
Preliminary Evaluation of a Remote Mobile Collaborative Environment

Kharsim Yousef

HCI Group
Dept of Computer Science
University of Bath
Bath
BA2 7AY
UK
kam26@bath.ac.uk

Eamonn O'Neill

HCI Group
Dept of Computer Science
University of Bath
Bath
BA2 7AY
UK
eamonn@cs.bath.ac.uk

Abstract

MCEs (Mobile Collaborative Environments) are systems designed to allow users to collaborate any time and anywhere using wireless networks and mobile devices. In this paper we report on our findings from the development and testing of a fully functional MCE photo-conferencing service that enables seamless synchronous collaboration between remote mobile users over existing 3G cellular networks. Key to the development of MCEs is an understanding of the effects of remote gestural interactions between mobile participants. We report on the results of an initial evaluation of our photo-conferencing service, examining the effects of two remote gestural interactions, 'Pointing' and 'Scaling', assessing their impact on performance measurements. Our findings begin to inform the design of future mobile collaborative environments.

Keywords

3G, Mobile, Collaboration, Conferencing, Mobile Collaboration Services, Mobile Sharing.

ACM Classification Keywords

H.5.2 Information interfaces and presentation: User Interfaces – User-centered design; H.5.3 Group and Organization Interfaces – Computer supported cooperative work.



Figure 1: Photo-conferencing pointing and scaling.

Introduction

Collaborative environments or groupware applications facilitate team working and typically enable a group of people to manipulate shared objects, and modify them in a coherent manner [9]. There are many collaborative activities that may be amenable to technological support, examples including electronic conferencing and cooperative design. In this paper we report an initial evaluation of a photo-conferencing service [12] designed to enhance social image sharing across mobile devices.

Previous research in mobile HCI has identified the limitations of existing mobile photo sharing solutions such as MMS [1, 6] and has identified the need for richer solutions. Kindberg et al. [7] and Van House [11] note that participants in their studies needed better capabilities to connect in the moment and would undergo the effort of using multiple devices to achieve ongoing conversations whilst sharing images. Reporting on camera phone adoption in Japan, Okabe [8] similarly found that users tend not to share images remotely with one another, but prefer to share directly using the handset screen itself and that “people are in fact frustrated when trying to share images remotely and interactively”.

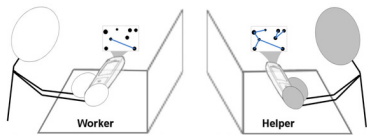


Figure 2. Helper/Worker set-up: mobile devices utilised local Wi-Fi connectivity instead of 3G to control for potential network-related variations.

Photo-conferencing was suggested by Frohlich et al. [5] as a means by which users can engage in interactive computer-mediated photo-sharing practices, supported by a simultaneous telephone conversation, minimising collaborative effort. However, no such photo-conferencing system has been presented to date. In an effort to further this research, we have developed a complete mobile photo-conferencing service [12] that

facilitates interactive photo-sharing and simultaneous voice communication between remote mobile users.

Our mobile photo-conferencing service enables users to interact with photos using two remote gesturing techniques: ‘pointing’ which consists of a cursor that simultaneously moves on both devices and ‘scaling’ which concurrently enlarges and shrinks the viewable content on both devices (see Figure 1). Pointing and scaling on each device can be controlled independently or simultaneously (i.e. synchronously across the devices) using dedicated hardware buttons. These facilities provide the mechanisms through which users can indicate focus [10] during a conferencing session and construct what Crabtree et al. [4] describe as “a host of fine grained grammatical distinctions”.

We have run an initial evaluation study of the remote pointing and scaling features offered by our photo-conferencing service, finding significant variations in performance measures based on the use of pointing, scaling or a combination of both. Here we outline some of our findings from this study and suggest implications for the design of such mobile collaborative services.

Method

We ran 12 pairs of participants, recruited from undergraduate and postgraduate students at the University of Bath. All participants were well versed in the use of mobile devices. The physical set up was similar to that in Figure 2. We used smart mobile phones without touch screens as they account for the majority of cellular devices sold worldwide.

