Exploring Remote Desktop Metaphor in Mixed Reality to Support Transitions Across Workspaces

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Short abstract: Collaborators often rely on multiple workspaces, distributed across various locations. For instance, in crisis management, it is common to move back and forth between simulation rooms and control rooms to cross-reference information. This situation also generalizes to on-site operation when a remote collaborator need to perform data analysis. Transitioning between such workspaces is challenging due to the lack of fluidity of current tool, and their inability to consider heterogeneous interaction space nor interaction resources privacy. This thesis aims to explore the metaphor of a remote desktop in collaborative Mixed Reality, aiming to enable collaborators to declare, transfer, and deploy relevant interaction resources across heterogeneous environments to support transitions from a workspace to another.

Short description of hosting research group / lab : This thesis will be hosted in the ELIPSE research group, which focus on the design, implementation and evaluation of advanced interaction techniques for spatial and tangible interaction, multi-display environments and assistive technologies. This team is hosted in the IRIT lab, which is a Unité Mixte de Recherche (UMR 5505) involving both the CNRS and multiple universities from Toulouse (UT1, UT2, UT).

Description of the PhD proposal (3 pages max)

- Context (and scenarios if any)

In many collaborative situations, teams operate across multiple physical locations with collaborators taking on distinct roles, responsibilities, and access to task and role relevant information. This context often changes dynamically, as the collaborative situation evolves, requiring continuous collaborator's adaptation and coordination. This is especially the case in the two primary application contexts of this PhD: crisis management, where collaborators move back and forth between simulation rooms and control rooms to make informed decisions; and smart-building monitoring, where energy specialists alternate between remote data analysis and on-site physical inspection to better understand environmental factors influencing system states.

Despite technological progress in remote collaboration, a central challenge remains: **how to share interaction spaces across locations to support transitions from a workspace to another, in regard to their spatial configuration, interaction capabilities, and privacy**. Indeed, current tools inadequately support fluid transitions between work environments, content, and heterogeneous devices, especially when collaboration must shift across different geographically distributed sites. Also, sharing interaction space often overlook visibility issues, considering that interaction spaces are public among all collaborators despite the often-required privacy of individual workspaces.

- Problem and Objective

This PhD focuses on exploring how to ensure that interaction spaces (i.e. information and interaction capabilities) can be shared between locations to support transitioning from a workspace to another, while the visibility of what is shared is controlled by the user.

More specifically, the work will investigate how to:

1. **Declare an interaction space** in a physical workspace in regard to the variety of devices, their spatial disposition and privacy.

2. **Deploy and share a coherent interaction** space across locations, devices, and collaborators permissions.

3. **Support transitions from one workspace to another** without losing context, situational awareness, information access while providing interaction continuity.

- Brief overview of the state of the art

Collaborators often switch from individual to collaborative activity to gather knowledge and share their expertise, frequently transitioning form tight to lose coupling [Olson00]. When their respective workspaces are not in the same close space, collaborators need to move from a workspace to another to cross-reference information.

A first approach to reduce time and facilitate spatial navigation consist in using teleportation between virtual representation of workspaces. Recent work provides interaction techniques providing awareness of both workspaces to facilitate such spatial navigation [Yang26], from portal selection [Linne25]to teleportation control based on collaborators proximity [Wang20]. But such navigation technique breaks the collaboration fluidity by letting collaborators rely on one workspace at a time, and overlook workspace privacy.

Another approach explored how Mixed Reality can be used to “blend” specific element from a workspace in another. Grønbæk et al. [Grønbæk23] [Grønbæk24] suggested to reproduce a remote collaborator’s interaction space and place it near a local user. Fages et al. [Fages26] generalize this approach in co-located collaboration. But these interaction techniques only investigate the benefit of such blending in static configuration, where workspaces are already defined and involve single displays. Workspace configuration often involves a wider diversity of interaction resources, and this asymmetry between collaborative interaction space raise several challenges [Bréhault25] that need to be addressed.

The goal of this thesis is then to investigate this tension between individual and collaborative workspaces, and more specifically the transition between such workspaces in regard to the diversity of workspace spatial arrangement, interactions resources and their privacy.

- Research questions

This thesis aims to answer the following research questions:

– How to design representations and mechanisms allowing collaborators to externalize and transfer interaction resources across multiple location?

– How to manage device heterogeneity and dissimilar spatial configurations across collaborator’s working spaces and externalised interaction resources?

– How to support collaboration fluidity and collaborative coupling when transferring interaction resources and transitioning between workspaces?

