Lessons From a Remote At-Home Evaluation of an Augmented Reality Application

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ABSTRACT

In this paper, we present the methods, challenges, and lessons from conducting a moderated, remote, at-home study of an Augmented Reality (AR) application that overlays omic information in users' kitchens. Due to the COVID-19 pandemic, our team adapted to remote studies, which have presented unique experiences and discussions. We explore ways that could lower barriers for researchers to conduct remote Mixed Reality (MR) studies and assume greater control over a remote study. We argue that remote studies conducted in study participants' personal spaces can lead to more insightful and nuanced results, but participants' privacy and issues related to equity should be considered and protected.

CCS CONCEPTS

• **Human-centered computing → User studies**; **Mixed / augmented reality**.

KEYWORDS

personal informatics, omic, microbiome, remote study

1 INTRODUCTION

Recent years are seeing a sharp increase in the availability of personal and environmental omic data (e.g. data about genomes or microbiome [13]) to non-experts. While rapid and real-time DNA testing platforms are not yet accessible for residential settings, we presume (based on trends in the DNA sequencing market [3]) that such platforms will be increasingly available and affordable in the next five years. In the past year, the COVID-19 pandemic has had an accelerating effect on the propagation of virtually guided, reliable, affordable at-home testing for health purposes where the results are delivered in minutes [5, 8, 12, 14, 16]. Currently, real time DNA testing can reveal the presence of allergens such as mold [6, 7, 15, 17], discover incorrect sushi labeling[9], identify microbes that can cause food-borne illnesses [10], and reveal the microbial composition of cooking areas [2, 4]. In our study, we examine a near-future scenario, where omic data are ubiquitous and are made visible within everyday living environments. We envision that users would be able to collect data samples from certain areas in the kitchen through scanning or swabbing, and then their results would be available within minutes or hours delivered to their mobile device. Home testing kits already exist today with results delivered online to users within a couple of weeks [1]. To test this near-future scenario, we developed a technology probe [11] AR app that superimposes omic data across users' living environment, empowering users to engage with their data. We chose to place the study in a kitchen environment where such data is highly relevant to precaution measures and health awareness. Our study's simulated data was based on the results of a direct-to-consumer DNA testing kit [1] that a researcher had used to swab surfaces in their personal kitchen. This study was originally intended to be conducted and evaluated in the lab environment within a shared kitchenette that researchers had set up; however, due to the COVID-19 pandemic, we had to adapt our study procedure and AR app to be relevant to a remote and online context. In this paper, we share our experiences and challenges of evaluating this AR app through user studies in a remote and out-of-lab environment.

2 APP PROTOTYPE DESIGN

To create our technology probe for the remote study, we designed and implemented a prototype AR mobile web app that would overlay omic information in the real-world environment. Because we had to adapt our study for a remote context, we implemented an app that required no additional download, accessed by any smartphone device, and did not require a researcher to set up the study environment beforehand. We built a web app using A-FRAME and AR.js so that our app can be delivered on any user's smartphone web browser. Although current AR tools cannot yet recognize objects (e.g. coffee machine, cutting board), we speculate that in the near future a scenario where users' AR apps would have the ability to automatically link data to their objects is likely. To tackle this issue, we used A-FRAME's ability to detect pre-determined images of surfaces and objects (used as markers) and then display corresponding AR information (Figure 1). When using the application, study participants move around the kitchen to scan the markers using their device to explore the data (Figure 3). AR information for the data samples would appear when the app detects a marker (Figure 1). Participants can tap on those data samples to learn more through the information page; different types of omic data (detection of traces, microbial information, DNA identification) are displayed, and data over time is shown to display changes in data samples as a result of simulated health behaviors (Figure 2).

Figure 1: AR info overlaying the physical marker

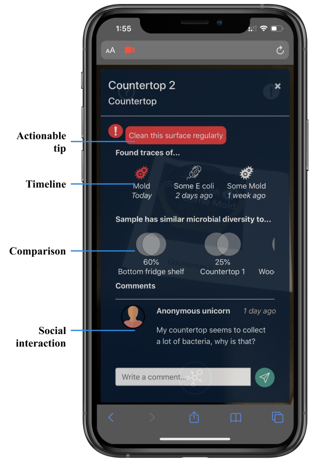

Figure 2: Information page

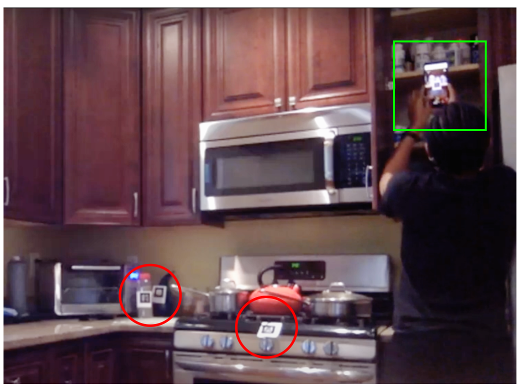

Figure 3: User study in a participant's own kitchen (markers circled in red, user scanning marker squared in green)

