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Effects of 'Spatialized' Communication in Tightly Coupled Work

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Abstract:

This technical report describes the advancements on our research on collaborative annotations of maps. Particularly, we are trying to answer the following research question: does making explicit the location references of the elements of a discourse enhance the participant's understanding and the related problem-solving?

1. Introduction and motivational questions

Recently, there have been a growing number of projects on location-linked information systems, whose core is to connect information pieces to positions in space. Quite a few focused on campus and city tourist guides [1][5] as well as electronic guidebooks for museums [12][18]. Others focused on archeological and other types of fieldwork [13][17], context-sensitive conference guide [18], and web information bridges to physical places [2][3][21].

A subset of these projects focused on the user's production of textual communication linked to location: it is the case of GeoNotes [10][14], a project developed at SICS in Sweden, and E-graffiti, developed at Cornell University [2]. Both projects allowed users to express opinions, preferences, recommendations, questions, jokes, etc. – all connected to a specific place. These last researches focused on the user 's experience: why and where the users where authoring the notes. Particularly how/why some locations attracted annotations. Furthermore, recent advancements in geographical information systems set the stage for location-based services and interfaces for resource retrieval that display the results of the user interaction as landmarks on a map: as is the case of Socialight[1] or Loopt[2], both based on Google Maps[3], among others.

We look at the same activity from the collaborative work/learning perspective. These new opportunities of communication pose new and interesting challenges: does spatially-contextualized communication help the user to better coordinate and collaborate? Some seminal research in this area seems to suggest that making the spatial context of the communication explicit helps disambiguating and remembering the connected information. This is the case with binding references to technical illustrations [15], or connecting parts of an online conversation about papers with the parts of the

[1] See `http://socialight.com/`
[2] See `https://loopt.com/`
[3] See `http://maps.google.com/`

text the discussion refers to [6][19].

Making these location references explicit offers an additional modality of communication which complements and interacts with the other conversation channels. Dillenbourg & Traum [9] showed, not only how the availability of a shared whiteboard during a collaborative task could be used to offload the cognitive charge and ground resolution strategies, but also how the availability of this new channel changed the way people interacted and solved the task. Cherubini & van der Pol [4] advocated for the use of these extra modalities as a way to reveal false-shared understandings that could help to monitor the task resolution process.

We want to study under which conditions making spatial-references explicit can help improve communication in a problem-solving scenario: is spatialized-communication beneficial to space-related tasks? Does it impact other reasoning situations? How does it compare to other forms of communication?

This report presents initial qualitative results from the controlled experiment we designed to answer our research questions (the setting is described in the section 3 below). We compare modalities of exchange of pairs in three different communication conditions, namely a chat where the spatial context was made explicit, a standard chat and a mixed condition where these two modalities are both available. Preliminary results show that the modality of communication embedded to a map is beneficial to spatial-oriented parts of the task, while a sequential chat gives better support for the organizational parts of the task. Finally, when participants are free to choose which modality to use for which purpose they tend to repeat the same pattern of use recognized in the two other experimental conditions.

2. Background Literature

Media influence in grounding at knowledge level

We would like to distinguish grounding at utterance level, as defined and studied by Clark & Shaefer [7], from the grounding at knowledge level. The former analyzes conversation on a micro or 'utterance' level and is not developed to describe the macro or 'knowledge' level, which is associated with learning. While the micro level focuses on the dialogue interchange occurring between two or more interlocutors, the macro level refers to the shared understanding that is constructed as a consequence of that exchange [9]. We argue that the observable presentation and acceptance of utterances, as described in Clark and Shaefer's contribution theory, cannot automatically be translated into the sharing of knowledge [4].

Clark & Brennan [8] argue that different communication media have features that change the cost of linguistic grounding, like the listener's ability to provide feedback, show understanding and ask for clarification. This cost escalation is even more salient at knowledge level, where the construction of mutual understanding necessarily needs a high level of disambiguation.

In a situation where the spatial context required for the task execution has been made explicit, we can expect the effort required to maintain the communication coherent to be lower than a similar situation where there

context is not explicit. Let us consider a case where two peers are discussing over the mobile where to meet. The first is guiding the second to the meeting point and is offering detailed information. The second is following this information to reach the first speaker. Without visual contact, the first speaker will tend to use a detailed description of the landmarks with a consequent high effort and high probability of misunderstanding and consequent repair. On a different situation, if the two peers can share a common map where the first speaker can use deictic, then the consequent dialog will be much lighter in terms of word use and effort required.

The question is: would this form of communication be better for a problem-solving scenario? To what extent would making the context of a discussion explicit be beneficial to the task resolution?

