Crowdsourcing for Effortless Creation of Collaborative AR Spaces

Jaylin Herskovitz
Computer Science & Eng.
University of Michigan
jayhersk@umich.edu

Junlin Mo
Computer Science & Eng.
University of Michigan
junlinmo@umich.edu

Janani Chinnam
Computer Science & Eng.
University of Michigan
jchinnam@umich.edu

Sang Won Lee
Computer Science & Eng.
University of Michigan
snaglee@umich.edu

Isabelle Wong
Computer Science & Eng.
University of Michigan
isawong@umich.edu

Walter S. Lasecki
Computer Science & Eng.
University of Michigan
wlasecki@umich.edu

Mengyao Liu
Computer Science & Eng.
University of Michigan
mengyliu@umich.edu

Abstract

Collaborative brainstorming helps teams collectively generate ideas that no individual would have been able to produce alone. Physical tools that are commonly used in this process, such as sticky notes and whiteboards, provide high flexibility, but are limited in both information capacity and indexability. Digital tools address many of these issues, but often reduce collaborators' ability to co-reference content, and typically cannot fully account for the diverse work-style preferences of different groups. Augmented reality (AR) provides an opportunity to bridge the gap between digital and physical tools, compiling the advantages of both with one primary disadvantage: the complexity of on-the-fly content creation in an AR space. Ideally, users could create objects in AR via intuitive requests (e.g., natural language), but this is currently well beyond the capabilities of automated systems. In this paper, we present a flexible, collaborative tool that connects crowd workers to a shared AR space to allow users to make descriptive requests for information to be added or modified in the shared scene.

Background

Physically reconfigurable spaces are useful in collaborative brainstorming processes because they can be adapted to different types of tasks and team member preferences as needed. However, they: (1) lack portability, so collaborators are confined to specialized, pre-configured spaces; (2) have

finite capacities for storing information; and (3) often make information difficult to review after a collaborative session has ended due to its temporary nature.

Personal-device based digital tools make it possible to reconfigure environments on-demand and create artifacts that are easily shareable, editable, and accessible from anywhere. However, most such tools limit collaborators' ability to easily co-reference information during working sessions, as collaborators may do when writing on a whiteboard [3]. Table 1 details some of the trade-offs between digital and physical tools.

	Physical Tools: (whiteboard, sticky notes, paper and pencil, smartboard)	**Digital Tools:** (GSuite, note taking apps for tablets/ smartphones)
Indexability: How accessible is information after the collaborative session?	Low	High
Capacity: How much information can be stored on or in the tool at once?	Low	High
Flexibility: Can the tool be used for multiple types of tasks?	High	Low
Transition effort: How easy is it to switch from one task to another?	Low	High

Table 1: Comparison of the properties of physical and digital collaborative tools.

AR provides an opportunity to create customizable spaces that merge the advantages of each type (both digital and physical), thereby providing capabilities that traditional collaborative environments do not account for.

Augmented Reality as a Collaborative Tool

To address the need for a collaborative tool that is both customizable and contextually situated, we propose a system design that connects online crowd workers (e.g., from platforms like Amazon Mechanical Turk) to a collaborative AR space and allows users to quickly make natural language requests describing how they would like to add or modify information in a shared scene. Such a tool allows users to modify their environments in real-time, simulating the action of physically reconfiguring a space.

Creating Portable Workspaces

Supporting collaboration in an AR space has some key advantages over traditional tools. AR makes it possible for a customized work environment to be portable, thus eliminating the need for specialized collaborative spaces that must be pre-furnished with different types of tools. This also removes the initial time cost of arranging whiteboards, monitors, and other tools to suit the needs of the group. The AR space can be maintained between different sessions and locations without the need for any significant initial setup, and participants can easily switch between tasks by saving their current configuration and returning to it at a later time.

Preserving Context and Spaces

AR allows for information to be contextually situated. Sticky notes have this property as well, as their content can relate to physical objects or other pieces of information that they are placed on or near. Once the notes are removed from their original placement, however, this context is lost. The ability to save an AR workspace and view it again at a later date preserves the physical context of the information, and teams could more easily resume discussion between meetings because of this. Annotation in AR would also not be constrained by capacity, and information of any type could be linked to a physical location.