The study utilised a puzzle task paradigm which required a Helper to guide the actions of a Worker in

the completion of a "connect the dots" diagram. This was chosen as it represents a generic object-focused task and is comparable to tasks used in previous work [2, 13]. It allowed for precise control over the number of referential points used by participants and the level of task difficulty.

Participants were randomly assigned roles (Helper or Worker) and given training in the use of the mobile collaborative service, allowing ample time for familiarisation. During the task the Helper was provided with diagrammatic instruction to guide the actions of the Worker. Participants were instructed that they could talk at all times and were provided a maximum of 10 minutes in which to complete the task.

Four collaborating Worker-Helper pairs were run in 3 conditions. In the first (pointing) condition, the participants were provided with only the pointing facility of the mobile collaborative service. In the second (scaling) condition, they were provided with only the scaling facility. In the third (mixed) condition, they were provided with both facilities.

Results

Our aim was to understand the effects of support for pointing and scaling on mobile collaborative interactions. In particular, we are interested in their effect on the collaborative effort [2] required by participants to perform their joint activity.

To this end we compared a range of performance measurements across the 3 conditions, including task completion time, number of words used by the participants, number of key-presses, error rates and a measure of cognitive workload.

Task completion time

The mean task completion time for each condition is presented in Table 1 (top row). A one-way ANOVA across the 3 conditions found a significant effect on task completion time ($f_{2,9} = 8.24, p \leq .002$). Post hoc pairwise unrelated t-tests found a significant difference between pointing and scaling ($t_s = 4.12, p \leq .001$), and between the scaling and mixed conditions ($t_s = -3.8, p \leq .002$). No significant difference was found between the pointing and mixed conditions ($t_s = 0.4, n.s.$).

	Pointing	Scaling	Mixed
Time	137.25 (45.52)	67.00 (15.86)	136.38 (49.08)
Words	204.63 (76.89)	151.63 (42.22)	196.75 (45.24)

Table 1. Mean performance of collaborating pairs across 3 conditions (Time: in seconds, Words: number of words). SDs in parentheses.

The pointing and mixed conditions produced almost identical completion time results. A bivariate analysis found strong linear correlation between the pointing and mixed conditions ($p \geq .80$). This may be because participants preferred pointing to scaling at a ratio of 62/38 in the mixed condition. The scaling only condition enabled participants to complete the task in almost half the time of the other conditions.

Conversation Analysis

The number of words used by the participants was taken as a measure of collaborative effort [3]. Transcripts were created from video recordings of the experimental trials and the total number of words used by each Helper/Worker pair was calculated for each

session. The mean number of words used by the pairs in each condition is presented in Table 1 (bottom row), with example excerpts shown in Table 2.

A one-way ANOVA found no significant difference between the number of words used in each condition ($f_{2,9} = 2.01$, n.s.) or between Helper/Worker pairs across conditions ($f_{2,9} = .92$, n.s.).

In addition to this quantitative analysis of the participants' dialogues, we performed a qualitative conversation analysis. Comparing the pointing and scaling excerpts in Table 2, we observe that whereas in the pointing excerpt the Worker is obliged to verify every single Helper instruction, with each object being identified and clarified one at a time, in the scaling excerpt the Helper is more directive, with many objects being identified sequentially and the Worker not needing to respond to every action.

Pointing	H: <u>This</u> one is the first one (.) W: y:es H: connect it with (.) <u>this one</u> W: >okay< H: and th:en to the one its <u>at now</u> W: yes
Scaling	H: The <u>three</u> ones at the <u>top</u> are connected and (.1) <u>thats</u> the <u>top</u> one with the <u>left</u> one (.) an:d the <u>middle left one</u> with the <u>right</u> middle one. W: (.) >okay<
Mixed	H: <u>This</u> tiny one, it goes to the <u>big</u> one W: >okay< H: Then to (.) both <u>big ones</u> above W: Whats this? (.) <u>both</u> left and right? H: >yes<

Table 2. Excerpts from the recorded transcripts from each condition.