Media influence in problem solving processes

From different studies we have suggestions that the medium has a huge impact on the problem solving processes. For instance, Dillenbourg & Traum [9] demonstrated that subjects in a MOO environment, who had at their disposal a shared whiteboard, did not use the extra channel not disambiguating the chat conversation but for offloading their cognitive charge. The whiteboard was the place where participants co-constructed their representation of the task and MOO dialogs served to disambiguate the information displayed on the whiteboard.

Purnell *et al.* [15] showed similar results in a different condition. They studied the effects on cognitive resources of splitting attention between technical illustrations and their descriptors. The results suggested that the format of technical illustrations was superior when descriptors were contained within the diagram, as cognitive resources were not required to integrate the descriptors and the diagram.

Finally, van der Pol *et al.* [20] inquired the context enhancement for co-intentionality and co-reference in asynchronous computer-mediated communication. The author developed a tool for anchoring students' conversations to documents that were the object of those conversations. They showed how the regulative and semantic 'distance' of electronic conferencing might impede the topical alignment and the unambiguous interpretation of messages, hindering collaborative learning processes. Results indicated that the tool reinforced the context, focusing the online discussion around a certain topic and providing a frame of reference for single messages. They concluded that for collaborative text comprehension, anchored discussion might be more suitable than traditional forum discussion.

3. Methodology

We are conducting an experiment to examine the influence of making explicit the spatial context a message refers to on conversational and task coordination. Participant pairs have to organize a concert on their university campus collaborating via a chat tool. The utterances of the chat are either displayed on a separate window, as in a classical chat, or displayed over the shared map of the campus attached to anchor points decided by the emitter.

The participants have to decide which parking lots to use, where to position the three stages of the event and how to allocate six artists to the three available stages. The task requires the participants to perform a number of optimizations, as for instance minimizing the distance the concert audience has to walk from each active parking to the initial stage and then from stage to stage according to the schedule of the event.

Task description: organizing a concert on the campus

The participants are asked to collaborate to organize a concert on the campus. They have to decide which parking lots to use, and where to position the three stages of the event. Finally they have to allocate six artists to the three available stages. The goal of the task is to perform the following optimizations:

1. **to minimize the distance the participants have to walk** from each active parking to the initial stage and then from stage to stage according to the schedule of the event;
2. **to maximize the distance between the stages** in order to reduce audio disturbances;
3. **to minimize the renting costs for the parking lots** (each parking has a different price);
4. **to minimize the overlapping time for each subsequent event** in the schedule in such a way to help the logistic of the concert.

To support the reasoning process and to offer their solution, the participants will use a map of the campus and a series of icons: a number of "P" signs to mark the active parking lots, three stage icons and six little circled numbers, one for each events to be allocated. Using a well-known interaction mechanism of 'drag-and-drop', the participants will be able to mark the selected points on the map. Figure 1 shows the layout of the participant display.

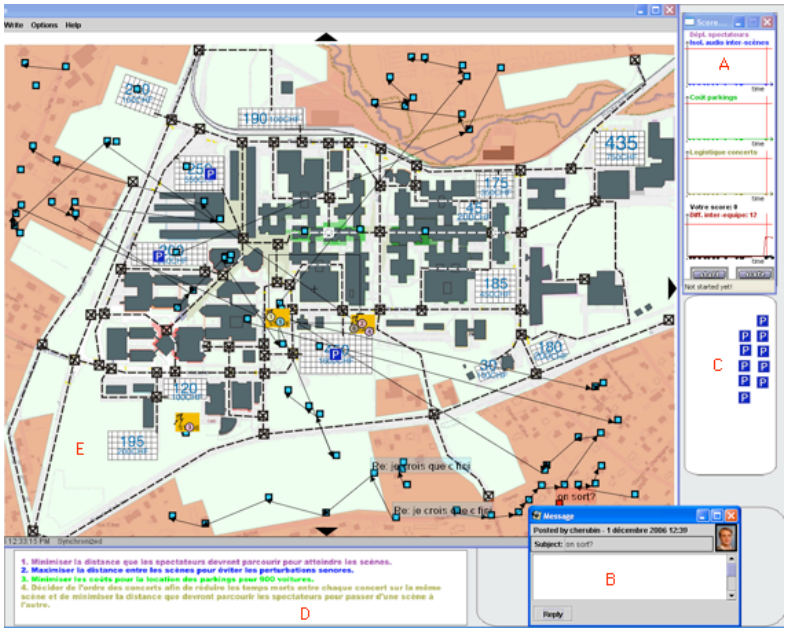

Figure 1. Experiment setup: (A) FeedbackTool; (B) Chat message window; (C) Task icons; (D) Task goals ; (E) Map window. Each 'spatialized' message is represented over the map with a small square. Lines connecting the squares represent threading between the messages.

