to one hour. After completing the design, participants have about 15 minutes to explain their design further. To gain a deeper understanding of participants' designs, researchers can ask follow-up questions based on their explanations to explore user design choices and intentions more comprehensively.

3 RESULTS

We generated two main findings. First, we identified the *Attitudes and Perceptions for cooking-based remote IG communication*. Second, we highlighted the *Design considerations for cooking-based remote IG communication*.

3.1 Attitudes and perceptions for cooking-based remote IG communication

According to our survey, most young participants (87.90%) encountered two types of obstacles and two types of needs in the cooking process. First of all, obstacles include challenges in the cooking task itself and the quality of communication. Challenges with cooking tasks include ingredient preparation, quantity determination, and lack of basic cooking knowledge. In terms of the quality of IG communication, nearly half of the participants (49.20%) believed that conversations with parents about food-related topics were superficial and needed more participation. Some respondents (33.30%) said that discussing food-related topics can evoke pleasant memories and make the conversation more enjoyable. Therefore, we summarized two types of needs: one is the type of discussion on food-related topics, and the other is the role of elders in the cooking process. Among the detailed topics, the most discussed were taste (41.90%), cooking techniques (33.30%), and nutritional value (23.60%). When it comes to specific foods, the most mentioned are hometown specialties (38.00%), elders' favorite dishes (30.80%), and new recipes they have tried (27.80%). When talking about the role of elders in remote cooking, most young participants (55.40%) expressed the hope that their elders would act as knowledgeable mentors in the kitchen. At the same time, some (29.40%) wanted to learn together with their elders, and a few people (13.6%) just hoped that their elders could accompany them quietly.

3.2 Design considerations for cooking-based remote IG communication

This section concluded four design considerations (DC) from observation study and the participatory design workshop: DC for Hands-free, DC for Cooking Skill Challenges, DC for Passive Assistive Functions and DC for Diverse and Exciting Communication(fig1).

3.2.1 DC for Hands-free. From the observation study, we found all younger participants frequently utilized mobile devices to ask questions or share information with their parents. While most parent participants expressed their concerns about the limited usability of the cell phone as a communication interface. P2 highlighted the small size of the phone, which poses a challenge for traditional video viewing and integration of additional features. *(P2: "the screen size of mobile phones is too small, and I often can't see clearly." and P5: "When my child puts the phone down, I can't see their actions and progress in real-time, I did not know they made a mistake unless they told me.")* Similarly, it was observed that most younger participants (C1,C2,C4,C6) were also observed to have to hold the mobile device with one hand and hole cooking tools with the other hand at the same time. They expressed their concern with the perspective sharing, stating that existing solutions lacked the ability to promote hands-free interaction and appropriately convey complicated information. *(C3: "I am concerned about hygiene. Every time I pick up a mobile device, I have to wash my hands, which is inconvenient."* . Given these issues, we expect the use of assistive devices, such as tablets (for instructional roles) and augmented reality (AR) technology (for cooking roles) could effectively address these limitations.

3.2.2 DC for Cooking Skill Challenges. Through our analysis, we identified several challenges faced by participants concerning their cooking skills. These challenges encompassed the adept utilization of *varied handling and cutting*, *expression of conceptually vague spice quantities* .

Varied handling and cutting Different ingredients often require distinct handling and cutting techniques in the cooking process, leading to significant challenge for participants (N=18)in effectively expressing the nuances of knife and tool use. Our observations revealed that participants across different age groups faced difficulties in this regard. Older participants encountered obstacles in accurately conveying their experiences through language, while younger participants needed help understanding specialized vocabulary due to their limited experience. To alleviate these challenges, participants offered insightful suggestions. P1 wanted a device capable of swiftly capturing videos demonstrating relevant techniques or recognizing their gestures while describing them. She explained, "For instance, if I want to replicate a specific action, my gesture should be recognized, enabling me to visualize it on the computer for others to observe immediately. This feature would be immensely beneficial." . P2 proposed the concept of a cutting auxiliary line, stating, "This auxiliary line could be drawn to indicate the width of the cut. It could also be applied to illustrate precise locations for cutting fish. A multi-functional auxiliary line feature catering to various requirements would be highly advantageous.".Based on these insights, we recommend incorporating line functions that can be drawn on the instructional side of the interface. Additionally,

