Joint Search Patterns in Mixed Reality

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Abstract
Most work concerning Mixed Reality (MR) is done on an individual level (e.g. using augmented reality glasses to fulfill tasks). Nonetheless the technology has great potential for cooperative tasks as well. In this paper, we present a visual search experiment that was conducted in a cooperative MR setting with Microsoft HoloLens devices. Participants were given search tasks representing typical challenges of cooperative mixed reality tasks in practice. The experiment aimed to explore the cooperation of participants and to be able to gather insights for supporting these tasks with augmented reality devices.

1 Introduction

Augmented reality (AR) is a prominently discussed technology with a lot of potential to support work in the age of digitalization. AR "allows the user to see the real world, with virtual objects superimposed upon or composited with the real world. (…) AR supplements reality, rather than completely replacing it." (Azuma 1997, 356ff.). AR and – more generally – Mixed Reality (MR, see Milgram and Kishino, 1994) create great opportunities, which have received recognition in both science and business contexts. Most research on AR and MR is done from the perspective of an *individual* user of a handheld or head-mounted AR device that supports the user, while – as recognized by some scholars (e.g. Gupta et al., 2016; Schmalstieg and Hollerer, 2016) – AR technology bears a lot of potential to support groups in different settings.

Cooperative visual search tasks have been used to analyze the costs and benefits of shared gaze in a search task (Zhang et al. 2017) or in remote helper-worker collaboration tasks (Gupta et al. 2016). This makes cooperative visual search appealing for research on coordination in MR, as it can provide insights for improving user support to varying tasks and suspected outcomes.

Literature suggests that different levels of difficulty may provoke different search strategies, with more complex tasks leading to more systematic strategies (Pomplun et al. 2013). In the experiment, we were interested in whether and how coordination would take place, including how people would use means of co-located coordination (direct communication, visual cues of others) to coordinate their searches. We analyzed the experiment with a novel analysis tool

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developed in our group that supports MR analysis based on activity logs (Rühmann et al. 2018), and we identified patterns of cooperation, which inform the design of support for these settings.

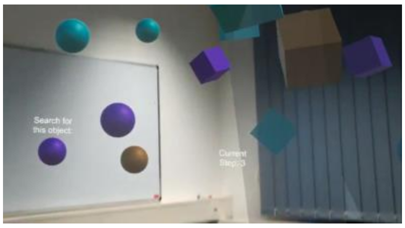

Figure 1: 3D Objects in the room as well as instructions for the search task. Current task is to search for the purple ball (“Search for this object” on the left).

2 The Experiment

The experiment followed a repetitive scheme: Find (as a dyad) a certain search object (SO) within a room and move it to a certain area of the room, the target area (TA). Placing of the SO in the TA could only be done **after both participants indicated that they had found the SO** (through clicking on it). This requires both of them to mark the SO as found and makes cooperation in the search process necessary. Searches were done in three conditions: A simple matrix search, a 2D search on the walls, and a 3D search in the whole room. This paper focuses on 3D as the most complex condition, omitting the two (simpler) conditions.

We used objects of three colors (orange, turquoise and purple) and two shapes (cuboid and sphere, cf. Figure 1). The object to search was unique in color-shape combination. Colors were chosen in respect to red-green color blindness and with enough contrast to ensure that no participant might encounter issues finding the SO due to being unable to identify it. 20 3D objects were randomly placed in the search space. This task represents cooperation in AR in which virtual information and objects are spread around in the room (cf. Datcu et al., 2016). For the experiment 20 participants (13 male and seven female participants) were recruited and formed ten dyads. Each group had to perform the task five times this created a total of 50 samples.

3 Analyzing cooperative MR search patterns

We used our analysis tool for MR settings to visualize the activities in the search space with the virtual objects (Rühmann et al. 2018). We identified a few patterns and following these are introduced (the patterns are also shown in (Rühmann et al. 2018)):

Spinner: The *Spinner* describes a circular movement throughout the complete search space from the starting direction to the SO (cf. Figure 2). It was used for movements when one of the participants turned around at least half of the room **or** when the gaze of both participants completed the motion, making it a full spin. It was found in two forms. In *Spinner*Wave* the gaze often went up and down, and in *Spinner** moves are interrupted through one of the participants finding the SO and the other one stopping the search and turning. This can be triggered by a verbal signal, realizing that the other one stopped moving or by another impulse.

Separated Space (*Sep. Space)***:** In this pattern the participants did not search the complete search space but restricted themselves to search only a specific part. Once the other participant found the SO the search strategy was stopped and the search task completed through turning

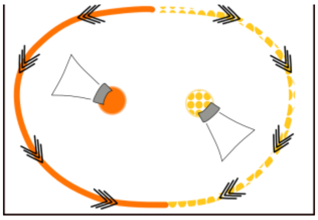

Figure 2: Spinner Patter. Participants spun around the room. Yellow / orange dots are the participants with their field of view and a line, in the respective colour, for their gaze. (Rühmann et al. 2018)

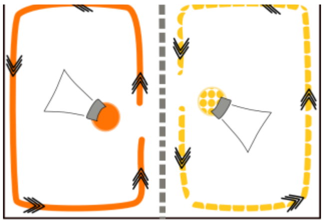

Figure 3: Sep. Space (My Half). The participants only explored their "half" of the room. (Rühmann et al. 2018)

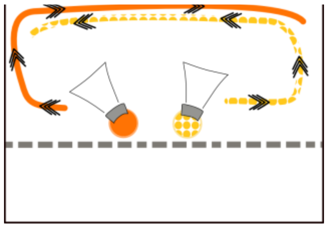

Figure 4: Sep. Space (front half). Only the space in front of the participants was searched and they did not turn to search the space behind them. (Rühmann et al. 2018)

towards the SO. Multiple facets were identified: *my half, front half* and *top low* (cf. Figure 3 and Figure 4).

