PEPR eNSEMBLE (PC1) – PhD proposal

Acronym and title: PercARSpace - Perception of Shared Spaces in Collaborative Augmented Reality

Host institution and direction: The PhD student will be hosted at IMT Atlantique (Brest campus) within the INUIT team of Lab-STICC. The proposed thesis director is Cédric Fleury, as he plans to defend his HDR before the beginning of the thesis. But, Thierry Duval can also be the thesis director if mandatory.

Context:
Remote collaboration in Augmented Reality (AR) involves that all users bring a part of their own physical environment into the shared environment [3, 8]. There are various ways to share these spaces [2], including: (i) equitable modes where all users bring an egal part of their physical space [4]; (ii) host-guest situations where the host imposes the shape of the augmented environment to the guests [6, 7, 10]; or (iii) mixed environments specifically designed for a collaborative task [5, 9]. Regardless of the configuration, the question of how users perceive this shared environment arises.
While spatial perception has been widely studied in Virtual Reality, it remains an open question in AR. Co-localization and integration of the real environment are crucial factors that significantly impact spatial perception. These factors are even more important in remote collaboration situations, as the presence of several collaborators with their own physical environment contributes to perceptual biases.

Scientific objectives:
The main objectives of this project are to study the spatial perception in AR remote collaboration and to propose rendering and interaction guidelines for improving collaboration and maximizing users' immersion. We will explore several collaborative situations, as those mentioned previously. However, we also want to investigate situations with more than two users. In particular, we want to target hybrid situations, such as a collaboration between a group of co-located people and a remote user. Creating a true common space is crucial in such a situation to prevent the remote user from feeling excluded from the collaboration.

Approach and challenges:
Most of the previous work mainly focuses on the technical aspects of reconstructing and blending users' physical spaces. The novelty of our approach is to tackle the problem in the opposite direction: we first want to study how users perceive the space of several remote collaborators in AR and identify the cues that need to be shared to establish a common ground [1] between them. We will then create new representations that mix symbolic and realistic elements to build a common space shared between users. This common space will improve users' mutual understanding and allow a fluid interaction between them.
This approach contains two main challenges. First, we need to understand how users perceive space in such a context and which level of information is mandatory to build a mental representation of the shared space.
Second, the proposed space representations must enable users to consider the AR environment as a unique common space and not as a superposition of environments belonging to each collaborator. They should also not overload users and hinder the achievement of the collaborative task.

Positioning within the PEPR eNSEMBLE:
This project fits inside the **PC1**. It will mainly contribute to the **1st priority theme** as it allows mixing different remote heterogeneous spaces and addresses hybrid collaboration as a targeted scenario. However, it will also

contribute to the **3rd priority theme** as the proposed guidelines will be useful to create hybrid collaboration environments.

Organization of the PhD project:

The PhD work will be organized according to the following steps:

- First 6 months: the PhD student will develop an augmented reality environment to connect remote spaces, in parallel with the state-of-the-art analysis.
- Next 12 months: the student will study spatial perception in several collaborative situations ranging from sharing a few virtual or real objects to a complete 3D reconstruction of remote collaborators' spaces.
- Next 12 months: the student will design and evaluate new space representations and propose some guidelines to combine remote physical spaces in a same AR space. He or she will test the proposed representations in more advanced scenarios including collaborative situations with more than two users.
- Last 6 months: the student will focus on writing the thesis manuscript and finalizing papers.

Partners:

- Cédric Fleury, MCF in computer science/HCI at IMT Atlantique / Lab-STICC, INUIT team:
  He will provide expertise on remote and co-located collaboration in virtual and augmented reality.
  He will also propose methods for evaluating such computer-supported cooperative work situations.
- Thierry Duval, Prof. in computer science/HCI at IMT Atlantique / Lab-STICC, INUIT team:
  He will provide expertise in remote collaboration in mixed reality.
- Etienne Peillard, MCF in computer science/HCI at IMT Atlantique / Lab-STICC, INUIT team:
  He will provide expertise on spatial perception in augmented reality.
- Nathalie Le Bigot, MCF in Psychology at Univ. de Bretagne Occidentale, Lab-STICC – COMMEDIA team:
  She will bring expertise on cognitive psychology and human perception. She will also provide support for user studies and data analysis.

All partners are involved in the **EquipEx+ Continuum** and the PhD student will benefit from the AR/VR devices, tracking systems and 3D reconstruction cameras available in the ATOL and CERV platforms.

References:

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