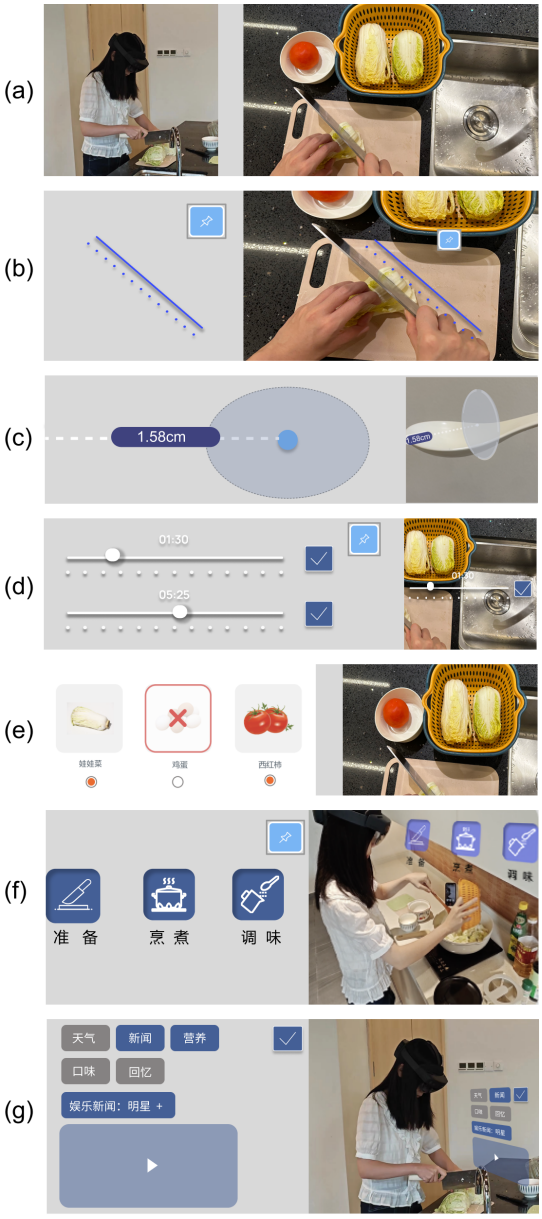

Figure 1: (a) Hands-free:use augmented reality (AR) technology (for cooking characters) to solve hands-free challenge.(b) Varied handling and cutting: the directing side enhances the description by drawing auxiliary lines, and the operating side is able to effectively mimic the cooking technique. (c) Expression of conceptually spice quantities: three-dimensional scanning of condiment containers (spoons) identified by computer to promote consistency in the understanding of condiment quantities. (d) Efficient timing function: remind users of multiple task times, allowing seamless switching between tasks and keeping them in sync. (e) Pre-view food selection and stocking: provide both parties with the ability to prepare and confirm ingredients to prevent both parties from being caught off guard by insufficient ingredients. (f) Brief step prompts: by combining visual cues, progress updates, and timely notifications, the feature gives users a way to simplify the state of remote cooking. (g) Topic prompts: provide different topics regularly during cooking, encourage participants to engage in other conversations outside of the task during cooking.

integrating a video interface on the practice side would enable users to effectively review and emulate cooking techniques.

Expression of conceptually spice quantities Another notable challenge in the cooking process revolved around effectively communicating the amount of seasoning used. Given the subjective nature of seasonings and the absence of standardized units of expression, older participants(N=8) needed help conveying precise dosage information. In comparison, younger participants required time to understand and make continuous adjustments due to their limited experience. To address this challenge, participants proposed various solutions. P11 suggested using a graduated measuring tool: "If I had a measuring bucket next to me or a measuring spoon, I could easily take about 5 ml of both seasonings, allowing me to provide an exact measurement." Another young participant emphasized the importance of improving the recognition of flat smears by incorporating volume recognition of the tool, expressing, ("It's difficult for me to imagine the impact unless a 3D representation is provided. When applying a flat amount, it's challenging to grasp the actual quantity added. Additionally, the small and non-transparent spoon makes it hard for others to visualize."-C2).Therefore, we recommend: the development of intuitive interactive interfaces with scales, and three-dimensional scanning through computer-recognized condiment containers (spoon) to promote consistency in the description and understanding of condiment quantities .

3.2.3 DC for Passive Assistive Functions. To optimize collaboration and avoid negative experiences, we propose two areas where the mentoring end can provide additional support, based on our observations and participant feedback. These areas include *efficient timing function* and *pre-view food selection and stocking feature* that can be viewed in advance.

