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## **Modelling Asymmetries of Collaborative Hybrid Environments**

### **Modélisation des asymétries dans les environnements collaboratifs hybrides**

VICTOR BREHAULT

IRIT, University of Toulouse, Victor.Brehault@irit.fr

EMMANUEL DUBOIS

IRIT, University of Toulouse, Emmanuel.Dubois@irit.fr

ARNAUD PROUZEAU

Inria, University of Paris-Saclay, arnaud.prouzeau@inria.fr

MARCOS SERRANO

IRIT, University of Toulouse, Marcos.Serrano@irit.fr

Hybrid environments consist of a mix of interactive resources of diverse nature, including large screens, personal devices, headsets, mixed reality systems, etc. Such environments facilitate user tasks in complex contexts, such as decision-making in crisis management, and several spatially distributed hybrid environments can enable remote collaboration. However, differences between remote hybrid environments can have an impact on the quality of collaboration. In this paper, we propose a model for describing hybrid environments that helps identify asymmetries between remote users. This model has not yet been finalized, but we believe that it will provide a better understanding of the problems caused by asymmetry, and will help in the development of solutions.

Les environnements hybrides sont constitués d'un mélange de ressources interactives de nature diverse, comprenant des grands écrans, des appareils personnels, des casques, des systèmes de réalité mixte, etc. Ces environnements facilitent les tâches des utilisateurs dans des contextes complexes, comme la prise de décision en gestion de crise, et plusieurs environnements hybrides répartis dans l'espace peuvent permettre une collaboration à distance. Cependant, les différences entre des environnements hybrides distants peuvent avoir un impact sur la qualité de la collaboration. Dans ce papier, nous proposons un modèle de description des environnements hybrides qui aide à identifier les asymétries entre les utilisateurs distants. Ce modèle n'est pas finalisé pour le moment, mais nous pensons qu'il permettra de mieux comprendre les problèmes causés par l'asymétrie, et contribuera à l'élaboration de solutions.

## 1 INTRODUCTION

Hybrid environments combine heterogeneous display and interaction devices, such as tabletops, walls, and augmented reality (AR) or virtual reality (VR) headsets, to facilitate user tasks in complex contexts [2]. For instance, in crisis management, such environments can help stakeholders collaborate around geospatial data to respond appropriately. A large display can provide a shared overview of the crisis area to all the stakeholders, while specialists can use personal devices to access a more detailed or immersive view. Hence, such environments can improve the collaborative decision-making process. These hybrid spaces can sometimes be distributed in space and support users in collaborating at a distance. In such case, collaborators may have displays of different dimensionalities (e.g. 2D for desktops, tabletop, and 3D for VR), with different input modalities (e.g. mouse for desktop, 6 degrees-of-freedom for VR), in different spatial configurations. All these differences are referred to by different names in literature as asymmetries [5], dissimilarities [4] or incongruous spaces [1]; we chose to use the word asymmetry. These asymmetries can hinder workspace awareness, and thus collaboration, as it becomes challenging for one collaborator to understand the others' interaction with the shared workspace. The main objective of this project is to design and implement the methods, techniques and/or tools to allow users to collaborate efficiently in those remote environments. Our first step is to explore how to describe such environments to identify the asymmetries between remote users, to help generate alternatives and to assess how those asymmetries can impact the quality of a collaboration task. This paper presents a first step towards a model for describing such hybrid environments, and its design process.

## 2 DESIGN OF A MODEL FOR DESCRIBING THE ASYMMETRIES OF TWO REMOTE HYBRID ENVIRONMENTS

We consider asymmetrical elements to be all elements linked to one environment that do not have an identical counterpart in the remote environment. Based on a literature review of works related to collaborative systems, we established that the elements that can fall into this category are the people involved in the collaboration task, the devices available in the different environments and the spatial characteristics of the environments.

The presence or absence of people with specific skills or particular roles in one environment define the tasks that can be realised in this environment, and thus it has an impact on the general realisation of the collaborative task. We call "asymmetry of people" the fact that the number of collaborators in one environment and their roles and skills are not exactly the same in the remote environment.