The excerpts in Table 2 illustrate that users of scaling tended to adopt a top-down approach allowing the identification of multiple onscreen objects in quick succession with less backchannel. In contrast, the pointing group adopted a bottom-up approach of identifying one object at a time, despite their ability to use a similar approach, in which pointing at a single object could be used to reference surrounding objects.

Event Analysis

Event-logs recorded during the experimental trials provided data on the number of key-presses utilised during each trial. The data were collected using the photo-conferencing service's built-in event logger, which was active throughout all sessions. The results of the event-log can be seen in Table 3 (top row).

A one-way ANOVA across the 3 conditions found a significant effect on the number of key-presses required to complete the task ($f_{2,9} = 7.08$, $p \leq .005$). Post hoc pairwise unrelated t-tests found a significant difference between pointing and scaling ($t_s = 3.58$, $p \leq .002$), and between the scaling and mixed conditions ($t_s = -3.8$, $p \leq .002$). No significant difference was found between the pointing and mixed conditions ($t_s = 0.71$, n.s.).

Error and Workload Analyses

We performed post-trial analyses of mental workload (Table 3, middle row) and error rates (Table 3, bottom row). Error rates are a representation of the number of incorrectly connected nodes from each "connect the dots" puzzle task. A one-way ANOVA across the 3 conditions found no significant effect on the number of errors made ($f_{2,9} = .56$, n.s.).

	Pointing	Scaling	Mixed
Events	32.88 (33.19)	10.50 (4.66)	22.63 (23.11)
Workload	137.83 (48.83)	152.75 (38.95)	130.83 (47.50)
Errors	0.28 (0.19)	0.32 (0.21)	0.25 (0.17)

Table 3. Mean performance across conditions (Events: number of key presses, Workload: NASA TLX, Errors: average per experiment). SDs in parentheses.

Mental workload (see Figure 3) was assessed by administering the NASA TLX, using both sections of the assessment, the sub-group scales and the paired comparisons section. A one-way ANOVA for each subscale across the 3 conditions found a significant effect on temporal demand ($f_{2,9} = 4.46, p \leq .05$), with post hoc pairwise unrelated t-tests finding a significant difference between pointing and scaling ($t_s = -2.89, p \leq .003$), and no significant difference between pointing and mixed ($t_s = -.76, n.s.$), or the scaling and mixed conditions ($t_s = 2.582, n.s.$).

These results indicating a higher temporal demand for scaling in comparison to pointing contradict to some extent our task completion time findings (see Table 1, top row).

Discussion and conclusion

An unexpected finding can be observed in the scaling only condition which enabled participants to complete the task in almost half the time of pointing only and the mixed condition. This finding potentially suggests that the use of scaling can accelerate the process of achieving conversational grounding [3] in this kind of

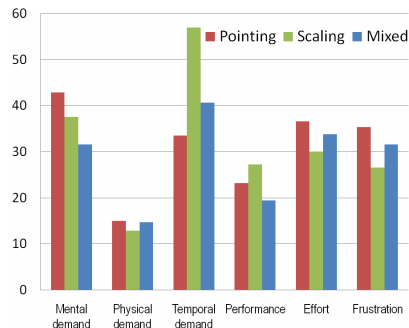


Figure 3. Weighted mental workload sub-scales by condition: Pointing, Scaling and Mixed.

mobile collaborative setting. According to the principle of least collaborative effort [3], people should try to ground with as little combined effort as needed and change their communicative strategies based on certain costs of the communication medium [2].

With scaling only we observe a reduction in combined effort taking place (see Figure 3). These results are corroborated by findings in the event analysis that show far fewer interactions are required when using scaling in comparison to pointing and the mixed condition.

However, a side effect of scaling can be seen in the subscale comparison of mental workload, in which a much higher temporal demand indicated participants perceived that faster results could have been possible, despite completing the task in almost half the time of pointing only and the mixed condition (see Table 1, top row).