Efficient timing function We found that in the remote cooking process, there is a phenomenon that the older generation (N=10) is out of sync with the children's cooking Settings, and time is the more prominent challenge. For example, P3 and P5 repeatedly ask how long the child has cooked, but their child is busy mixing other ingredients. In interviews, parents and children also discussed the issue. As C3 says: "I was so busy mixing the ingredients that I forgot I had food in the pan and I didn't know how long it had been cooking when my mother asked me." Parents also want to be able to access their children's timing at the same time in order to provide better guidance. "I wish I could see how long my child has been cooking so I could remind him to turn off the heat when he needs to." P3 said. Therefore, we suggest adding the following feature: timed reminders for multiple simultaneous sections. Managing multiple cooking sections at the same time can be a challenge, and a time reminder feature is critical. The interface should provide clear and unobtrusive notifications to remind users of multiple task times, allowing for seamless switching between tasks and keeping them synchronized. Visual, auditory or tactile cues should be considered to accommodate a variety of user preferences and situations.

Pre-view food selection and stocking features During the remote cooking process, we observed that the majority of young participants (N=5) had difficulty repeatedly asking their parents for descriptions. Especially when it came to confirming food preparation, the older participants often described everything completely, causing the children to double-check. For example, P6 mentions five or six ingredients that need to be prepared at once, but the children can't remember them and have to double-check them before cooking. At the same time, P6 could not determine whether the children had correctly purchased the ingredients as described by her. In addition, in the workshop, almost all participants (N=20) wanted functional assistance that would allow both parties to view the ingredients in advance. As P12 said, "If I can see ahead of time if she's preparing the right ingredients, or if there's a clue to what my child has, I'm less anxious.".To facilitate smoother collaboration, the mentoring end should include features that enable ingredient preparation and confirmation, preventing both parties from being caught off guard by inadequate ingredients. Additionally, incorporating ingredient substitution options can assist younger participants in preparing ingredients more easily. These features aim to improve the overall cooking experience.

3.2.4 DC for Diverse and Interesting Communication. Through our observations and workshops, we found that there were a large number of repeated exchanges related to cooking tasks in the communication between the two sides, and there was a lack of richer dialogue themes and communication opportunities. In order to solve this problem, we propose the following two effective interface design strategies: brief step prompts, and topic prompts.

Brief step prompts We found that intergenerational confirmation of steps in cooking consumed most of the time. First of all, most participants (N=18) needed multiple conversations to confirm that each step was completed, for example, C2 said in the workshop: "Sometimes I have completed my mother's request, but she may not see it." I had to cook and answer her questions about what I had already done, which affected the experience." . Second, the older party (N=10) needs to repeat the description of the steps several times to ensure that the younger person understands them. We observe that they usually start by describing how to cook a dish, but the description is so extensive that they still need to repeat the description over and over again. Therefore, we recommend adding the functionality of a brief step view. In order to facilitate effective coordination and cooperation among participants, clear and unobtrusive communication is essential. By combining visual cues, progress updates, and timely notifications, the feature gives users a way to simplify the state of remote cooking. The optimized interface design ensures efficient presentation of information, facilitates successful real-time monitoring, and enhances the communication experience of remote cooking.

Topic prompts We found that among the participants (N=8), most of them discussed relatively simple contents in the cooking process, mainly focusing on cooking teaching, and rarely related to other topics. For example, P6 mentions: "I wish we could not only teach our children to cook, but also take this opportunity to fully communicate and learn about our children's lives, but sometimes I forget this in the process of cooking together.". C12 also said, "Besides learning how to cook a certain dish, I also want to know more about my parents' lives.". We propose to design a variety of communication theme features. The feature can provide different topics on a regular basis during the cooking process, encouraging participants to start a broader conversation during the cooking process.

4 CONCLUSION

This study explores the current state of remote IG communication in cooking, inspired by previous research on this topic. We identified challenge such as the limitations of viewpoint sharing, the difficulty of clear communication, and the challenges of an asynchronous cooking setup. Based on these findings, we developed a participatory design workshop. We came up with four main DCs: DC for Hands-free, DC for Cooking Skill Challenges, DC for Passive Assistive Functions and DC for Diverse and Exciting Communications. We plan to implement these design considerations through AR device, and presented a demonstration of the design probes. Our research incorporates situational factors on remote cooking, recognizing the importance of cooking for maintaining family relationships and IG communication. Through a deep understanding of food culture and addressing identified challenges, we aim to create a meaningful and effective assistive technology that promotes stronger family bonds and cultural exchange through remote cooking experiences.

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