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Genny Tortora, Giuliana Vitiello and Marco Winckler
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Designing different features of an interactive tabletop application to support collaborative problem-solving

Hoorieh Afkari

Valérie Maqui

Luxembourg Institute of Science and Technology

firstname.lastname@list.lu

Béatrice Arend

Svenja Heuser

Patrick Sunnen

University of Luxembourg

Luxembourg

firstname.lastname@uni.lu

ABSTRACT

The design space of tangible and multi-touch tabletop interfaces is complex, and little is known about how the different characteristics of tangible and multi-touch interactive features affect collaboration strategies. With this work, we report on five different features designed for an interactive tabletop application to support collaborative problem-solving. We present the design details and describe preliminary results obtained from a user study with 15 participants.

CCS CONCEPTS

• **Human-centered computing** → **User studies; Collaborative interaction; User centered design.**

KEYWORDS

Interactive Tabletops, Collaboration

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1 INTRODUCTION

Many previous studies were able to demonstrate potentials of interactive tabletops to support group work [1, 3, 6, 7, 9]. However, there were also studies that argue to be careful with interpretations. For instance, in comparison between multi-mouse GUI and multi-touch tabletop [4, 8], researchers found no difference in terms of verbal and physical participation. In another work, users in a multi-touch condition were even found to show less equal contributions than in a single-touch condition [2]. We agree with [11] that there is not just one ideal design of a multi-user interface. It depends on the aims of the application, the level of required awareness and control, and the composition of the group. Therefore, more work is needed to understand how the design of tabletop systems can



Figure 1: Overview of the activity (Level 1)

support collaboration in different settings by taking into account the possibilities of tangible and multi-touch interaction.

With this in mind, here, we report on designing different features of a collaborative tabletop activity, called Orbitia, developed as part of an iterative design process [10]. We call feature as a distinctive piece of functionality of the tabletop application, potentially involving user interactions. The aim of Orbitia is to enhance users' awareness of their collaboration strategies by providing them with tasks and features that induce their collaboration and create a positive experience. With our research, we see to contribute to an understanding of how the design of tangible and multi-touch interaction affects participants' collaboration in a tabletop-based joint problem-solving activity.

2 ORBITIA AND ITS FEATURES

Participants are located on Orbitia, an imaginary planet where they need to act as space mining crew in order to mine valuable minerals and ship them to earth. The main tasks of the activity are designed as steering a rover and operating a radar drone to find and collect the required minerals. Meanwhile, participants need to deal with limitations of the environment such as obstacles, energy and movement constraints.

Activity grid. The activity takes place within a 9×11 grid in center of the screen (see Figure 1). The shared grid is designed to provide equal access for each participants over the task and enable them to exchange the needed information in each moment of the problem solving process. The rover is initially located at the central cell of the grid, which is defined as starting and ending point. Additionally, there are other special cells available in the grid: canyons are marked darker than normal cells (Fig. 1 (2)), minerals represented as diamonds (Fig. 1 (3)), sharp rocks representing dangers (Fig. 1 (4)), and batteries as sources of energy (Fig. 1 (5)). Furthermore, a part of the grid is marked as cloudy-like area (Fig. 1 (7)) and the items located in any of those cells are hidden. Participants need

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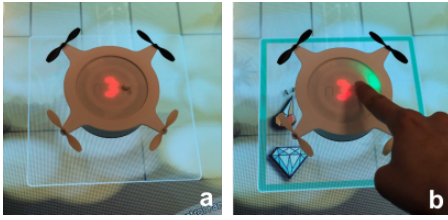


Figure 2: The radar drone shows the total number of items hidden in the highlighted frame (a); Pushing the button of the drone reveals the hidden items for 1 second (b).

to use the radar drone in order to find and reveal the hidden items (see below). In each of the missions, grid configuration including the location of special cells differs. The area affected by the dust storm increases, affecting the whole grid in the last mission.

Steering controls. The rover (Fig. 1 (1)) is the only mobile object on the grid. To steer the rover, each participant is provided with two touch-controlled arrows (Fig. 1 (9)) showing two out of six different directions. Two directions are not directly available and need to be compensated using the available directions. The reason to design the shared steering mechanism is twofold: 1) to distribute equal control over one of the main tasks of the activity among participants, and 2) to prevent that one participant takes the lead over the steering task. Moreover, the missing directions triggers extra discussions for the best compensation strategy.

