Motor activity-perception based approach for improving teleoperation systems

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***Abstract*—This paper reports on a part of the project we are conducting to reformulate the teleoperation problem with regard to the recent researches within neuroscience field. According to the latter, perception can be viewed as a simulation of motor activity, i.e. a pen is seen as a pen because one simulates its use within one's brain. For teleoperation systems, motor activity, namely changing physically the remote world, is done through a mediator, e.g. an interface. Indirect motor activity leads undoubtedly to conflicts or at least difficulties for operators. Indeed they have to simulate both the motor action as if it were a direct action and the physical interaction itself to be done by the remote robot. With such scheme, the solution of a major issue of teleoperation systems, namely sensory feedback, can be reformulated as follows: the design of teleoperation system's interface must simplify the operator's mental simulation. Through a "ball catching" experiment we show the validity of this new paradigm. We discuss also its potential use in worlds where physics (gravity forces, viscosity, etc.) aren't conventional.**

I. Introduction and Objectives

Classical *teleoperation* usually refers to the principles and techniques enabling a human operator to control in real-time a remote machine in order to act on the remote environment. The main issue for these systems is dealing with the lack and/or distorsion of sensory feedback. It is obvious that one cannot address each sense. Kisthetic, visual, auditory or even tactile feedbacks cannot be perfectly rendered. Thus, one must deal with partial information to perform remote actions. One way to improve these systems is to train intensively teleoperators through simulators. Unfortunately, this is time consuming and simulators cannot generate all potential situations. We propose to reformulate teleoperation issue regarding recent neuroscience results about motor-learning activity. It is argued that perception is a simulated motor activity. For instance, perceiving a tool is equivalent to simulate its use. Translated into teleoperation words, perceveing remote environment through interface is equivalent to create an internal model able to simulate and predict changes in the remote world. This model includes both remote actuator activities and remote sensor transductions. Such a model is too complicated and lead surely to fatigue and overloads.

II. Experimental Setup and Protocol

Experiments take place in TERA department's virtual reality room and come in the form of a game. As shown by Fig. 1, the subject stands in front of a large screen which displays a virtual 3D scene. The scene depth is rendered by the use of a home-made passive stereo system composed by two projectors equipped with two oppositely polarized filters. By wearing a pair of glasses also containing two opposite filters, the subject can see in 3D. Moreover, subject's hand pose is measured in real-time thanks to a magnetic 6D tracking system.

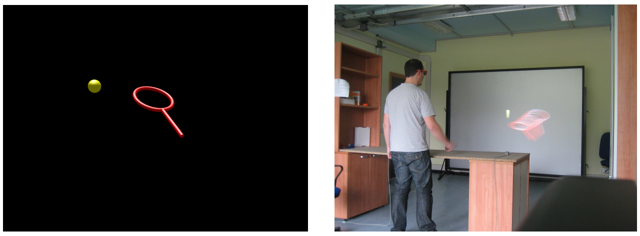

Fig. 1. Experiment in process: synthetized image (left) and a subject controlling a virtual racket to catch virtual balls (right)

Subject's goal is to catch a virtual tennis-like randomly thrown ball thanks to a virtual racket of which pose (position and orientation) is computed from subject's hand pose. Ball's trajectory is influenced by gravity, by surrounding viscosity of and eventually by a continuous flow (liquid stream or wind). A first run of random throws is performed with simulated conditions that are similar to real ones: $1g$ gravity in steady air. When the subject get used to the interface and to the task, one parameter is changed. Finally, parameters are set back to initial conditions. Two other similar experiments are carried out. First, the racket is held by a mechanical-looking robot arm. Then a virtual human arm handles the tool.

III. Results and Conclusion

The campaign of experiments is currently being carried out.

IV. Benefits for Space Systems

Improving teleoperation systems by a better understanding of human-machine interaction and thus a better design of interfaces could potentially have a big impact for space systems. Indeed teleoperation is a technological field that specially well fits space mission requirements either in case of orbital extravehicular activity (EVA) or in case of planetary exploration by rovers. Reducing operators' training while improving mission success rate and reducing human risk-taking would obviously be a huge benefit.