The devices available for each user determine how this user can interact with content and with its colleagues. Moving a virtual sticker on a screen is not done the same way if we use our fingers, a mouse or a keyboard. And we perceive the height of a building differently if we look at a drawing or a model or a real-size hologram. We call "asymmetry of devices" the fact that input modalities and output modalities are different in the remote environments.

For certain collaboration tasks, the spatial characteristics of the environments have to be considered, for example, when the collaboration task requires coordinated movements, a large display space or a particular layout of screens and tabletops. We call "asymmetry of environment" the fact that the spatial characteristics of one environment are not exactly the same as the spatial characteristics of the remote environment.

We observed that the asymmetry of people and the asymmetry of the environment are both strongly related to the task, and we decided to focus our effort on describing more precisely the asymmetry of devices. We wanted our model to show in the clearest way possible the different kinds of asymmetries that can appear in a remote

collaboration between two hybrid environments. The model lists, for the two environments, the input modalities and the output modalities, and describes how the feedback of the inputs of a user is shared with the remote users. It also highlights the differences between the two environments and categorises those differences.

The input modalities are described by their name and the action it detects or the dimensions it receives (e.g. a mouse detects clicks and perceives a 2D position). This description has yet to be refined or completed. The output modalities are described by their name and the medium used to pass an information (e.g. a computer screen passes information by visually displaying it in two dimensions). This description also needs to be refined or completed. In particular, we are considering adding the mobility of the output device for example (e.g. a wall screen is fixed while a tablet is mobile). The categorisation of the differences between the two hybrid environments is rendered by labelling those differences with a kind of asymmetry from a list of possible asymmetries. This list needs to be refined and completed as well.

### 3 EXAMPLE OF MODEL APPLICATION

In this section, we will apply our current model to a simple example already studied [3]. We consider a user with a VR Head-Mounted Display on one hand, and a user with a desktop and a mouse on the other hand. Their task is to do a physical jigsaw puzzle. The jigsaw puzzle is assembled horizontally on a virtual table for the VR user and vertically in the centre of the desktop's screen for the desktop user (Figure 1). The pieces are scattered around. The VR user can grab the pieces with his or her hands to move and rotate them. The desktop user can left-click a piece to grab it and release it, and right-click it to rotate it. We consider that the users can speak to each other.

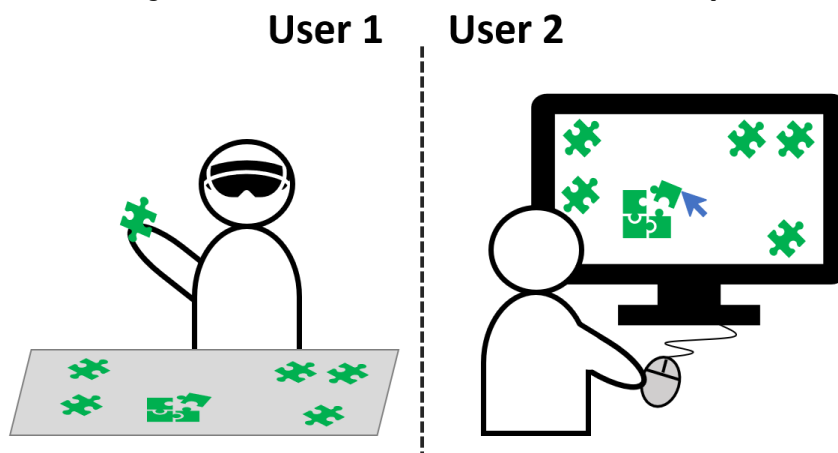


Figure 1: Diagram of the system studied as an example with a user equipped with a virtual reality headset and a user using a computer