The steering controls are spatially distributed in three distinct control panels (Fig. 1 (6)). Each of them provides a participant with the opportunity of individual control over certain aspects of the activity: mining, energy and damage. To collect minerals, participants need to steer the rover towards the cells containing minerals, then touch the claw button located in the control panel to retrieve the item. Retrieving batteries follows the same mechanism as retrieving the minerals. Furthermore, steering the rover into one of the cells containing sharp rocks results in damaging the rover's wheel. In such a condition, participants are unable to move the rover unless they repair the damaged wheel by touching the wrench button in the damage control panel.

What makes the steering challenging is the movement restrictions which are provided by energy consumption and dangers. Each movement of the rover costs one unit of energy and if the rover runs out of energy, the mission is failed. Also damaging the rover more than three times causes failure. Finally, leading the rover to a canyon results in destroying the rover and failing the mission.

Radar drone. Minerals, as well as other items on the grid are partly hidden in the cloudy area. In order to provide participants with the clues regarding location of the hidden items, an active tangible object called radar drone is presented to them (Figure 2). Once the tangible is placed on the grid, a highlighted frame appears that covers nine cells (Fig. 2-a). The integrated LED matrix display shows the total number of items hidden within this frame regardless whether they are minerals, sharp rocks or batteries.

To reveal the items, participants need to push the button on the drone. The hidden items appear for one second on the grid (Figure 2-b) and then after, they disappear; though, a border remains on the screen indicating the revealed area. In each mission, participants can use 4 scans. The information that radar drone provides is crucial for the route planning and triggers discussion for the best revealing

strategies. Moreover, the restricted number of times for pushing the revealing button, similar to the energy restrictions, necessitates participants to discuss and decide carefully when consuming this resource. To help participant relocating the revealed items, a scan of the disclosed area is sent to the control panels (see below).

Information display. Each control panel provides participants with different information. First, it shows the current status with regard to each role, i.e., the energy level, the number of collected minerals and the number of spare wheels available. Furthermore, the control panels show the scans provided by the drone which are small grids of 3×3 indicating the location of the revealed items (Fig. 1 (10)). Scans in each control panel indicate only the location of the items respective to that control panel. The third type of information is related to the use of the tools and features (info tips). To activate them, participants need to tap the info button (Fig. 1 (11)). Here, the aim is to give each participant a specific yet different piece of information which is needed during the problem solving process. The participants are required to monitor the information they receive in their personal control panel and share them with their peers and by this, solve the problem collaboratively.

Highlight marker. The highlight marker, a 3D printed marker-shaped tangible is added to the activity to facilitate route planning in which different strategies could be highlighted by participants during the discussion. Once the marker is put on a cell, the cell becomes highlighted; the same action undo the effect. Moving the marker over the grid marks or unmarks a group of cells.

3 USER STUDY

We conducted a user study with 5 groups of 3 participants each. Our study involved collecting demographics data, perceived user experience and data logs tracking the time, successes, and failures of each mission. To measure the perceived user experience, we used the UEQ questionnaire [5].

Preliminary results showed that the groups took between 23 min (Group 4) and 49 min (Group 1) to solve the three missions. Group 1 and 4 solved all the missions without failing, the other three groups failed between 1 and 8 times. Regarding user experience, Orbitia was evaluated positively with regard to all scales. Attractiveness (M:1.924; SD:0.47) and stimulation (M:1.952; SD:0.65) received the highest score, followed by perspicuity (M:1.536; SD:0.57), novelty (M:1.440; SD: 0.42), efficiency (M:1.268; SD:0.81) and dependability (M:1.202; SD:0.43). Compared to the UEQ benchmark set, the scales of attractiveness, stimulation and novelty can be considered as "excellent" and "good", whereas perspicuity, efficiency and dependability can be considered as "above average".

4 CONCLUSIONS AND FUTURE WORK

This work focused on how the design of tangible and multi-touch interaction affects participants' collaboration in a tabletop-based joint problem-solving activity. We have presented the design details of five different features of the tabletop application Orbitia. Our preliminary results from a user study with 15 participants showed that all the features were understood and used by participants and enabled a positive user experience. In future work, we will analyse the video data to understand how they are used for negotiating in a collaborative task, and how their design can enhance participation in this context.

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