Teleoperation / telepresence / telesymbiosis

Annie Luciani

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Annie Luciani [ACROE&INPG]

Contributors: Carsten Preusche [DLR]

In parallel with the evolution of visual tools of Computer Graphics for representation and interaction with computers [→ Computer graphics], the link between action and vision has been also fundamentally questioned in teleoperation.

Teleoperation (almost synonymous to telemanipulation) means physical manipulation of materials and objects located in distant worlds, in one piece of time, i.e. with no need of memory in the teleprocess. Teleoperation inherently introduces a separation between two distant spaces: the user's space and task's space. Usually distant means distant in space. However, as explained in [Luciani et al., 2004], distant may benefit from being understood in a larger sense, as not accessible immediately to our senses: distant in space (far away as a distant planet), in scale (at a larger or upper scale that the world at our scale, called macroscopic scale), or in nature (with different laws of physics, such as world under the nanoscale, chimical, electrical, but also mathematical (virtual)).

Telesymbiosis - Telepresence

The teleoperation process was historically the first to address the question of presence [→ Presence, in computerized environments]. [Vertut & Coiffet, 1986] coined the term telesymbiosis in the teleoperation context in 1974. Since 1950's, the manipulation of dangerous materials, such as nuclear materials, had required a distant manipulation in two different spaces: the user's space and the task's space. As long as the manipulation remained mechanical, i.e. as long as the two spaces are near in space, in time and in nature, there was no problem of presence. The experimenter manipulated the block of nuclear matter through a mechanical pantograph, feeling it mechanically and seeing it through the glass that separates the two spaces. When this direct physical communication got replaced by electrical communication between the two spaces, and when the both spaces became more and more distant, the immediate and trivial presence disappeared. The question of presence of the distant world for the user came into the way.

Telepresence in electrically-equipped teleoperation systems

With the separation of the manipulation space from the task space described before, the classical (i.e. mechanical) teleoperation instrument has been decomposed in three parts: the part which is in the user'space, the part is in the task's space, and the communication between them. Establishing an appropriate communication between these two different worlds first necessitates equipping correctly each of the three part of the communication chain.

As stated in [Luciani et al., 2004], firstly, both sides are equipped with actuators and sensors that work in pair: sensors on one side and corresponding actuators on the other side (figure 1.2 in the related document) and vice-versa: from microphones to loudspeakers, from cameras to displays, from mechanical sensors to register the user's actions to mechanical actuators to perform these actions, etc. Each pair of sensor/actuator is dedicated to a sub-part of the sensory-motor human apparatus: vision, audition, haptic perception and action. Thus, the physical reality of the each space is necessarily split into different channels clearly segregated according to the pairs of transducers employed. Continuing, the perception of the physical reality of each space is drastically impacted by this splitting: hearing through a specific device (loudspeakers), seeing through another device (display), touching through another (tactile stimulator, force feedback

device, etc.) and acting through keyboard, stick, mouse, etc.). Once these two realities is conveyed by separate signals between each side, layers of signal processing are inserted on each part in order to reconstruct some parts of one space in the other that have been lost or degraded during the capture and transmission processes. As long as the user can build a sufficient mental representation of the distant space, as long as this space remains an alter ego space, one can say that the reduced information is sufficient to restore the distant space.

Teleoperation and VR

However, sometimes, the real phenomena cannot be sufficiently reproduced to enable presence of the distant world, either because the above means are not sufficient, or because the distant scene cannot, intrinsically, be equipped accordingly. This is the case, for example, when teleoperating microscopic world. In such a case, a third module has to be inserted in order to reconstruct locally, in real time, the lost information. This third module that handles the re-creation of the unknown information by inserting virtual entities on each side (virtual objects, virtual humans, etc.) is, typically, a computer synthesis/simulation system.

At this point, one may notice that each space is being equipped by a similar platform (figure 1.2 in related document). On both sides, there is a VR-equiped teleoperation system composed of pairs of sensors and actuators corresponding to all the sensory-motor capabilities (for the human on one side, for the physical object on the other), extended by real-time computation systems, including signal processing from and to the alternate distant world, but also simulation/re-synthesis means and virtual representations.

Perspectives

The complete specification and implementation of this type of platform is yet nowadays pending, but it is with no doubt a promising evolution for the future, able to lead to a strong convergence between teleoperation, virtual reality systems enhanced with augmented reality and mixed realities functionalities [→ Reality, augmented and mixed], and further to the design of an extended teleoperated mixed reality architecture, as a generic architecture for all the our computerized instruments to observe and act on the world.

References

[Luciani et al., 2004] A. Luciani, D. Urma, S. Marlière, J. Chevrier. PRESENCE : The sense of believability of inaccessible worlds. Computers & Graphics. 2004. Vol 28/4 pp 509-517.

[Vertut & Coiffet, 1986] J. Vertut, Ph. Coiffet. Téléopération : évolution des technologies. Hermes éditeur -1986.

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