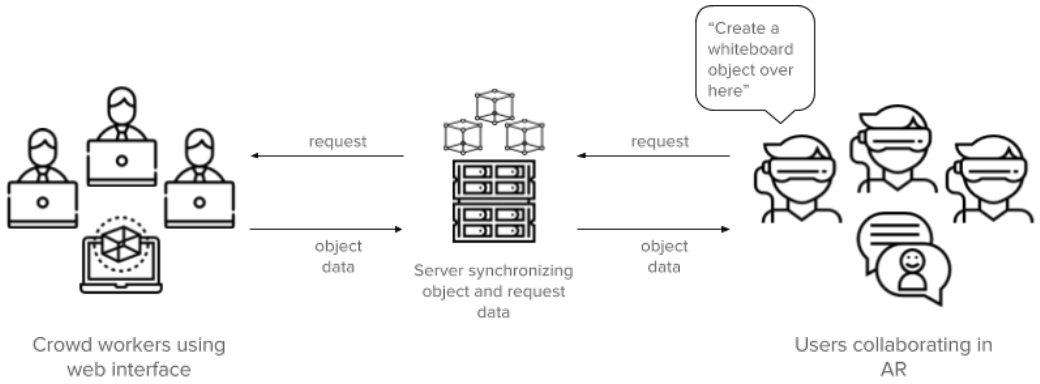

Figure 1: System diagram showing connection between crowd workers and users via a shared database. Users could make requests through audio or video, and the request and any necessary contextual information (i.e., relative position of the user to a global anchor or selected object, or direction of the users gaze at the time of the request) are sent to a shared server. Crowd workers view this request and edit a scene in response through a web interface, which renders objects from the shared database of object information.

Facilitating Communication Through Shared Context
Collaboration in AR enables the sharing of large scale spatial context between participants, better facilitating communication. Collaborators can make easily understandable physical references to pieces of information, a difficulty with digital tools. Users can even have visible lines of sight or other pointers as visual cues to further clarify their references to information. Additionally, in an AR space, collaborators can better leverage non-verbal cues and eye contact in their conversations, an advantage over having to periodically focus on a laptop screen or face the same direction to view a whiteboard. AR also makes it possible to view the same information easily from various positions within a room through copies and multidimensional objects. Because information is also semi-transparent, it is less obstructive than having to work around physical objects.

Crowdsourcing for Effortless AR Interactions

The primary limitation to collaboration in AR is the complexity of on-the-fly content creation within an AR space. Systems based on gaze and gesture alone (i.e., without other input devices) are intuitive but make precise interactions, such as typing on a virtual keyboard, very difficult. Especially in a collaborative setting, where complex tools cause unnecessary slowdowns and distractions from productive work [2], allowing relatively inexperienced users to complete tasks without an understanding of AR content is crucial. Otherwise, attempting to complete complex operations would lead to significant obstacles that negate the advantages of using AR. In order to make the generation of content in this space effortless, it is necessary to have a robust system that can fully understand participants descriptions and references.

Using crowd worker intelligence to solve the issue of task complexity is not new: Apparition [5] and SketchExpress [6] use crowd workers to create on the fly 2D prototypes that are immediately functional based off of natural language input from users, and Crowdboard [1] has workers assist with idea generation in collaborative brainstorming tasks. Applying this idea in an AR setting would allow users to quickly describe how they would like information to be added or modified in a shared scene to perfectly fit their team's needs. Crowd workers, upon hearing a user's input, would then be able to immediately generate an AR representation of the user's idea using keyboard and mouse, which allows for more precision than gesture based interaction. This minimizes user distraction by channeling content creation and functionality to the crowd worker, streamlining the flow of ideas. It also results in a flexible and robust system, as crowd workers can create new functionality on the fly, allowing the system to adapt to new tasks easily.

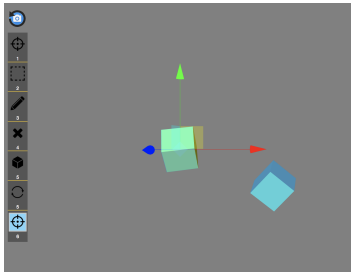

Figure 2: Initial crowd worker interface development

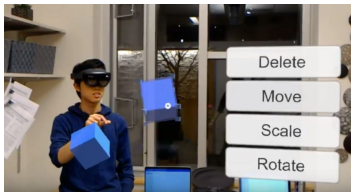

Figure 3: Initial HoloLens interface development

Initial System and Efforts

Figure 1 shows the architecture of our proposed system and details the request workflow. Figures 2 and 3 show our initial crowd worker interface and Microsoft HoloLens interface respectively for editing shared objects.

Future Project Direction

Our proposed method focuses on collaborative information tasks — those that focus on the generation and exchange of ideas — and aims to improve the collaboration outcomes and overall success of diverse teams during the beginning stages of a project. However, there are many other useful applications for such a system. For example, AR could create collaborative spaces more accessible to deaf and hard of hearing individuals, who rely on visual cues. Users could request to send a visual notification to another to get their attention, which could also include a direction to turn or additional text. Automatic captioning for participants could also be provided, as crowd workers have been used for real time transcription in the past.

There are concerns, though, about the risk of revealing users' privacy to crowd workers [4]. While immediate work on this approach will focus on the effectiveness of introducing effortless creation into collaborative AR spaces, future work will consider issues in protecting user privacy [4], and in providing the appropriate tools for workers to ensure that they can assist with this task efficiently despite its difficulty.

Conclusion

We propose an approach to addressing many current limitations of collaborative tools by leveraging the input of crowd workers to create effortless interactions for customizing augmented reality collaborative spaces on-the-fly. Our ultimate goal is to allow crowd workers to enable precise changes in information or models, and quickly create new tools during live collaborative sessions, saving user time and preserving the flow of conversation and ideas.

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