The high proportion of pointing used in comparison to scaling (62/38) in the mixed condition also supports that given a choice of pointing or scaling users prefer pointing. Also, in their post-trial qualitative feedback, users in the scaling only condition – where no pointer was present – explicitly requested a pointing “cursor” as a means to simplify performance of the task.

In summary, these initial findings suggest that the use of scaling accelerates grounding and supports the principle of least collaborative effort. Though the users’ expressed desire for a pointing cursor may be attributable to first time use of the system, it does highlight the need for remote mobile interactions that take into account familiar input mechanisms.

Clearly, the number of participants (24) in this initial evaluation was low. This is very much work in progress and we are currently planning further trials with more participants. This ongoing work will increase our confidence in the statistical analyses from our experimental studies and may turn up other interesting results. In addition, the running of further trials will provide further qualitative data for analysis of new remote mobile interactions.

The photo-conferencing service is in its early iterative development cycle. We plan to further investigate the effects of remote gesturing mechanisms on mobile collaboration to further enhance the photo-conferencing experience. We subsequently plan on leveraging the existing infrastructure and remote mobile interactions to develop additional mobile-conferencing services, for example collaborative map sharing to assist with selecting meeting points.

Acknowledgements

Thanks to Vodafone Group R&D for their support throughout this research.

References

- [1] Aoki, P., Szymanski, M., Woodruff, A.: Turning from Image Sharing to Experience Sharing. In First Workshop on Pervasive Image Capture and Sharing, Ubicomp'05 (2005)
- [2] Clark, H.H., Brennan, S.E.: Grounding in communication. *Perspectives on socially shared cognition* (1991), 127-149.
- [3] Clark, H.H., Wilkes-Gibbs, D.: Referring as a collaborative process. *Cognition* (1986), 1-39.
- [4] Crabtree, A., Rodden, T., Mariani, J.: Collaborating around collections: informing the continued development of photoware. *Proceedings of the 2004 ACM conference on Computer supported cooperative work* (2004), 396-405
- [5] Frohlich, D., Kuchinsky, A., Pering, C., Don, A., Ariss, S.: Requirements for photoware. *Proceedings of the 2002 ACM conference on Computer supported cooperative work* (2002), 166-175.
- [6] Ito, M.: Intimate Visual Co-Presence. In First Workshop on Pervasive Image Capture and Sharing, Ubicomp'05 (2005)
- [7] Kindberg, T., Spasojevic, M., Fleck, R., Sellen, A.: The ubiquitous camera: an in-depth study of camera phone use. *4. Pervasive Computing, IEEE* (2005), 42-50.
- [8] Okabe, D.: Social practice of Camera Phone in Japan. In First Workshop on Pervasive Image Capture and Sharing, Ubicomp'05 (2005)
- [9] Sun, C., Jia, X., Zhang, Y., Yang, Y., Chen, D.: Achieving convergence, causality preservation, and intention preservation in real-time cooperative editing systems. *5. ACM Trans. Comput.-Hum. Interact.* (1998), 63-108.
- [10] Turner, J., Kraut, R.: CSCW'92: Sharing Perspectives: *Proceedings of the Conference on Computer-Supported Cooperative Work*, October 31 to November 4, 1992, Toronto, Canada. ACM (1992)
- [11] Van House, N.A., Davis, M.: The Social Life of Cameraphone Images. In First Workshop on Pervasive Image Capture and Sharing, Ubicomp'05 (2005)
- [12] Yousef, K., O'Neill, E.: Photo-Conferencing: a novel approach to interactive photo sharing across 3G mobile networks. In *Proceedings of Social Interaction and Mundane Technologies Workshop*, 26-27 November 2007, Melbourne, Australia. (2007)
- [13] Zanella, A., Greenberg, S.: Reducing interference in single display groupware through transparency. *Proceedings of the seventh conference on European Conference on Computer Supported Cooperative Work* (2001), 339-358.