Figure 2 represents the modeling of the collaborative situation and its asymmetry. It highlights several differences between the two environments for the input modalities and the output modalities. Those asymmetries can cause difficulties to communicate and thus to collaborate. For example, the VR user could put a piece up to highlight it for the desktop user but the latter cannot see this movement (asymmetry of dimensionality between 2D and 3D), or the VR user could move a piece away from the puzzle and thus make it disappear from the desktop's screen (asymmetry of size). The desktop user could move a piece somewhere while looking elsewhere and the VR user could not perceive both information at the same time because of the desktop user's input modalities'

limitations while the reverse is possible (asymmetry of richness of data). Moreover, using common spatial references is difficult when the VR user can turn around the table and see it from above, unlike the desktop user. And using deictic gestures to complete the oral communication is impossible if the hands are not rendered to the collaborator. Therefore, this modelling can be the basis for devising solutions to improve the system. And once some solutions or modifications are added to the system, we can reapply our modelling to the new system to compare with the ancient one.

**Task: Do a jigsaw puzzle**

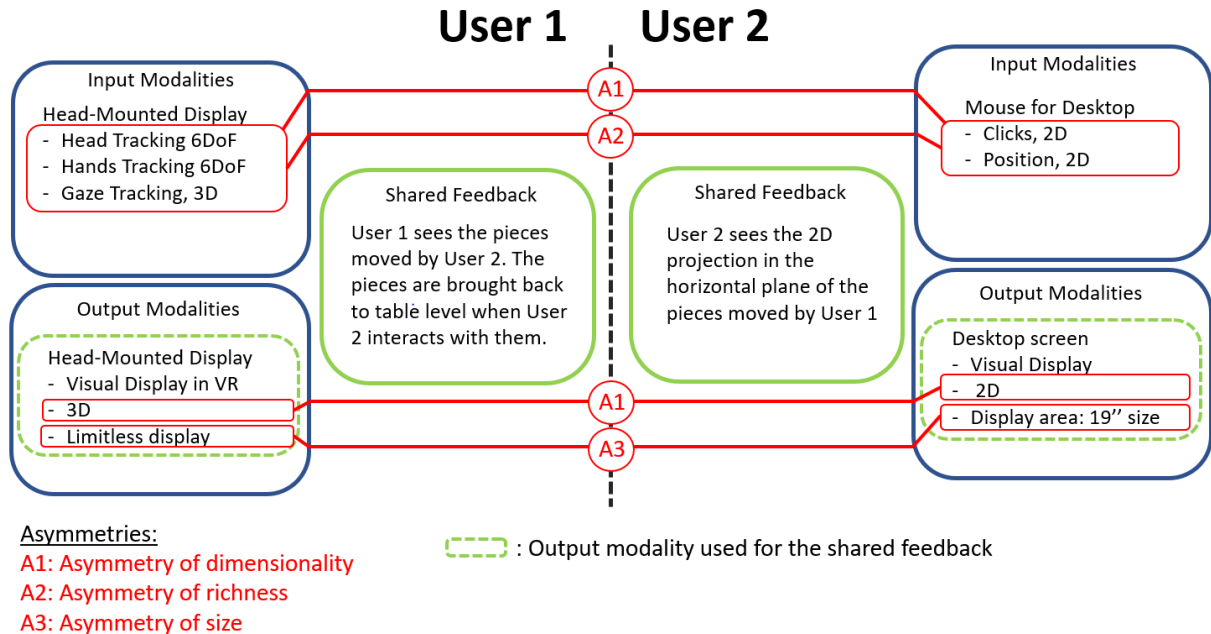


Figure 2: Our model applied to the system studied as an example

#### 4 CONCLUSION

In this paper, we presented a model describing a system of two remote hybrid environments and highlighting its asymmetries. This model is a first step to support the identification and description of asymmetries in a remote collaboration. We believe this model to be also useful to help anticipate solutions preventing bad impacts. We submitted this paper in order to confront it with the knowledge and the ideas of the participation of this workshop. Indeed, the model presented here is not completely satisfying at the moment and need further work.

#### 5 ACKNOWLEDGMENTS

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