Robotics with Augmented Reality for Training and Rehabilitation

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Introduction. This work presents an Augmented Reality application that can be used in connection with either a collaborative robot or its simulator as an interactive and assistive tool for rehabilitation processes. Physical and neuro rehabilitation processes are frequently based on the execution of well-defined movements in terms of trajectory, velocity, and applied force [1]. Here, robots can be used to help in performing and monitoring these parameters. On another side, it is well known that low motivation and consequent lack of adherence to rehabilitation treatments affect patients' recovery [2,3]. Therefore, the use of gamification on the rehabilitation processes suggests to be a promising approach [4] and a motivational driver to engage patients. They are expected to increase patient retention and endurance through entertainment. Although VR has been extensively explored to this end, the possible connection with physical elements such as robots can be much better achieved through AR-enabled headsets such as Microsoft Hololens [5]. **Methodology.** This Hololens application explores a connection with Robot Operating System (ROS)-based motion planner (MoveIT) and controller that may be connected to a physical UR robot or simply simulate its behaviour. The application was developed in Unity exploring ROS Bridge for communication with the robot planner/controller. **Results.** Currently, the application displays a virtual representation of the robot and supports the definition of therapeutic movements as robot "tool" trajectories and their execution (Figure 1). In addition, a basic game was implemented based on a reward-points accumulation for the user who succeeds in keeping his hand inside the virtual robot endpoint zone while executing a movement, following prior advice from the therapist. A video of the application working with the virtual robot model is present in the link https://www.youtube.com/watch?v=s-5Y2gTgqwc. **Discussion.** Therapists can benefit from this virtual robot representation to determine if a defined exercise is suitable for a specific patient before trying it with the physical robot. Another possible usage of the virtual robot is on serious games for fine motor control activities for upper limb rehabilitation. Using a reward-based approach for the precision in following the robot, we can stimulate the patient's engagement with the treatment. Additionally, a ROS-based system has the advantage that the movements defined can always be transferred between the virtual and the physical robot when desired. **Conclusions.** Future development iterations of the application will also interact and communicate with real robots of the URe family, allowing the user to interact with the virtual and physical versions. Then, as a rehabilitation tool, it can generate opposing forces to create resistance or help the user's movement, expanding rehabilitation in immersive interactive environments.

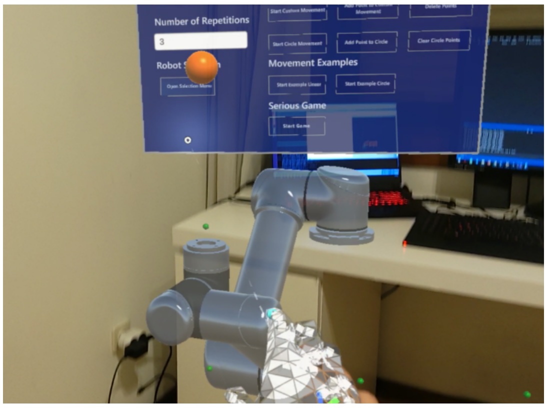

Figure 1: Virtual model of the robot performing an example stored movement.

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