3 AUGMENTED REALITY DATA EXPLORATION STUDY PROCEDURE

We conducted a remote user study using the web-based technology probe with 10 participants from August - December, 2020. The study consisted of five phases:

(1) **Recruitment and setup.** After participants signed up and filled out a pre-study questionnaire, researchers mailed 24 markers and set-up instructions to the participants.
(2) **Study session 1** was conducted over a recorded Zoom meeting where participants used the AR app to "think aloud" how the data relate to their kitchen usage and to their health for 15 minutes. We asked them to screen-record and audio-record from their own mobile phones. Researchers then asked interview questions to assess subjective understanding of the omic data, user experience, and perceived usefulness.
(3) **Study session 2** is conducted 3-5 days after session 1, in a similar format.
(4) **Post-Study questionnaire.** A post-study questionnaire was emailed to participants, where the questions were the same as the pre-study questionnaire in order to compare their answers. We used the likert scale as a metric for perceived self-efficacy and health perception change.
(5) **Data collection.** Participants mailed their audio and screen recordings to researchers.

4 LESSONS LEARNED

4.1 More insightful results from at-home study

Prior to this moderated, remote, at-home AR study, our team conducted an in-lab study where users explored a simulated kitchen on a similar AR app that displays omic information. Although we asked users to pretend that the simulated kitchen was their shared dorm kitchen, users felt more distant to the urgency of risks such as allergens and pests. In contrast, while our at-home study displayed similar simulated data as the in-lab study, the study location in users' personal spaces made them feel more concerned about those risks and their personal health. For example, our simulated data shows there are dust mites on the cabinet shelves, and one user reflected "yea there probably are dust mites there, we never clean our spice pantry"; or when our simulated data shows mold in the fridge, one user said "that might be the avocado I left there for days". The at-home study created a more realistic setting of using an AR technology probe, which resulted in a stronger connection between our study's simulated omic data and the users' experience.

4.2 Telepresence during moderated study

During remote study, it was often difficult for researchers to take control over the telepresence experience. Technical difficulties such as unstable connection, low-resolution cameras, and battery-deficient laptops become challenging for researchers and participants to communicate clearly. Researchers watched participants' general behavior through their computer's camera on the Zoom call, but researchers were unable to see how participants were interacting with the AR tool on their mobile screen.

To create a better moderated study, we conducted two sessions so participants can acclimate to understanding the app's functionalities and study expectations. To assume more control over the remote study, we often asked participants if they have any questions, and maintained a study progress document during their exploration to ensure they have seen all data samples. We also found it helpful to display interview questions on a slideshow to prevent misunderstandings due to unstable audio.

4.3 Logistical complications and lowered retention rate

Because our AR app required markers, researchers mailed them to each participant; this often resulted in delayed mailing, lost markers, participants' changing in their personal schedule or living arrangements. We retained 10 out of 16 participants to complete the study, and 5 out of 10 participants failed to record either their audio or screen for data collection. Compared to our previous in-lab study in which we retained 25 out of 28 participants. Overall, the waiting time resulted in deterioration of interest and a low retention rate of participation in our study.

We propose to researchers to simplify and condense the study procedures as much as possible in order to retain participants within their attention span. For example, our sign-up form, consent form, and pre-study questionnaire were all on one GoogleForm. We also learned that conducting iterated pilot studies were helpful to tackle loopholes and technological limitations in our study process. Some participants failed to follow instructions that we sent over email, so we recommend for researchers to call or text participants or ask them to complete a task on a moderated Zoom call.

4.4 Dependence on participants for data collection

After the study, we depend on participants to send us their audio and screen recordings as part of our data collection and analyses. However, a few participants would accidentally lose or forget to save their recordings, and this resulted in gaps in data collection. We attempted to resolve this problem by asking participants to share their mobile screen through Zoom while using the AR app, so that researchers have control over recording their screens; however, the Zoom share screen feature made the AR feature on our study's app cease to function.

In the future, it would be advantageous to create apps that could integrate the AR function with the ability to share screens for remote settings. It was important to follow up repeatedly with participants by sending a detailed study manual, update emails for every step of the study, and repeated follow-ups if they have not completed their tasks.

4.5 At-home studies and privacy considerations

At-home studies presented more nuanced results because users' personal spaces made the data more relevant to their own experiences.

However, there are important privacy issues that researchers should consider. We propose that demographic and personal questions should be delivered in writing as opposed to verbal communication. For example, we asked a participant for their gender identity to which they responded, "if my parents were here right now, I would be very mad that you asked that question". Another issue was household information captured in the video recording, or texts/notifications captured in their mobile screen recordings. To address this issue, we remind participants to prepare by reminding household members to stay quiet and to use Do Not Disturb mode on their phones.

5 CONCLUSION

In this paper, we shared our study methodology and lessons learned for conducting an AR study remotely and at-home for participants. While there were many challenges to recruiting, interacting, and following up with study participants, we saw many insights regarding contextualizing omic data in participants' personal homes. We hope that our experiences will help research to better prepare for and conduct remote at-home studies.

ACKNOWLEDGMENTS

This work was partially supported by the National Science Foundation grants IIS 1814628 and IIS1814932.

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