Independent Variable

We want to vary the communication mechanism of the participants: in one case the text is completely detached from the object of the interaction, namely the map of the campus, while in the other case the communication is displayed as an overlay on the map. Additionally we are using a mixed condition where participants have both the standard chat and the 'spatialized' one at their disposal.

Participants and procedure

Thirty pairs of students from the EPFL community will be selected to participate in the research. To increase the probability to have similar typing skills and prior use of instant messaging software, we will recruit the subject from the university community. This will also ensure that the participants would have knowledge of the campus site. The number of pairs in each experimental condition will be counter-balanced across trials.

As the task requires multiple optimizations, we decided to allow each pair to submit multiple solutions to solve the task. A feedback tool offers the intermediate score and the remaining time to complete the task. The pair could end the task at any time by finding the optimal configuration, which corresponded to the score of 93%. All the intermediate scores were evaluated from this solution and assigned an intermediate value. Figure 2 shows the score feedback tool.

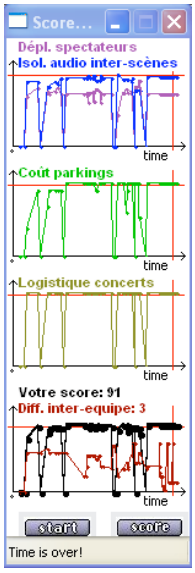

Figure 2. The feedback tool. The score command push an evaluation of the score on both machines, however given two different positioning it is possible to have two different scores on the two machines

The history of the scores is displayed in a graph. Each of the four partial scores associated with each constraint are displayed with a different color to offer additional information to the participants.

Finally the application has some networking abilities to synchronize the actions of the users across the network. The remaining time is also offered in the bottom-lower corner.

Apparatus and measures

As we want to observe the emergence of strategies connected to the task resolution, we decided to analyze the coupling of eye movements between the participants as this could reveal a misalignment of perspective or false linguistic grounding [Cherubini]. To record which area of the map was salient at each point of the interaction, we employ two eye-tracking displays in two different observation rooms. Participants wont u se other communication channels than the provided chat system. A similar setup was used efficiently by Richardson [16] and Hanna [11].

Additionally, tracking the eye-paths and the eye-gaze, could suggest different modalities of reading the map in the different experimental conditions. We plan to enquiry these factors as process variables.

4. Analysis of the data

Task performance

The pairs will be instructed to complete the task as quickly as possible and with the fewest number of mistakes between the individual final solutions. We will use a combination of final average score, time, and inter-pair mistakes as a measure of task performance.

Process measures

To better understand how the pairs will perform in the different conditions, we will explore several features of conversational structure. We will look initially at the conversational efficiency of the communication. The length of utterances, the total number of words and other quantitative measures will

allow us to examine the coarse communication differences between conditions.

In the second part of the analysis we will perform qualitative explorations of the ways in which the form of the conversation changed in the different conditions.

Statistical analysis

A single factor between-subject ANOVA will be conducted to test whether the experimental condition (levels: spatialized-chat, control) affects the task resolution performance.

5. Initial results

Initial qualitative explorations of the data revealed different trends in the strategies that the participants employed during the task resolution. Participants in the control group for instance, were extremely effective in developing a strategy. A standard chat revealed to be extremely effective in maintaining the flow of the conversation, because the utterances follow a temporal order, which support the micro-context of the conversation and whether the other partner is typing. Additionally, the participants were all used to this communication medium while those in the experimental conditions had to adapt to the modalities of communication of a chat attached to a map.

The optimization of the task constraints that did not require a precise positioning on the map, like the match of concerts and stages, were those that were more easily addressed using a standard chat. On the contrary for the choice of the parking lots and the positioning of the stages the participants in the experimental condition were facilitated.

Both media constrained specific parts of the task resolution. For instance, the standard chat impeded an easy positioning of the icons, which on the other hand is facilitated by the spatialized communication. Conversely, the map-based conversation did not support efficiently the strategy and management-related utterances. Participants in this condition had to 'de-spatialize' the conversation, moving these messages over non-functional parts of the map in such a way to not jam other important parts.