Additionally, during some of the searches we were not able to clearly identify one pattern as the participants just looked around the space in a random fashion. We referred to this as *Random* search. Looking at the dyads, seven of the ten started with the *Random* search. *Spinner* was used, but only one dyad started with it. The three patterns were almost used equally: 14 out of 50 searches were categorized as *Sep. Space* (main variant was the *My Half* pattern, present ten times), *Spinner* was found 15 times and the *Random* was identified 16 times. All dyads switched between patterns at least twice during the five tasks.

4 Discussion

During the analysis we found various patterns and changes in strategies of the dyads. We attribute this to the high complexity of the search task as the search space could not be scanned systematically. Also, the search tasks required head as well as body movement while searching. This leads to the impression, that a systematic search is not present. A few things stand out: First, the *Random* search pattern was used at least as often as other patterns, with a prevalence for the initial search task. This shows that some learning may have taken place, as other patterns come in when the tasks progresses. It also suggests that no obvious, systematic or simple strategy for the participants was obvious. Second, we found that the search patterns were not entirely homogenous, and that pairs show a big variety of patterns. This underpins the impression that it was difficult for the participants to find a good strategy, and that therefore they alternated strategies. Third, *Sep. Space* shows that the participants felt the need to search more systematically, and that they divided the room into two to deal with half of the complexity each. This complies with the strategy of a *"look where I'm not looking"* identified by Brennan et. al. (2008). This also became obvious while using the analysis tool (Rühmann et al. 2018) we developed.

Cooperative visual search has been used in the past as proxy for other cooperative tasks (Zhang et al. 2017), we only looked into one specific type of cooperative (dyadic) task. An additional limitation to our study is that further research needs to explore the effectiveness of search patterns and additional aspects e.g. communication affecting the conduction of searches. Also, a bigger sample size for participants and search types is needed. Further work will study the effects described in the paper deeper.

5 Conclusion

For cooperative MR, we found the 3D visual search in AR resulted in little systematic ways of coordination and cooperation when it comes to search patterns. This uncovered some possibilities for supporting this kind of setting. Even though we are aware of the limitations concerning our work, we strongly believe that it presents new insights and opportunities that could be used for development as well as research within the field of cooperative MR settings. Our future work will investigate the aspects discussed here, expand and refine the analysis tool (Rühmann et al. 2018). At the conference we would like to show the analysis tool, discuss the results and approach to find the described patterns. In addition we would like to gather ideas on how to improve the analysis tool with aid of the community.

6 References

Azuma, R.T. (1997). A Survey of Augmented Reality. *Presence: Teleoperators and Virtual Environments*. *6*(4), 355–385.

Brennan, S.E., Chen, X., Dickinson, C.A., Neider, M.B. & Zelinsky, G.J. (2008). Coordinating cognition: the costs and benefits of shared gaze during collaborative search. *Cognition*. *106*(3), 1465–1477.

Datcu, D., Lukosch, S.G. & Lukosch, H.K. (2016). Handheld Augmented Reality for Distributed Collaborative Crime Scene Investigation. *Proceedings of the 19th International Conference on Supporting Group Work*., 267–276. Sanibel Island, Florida, USA: ACM.

Gupta, K., Lee, G.A. & Billinghurst, M. (2016). Do You See What I See? The Effect of Gaze Tracking on Task Space Remote Collaboration. *IEEE Transactions on Visualization and Computer Graphics*. *22*(11), 2413–2422.

Milgram, P. & Kishino, F. (1994). A taxonomy of mixed reality visual displays. *IEICE TRANSACTIONS on Information and Systems*. *77*(12), 1321–1329.

Pomplun, M., Garaas, T.W. & Carrasco, M. (2013). The effects of task difficulty on visual search strategy in virtual 3D displays. *Journal of vision*. *13*(3), 24–24.

Rühmann, L.M., Prilla, M. & Brown, G. (2018). Cooperative Mixed Reality: An Analysis Tool. *Proceedings of the 2018 ACM Conference on Supporting Groupwork*., 107–111. New York, NY, USA: ACM.

Schmalstieg, D. & Hollerer, T. (2016). *Augmented Reality: Principles and Practice*. *01. edition*. Boston: Addison Wesley.

Zhang, Y., Pfeuffer, K., Chong, M.K., Alexander, J., Bulling, A. & Gellersen, H. (2017). Look together: using gaze for assisting co-located collaborative search. *Personal and Ubiquitous Computing*. *21*(1), 173–186.

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Michael Prilla hat die Professur für das Gebiet „Human-Centered Information Systems“ (HCIS) an der TU Clausthal inne. Er beschäftigt sich mit der Gestaltung und Evaluation von Mensch-Maschine-Interaktion mit besonderem Fokus auf die Unterstützung kooperativen Arbeitens und Lernens. Anwendungsbereiche sind IT und Digitalisierung im Gesundheitswesen, digitalisierte Arbeits- und Lernprozesse sowie Chancen und Risiken neuer Technologien. Ein Schwerpunkt hierbei sind Potentiale und Wirkmechanismen von Augmented Reality für Lernen und kooperative Arbeit. Paradigma ist dabei stets das Verständnis von IT und menschlicher Interaktion als sozio-technisches System, dass beide Seiten in einem partizipativen Prozess eng miteinander verbinden. Prof. Prilla hat mehr als 110 Publikationen in Journals, Konferenzen und Büchern als (Co-) Autor geschrieben. Er ist Mitglied im Lenkungskreis des Fachgebiets „Mensch-Computer-Interaktion“ der Gesellschaft für Informatik und stellvertretender Sprecher der Fachgruppe CSCW und Social Computing.