Mixed reality for biological applications

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I. CONTEXT AND SCIENTIFIC CHALLENGES OF THE PROJECT

Common tasks like manipulation, precise positioning or grasping have been successfully realized in conventional robotics. However, when downscaling the system, other problems may be faced and strong scientific challenges remain. First of all, the forces encountered at micro/nano-scales are very different since adhesive and electrostatic phenomena overtake gravitational effects. As a consequence, specific tools and manipulation strategies are often required to perform the tasks.

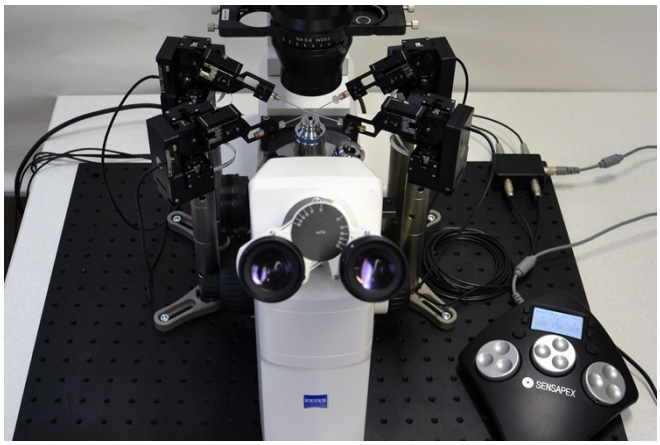

Figure 1 : A complex system of manipulation

In this project, we are interested in another scientific challenge. As illustrated in Figure 1, the systems used for manipulation are quite complex. The system might be composed of several stages. Each stage is capable of multi degrees of freedom to:

- hold or displace elements like pipette, petri dishes, microscope objective...
- partially compensate for the limited available workspace.

This makes the system particularly difficult to apprehend and to control. Even if full automated task remains a hot topic, other solutions are considered to success in the task completion. For example, it is possible to better include the human operator in the loop. Therefore, we can thus expect that he/she will be able to redefine the control strategies in real-time and acts as the supervisor of the final system.

The main objective of the project and of this PhD proposal is to provide the user with relevant information to address the task which needs to be completed. Virtual reality and/or augmented reality appear as possible good solutions to succeed. This is especially true for applications at micro/nano-scales since visual feedback is still lacking good rendering at this scale. For most

applications, 2D visual feedback is the only available solution which makes difficult the interaction between the object and the tools.

II. EXPECTATIONS & APPLICATIONS

The purpose here is not to perfectly reflect the phenomena that occur at this scale nor to reconstruct the environment with high resolution and precision. The key point is to establish a virtual link between the two worlds with data enrichment and by using latest technologies of computer sciences which are usually not available in labs specialized in biology (see applications below). As a consequence, non-expert users will be able to interact with experimental setups that involve multiple degrees of freedom.

Figure 2: HTC Vive

The main challenge is then to establish the link between the virtual world and the system used at microscale. Therefore, the candidate should investigate what would be the best scientific solution to facilitate user's immersion. For example, the candidate could propose helmets that enable for 3D visualization as illustrated in Figure 2. Besides visualization, the user should be able to better interact with the system meaning that devices like haptic systems or motion tracking must be also considered.

To better understand the targeted applications, we consider intracellular electrophysiology applications. They allow for measuring electrical activity in neurons and other cells. This kind of applications is very challenging since the systems used are complex (several stages for manipulating) and require a high degree of expertise. The precision of the mechanical stages and the decisions taken by the user may drastically increase the success rate while co-performing the task. We do believe that solutions based on virtual/augmented reality may be of primary interest to establish and consolidate this link.

The project mainly relies on the shared knowledge between the LISV and ISIR laboratories for systems dedicated to micro/nano-scales. This project was granted by the Paris-Saclay University and the Région île-de-France. It implies good working conditions to succeed during this PhD. We except to publish in the best conferences like World Haptics, CHI, ICRA and in journals with high impact factor in the field of virtual reality.