Participants in the control condition had to develop positioning and routing strategies for the objects. Almost all of the participants in this condition noticed that the capacity of the parking lots, marked on the map, was a unique number and used that as an anchor for disambiguating the positioning with the partner. Figure 3 shows an example of eye-gaze and hotspots in the three experimental conditions. Participants in the sequence used to produce the images were all positioning one of the stages. It is possible to see how the lack of visual references in the MSN condition brought the participant to be much more visually concentrated in the spot that was in the center of the interaction. On the contrary participants who could benefice of visual landmarks were 'free' of exploring other possibilities or parts of the map.

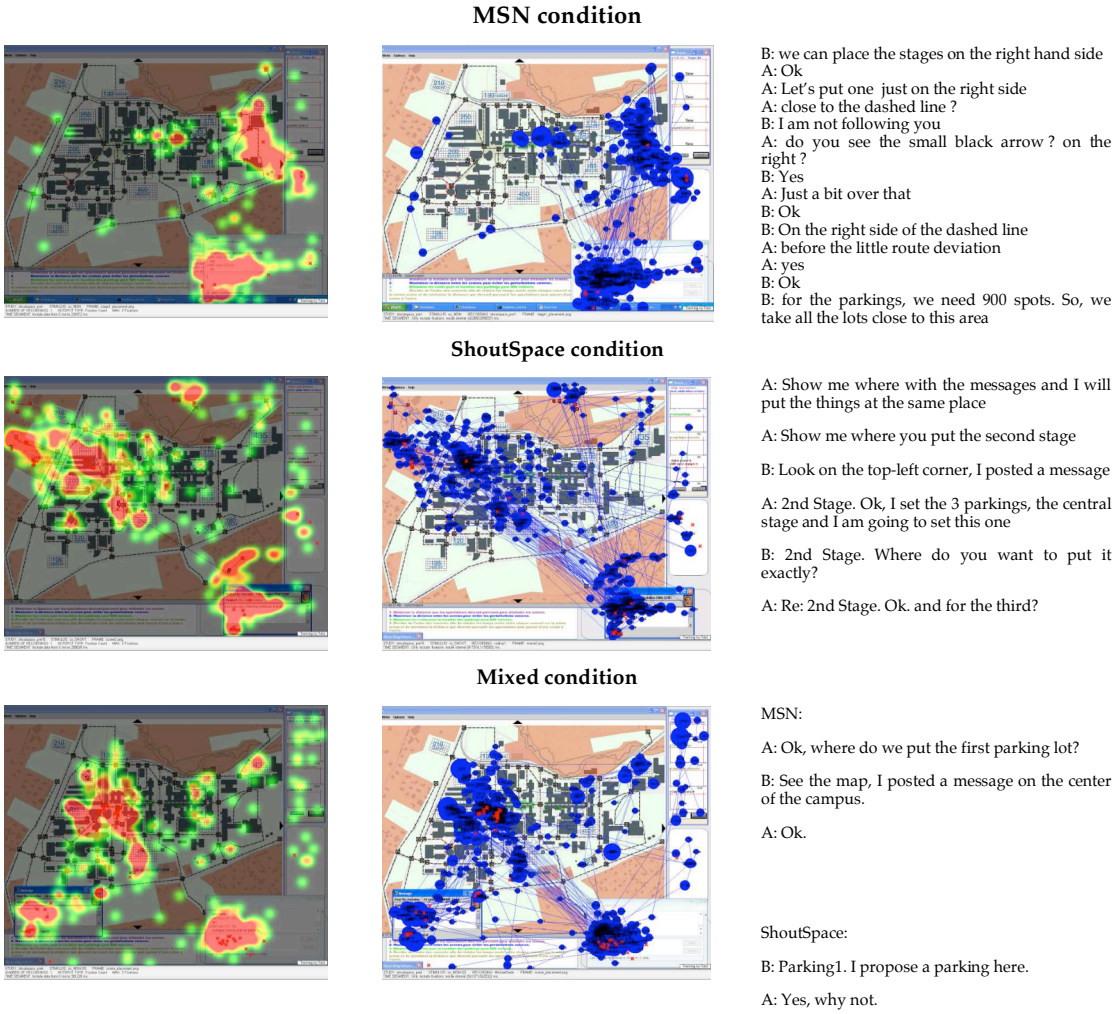

Figure 3. Hotspots (left column) and eye-gaze (center) as captured by the eye-tracker during experiments in the three different conditions. The length of the segments observed is equal in the three sequences. In the three cases the participants were trying to position a stage.

6. Conclusions

We are currently conducting the experiments described in this paper and preparing the stage for the quantitative analysis of the results. Additionally we are developing a coding scheme of the dialogs that can incorporate information from the eye-tracking logs. We plan to publish these results in a mainstream conference.

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