- Theoretical foundations

This research builds upon a rich theoretical ground from the field of CSCW. It investigates collaborator’s ability to communicate across multiple workspaces, questioning the complex intertwine between speech and gesture [Kendon04]. This communication is crucial to achieve common ground [Olson00], but also sustain collaboration dynamic as it influences the way collaborators perform coordination, and cooperation [Ellis91]. As the interplay between communication, coordination and cooperation fosters and mediate the awareness of collaborators [Fuks07], this research also aims to explore how to achieve collaboration efficiency with new mechanisms to reinforce workspaces awareness [Gutwin02].

Spatial configuration and opportunities of the physical environment also shape interpersonal distance and orientation between collaborators [Hall66]. Collaborators adopt f-formation

[Kendon77](e.g. face-to-face, side-by-side), which influence collaboration strategies, and help define territoriality [Scott04]. With Mixed Reality technology, this spatial relationship between collaborators and workspace can also be extended beyond physical limitations with Blended Interaction Space [Ohara11]. One goal of this thesis is to explore how traditional collaborators dynamic can be supported across physically constrained configuration, in regards to such design dimensions.

- Approach and methods

The proposed research explores the metaphor of a **REmote Desktop in cOllaborative Mixed Reality (REDO-MR)**, aiming to enable collaborators to declare, transfer, and deploy relevant interaction resources across heterogeneous environments, from an initial personal workspace, to a shared collaborative target space. The concept relies on three core mechanisms:

1. **Declaring interaction resources of interest** in an initial workspace (input/output features, visualizations, controls, data views, ...).
2. **Sharing and deploying these resources** onto available devices or virtual replicas within a static remote collaborator's workspace.
3. **Accessing these resources** while transitioning from a workspace to another (e.g. switching from an individual to collaborative workspace)

This metaphor will be investigated through the development and evaluation of interactive prototypes in collaborative tasks, using Mixed Reality (MR). MR techniques will be explored as a potential to instantiate, anchor, and manipulate these remote or replicated resources, ensuring continuity of interaction despite spatial transitions.

- Evaluation of the contributions

Contributions will be evaluated through controlled user study collecting both qualitative (semi-structured interview, experimenters' observation) and quantitative data (likert-scales questionnaire, task completion measure, sensors data). Their analysis will mainly rely on the following topics:

1. **Usability:** user efficiency to complete a collaborative task, based on predefined questionnaire such (e.g SUS, USE) but also task time completion, error, user satisfaction or perceived effectiveness.
2. **Cognition**: collaborators spatial understanding of their working space, comfort (e.g using PSIAL questionnaire, ...), social presence (e.g using NMMSP or MEC spatial presence questionnaire) or cognitive workload (e.g with NASA-TLX questionnaire)
3. **Communication**: how collaborators explicitly or implicitly exchange informations (verbatim analysis, f-formations, ...)
4. **Collaborative strategies**: analysis of user's positioning (body, gaze and hand trajectories) and collaborative behaviour patterns.

Nature of digital collaboration (1 page max)

This thesis aim to explores new interaction techniques for dyad of users, synchronously solving a cross-referencing task involving interaction resources spread in physically separated workspaces. In such collaborations, collaborators need to switch between remote and co-located working space, while coordinate with various coupling and resource visibility within a few minutes.

Contribution to digital collaboration: Expected results and Impact (1 page max)

What type of contribution(s) is the PhD expected to make?

This thesis aim to generate:

- **Technical contributions** by developing prototypes using new interaction techniques supporting workspace transition based on the REDO-MR metaphor.

- **Empirical contributions** by providing observations and empirical results from controlled studies assessing the added value of such interactions techniques on collaborative tasks.

- **Methodological contributions** by defining design guidelines for system supporting transition between workspaces in collaborative cross-referencing contexts.

These thesis aim to contribute to the field of Human Computer Interaction, with targeted publications in the ACM conferences such as CHI, UIST, CSCW, IEEE conferences (ISMAR), or journals such as Transactions on Visualizations and Computer Graphics (TVCG) or Transactions on Computer-Human Interaction (TOCHI).

Positioning in the eNSEMBLE program (½ page max)

How does the project relate to the themes of the Targeted Project(s) (Projet(s) Ciblé(s)?

This thesis is grounded in the Axis 4 (Transitions between collaboration spaces - dynamic collaboration space) of the PC1 CATS (Collaborative Space), by focusing on new interactions for dynamic transitions between workspaces, both physical and digital, and assessing their perceptual and interactive aspects. More specifically, this thesis will focus on interaction techniques to perform this transition (Axis 4.1), and allow transitions between user's workspaces, from individual to group activity (Axis 4.2). Moreover, its goal is to contributes to the WP4.4 by building upon previous and current work from the PEPR, for instance by generalizing the work from Bitar et al. on the transition between places in VR with AR interactions, and extending the design space from Brehault et al. on collaborative spatial layout in hybrid environment by focusing on transitions between layouts.

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