MEDICAL TELEPRESENCE: THE NEW WAY OF TRAINING AND PRACTICING MEDICINE AT A DISTANCE

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Like virtual reality, the concept of telepresence has many definitions. One of the most pertinent ones has been offered by the Telepresence Group of the University of Strathclyde (UK), stating that telepresence is "the experience of being fully present at a live real world location remote from one's own physical location."

While the "Strathclyde definition" is sufficient for most applications, it is inadequate for many of the potential medical uses of telepresence such as the execution of diagnostic (e.g., auscultation) or invasive (telesurgery, insertion of catheters, etc.) procedures, or certain aspects of medical education and training where space separates the operator (physician) from the subject (patient/trainee). Hence, the concept of "medical telepresence," i.e., the sensation of one's being within the remote three-dimensional space where the medical event takes place, must also include the provision for interaction with the remote environment (objects, people). Moreover, the interaction has to occur in real time, and in such way that the course of the events taking place within the distant environment, or even the environment itself, can be changed by the telepresent participant.

Several approaches to medical telepresence have been envisaged, and some have been tested in practice. At the technologically least complex level, teleconferencing is used as a convenient substitute for true telepresence. While offering quite satisfactory results in some contexts (e.g., training or consultation), the typical video displays used in teleconferencing offer 2-D imagery that limits its uses in situations where full 3-D acuity is required. When the latter is needed, immersive virtual reality (VR)-based systems offer a much closer approximation of telepresence by placing the participant in the three-dimensional environment of a distant location.

Video-walls provide an example of the semi-immersive expression of VR telepresence, where the observer "looks into" the 3-D environment from the outside. The experience of being completely surrounded by the distant environment is possible either through the direct immersion in the VR space (CAVE systems) or by providing the sensation of such immersion by using a Head Mounted Display (HMD). The major disadvantage of VR-based telepresence is the impossibility to render the events as they take place in real space, in real time, and in real life. In other words, VR telepresence systems are suitable for placing the participant in the environments that are relatively "stable" and "predictable", i.e., where any change that may occur is incorporated as a pre-programmed event whose trigger is provided by the action of the participant. Moreover, current immersive VR visualization methods do not render sufficiently convincing bitmaps of the medical objects such as human tissues or organs. In summary, VR-based telepresence platforms can be considered as "portals" that allow the participant to enter and interact with a different environment that, in itself, is based on an artificial recreation of a live location.

Presently, the complex technology requirements and extensive programming effort needed to produce satisfactory experience of VR-telepresence make this approach unsuitable for widespread practical use outside technically sophisticated locations. The principal application of medical VR'based telepresence centers on "environmental habituation," where VR provides a "backdrop" for the specific activity under practice, e.g., training of medical team interactions within a specific environment in which the team will eventually operate (e.g., a post-earthquake village, busy ER, etc.) The importance of such training must not be underestimated, since the trainee may interact either with the "patient" or medical environment (instruments, diagnostic devices) in the most hazardous manner without truly harming either.

Stereoscopic, particularly autostereoscopic, displays offer the most realistic approach to medical telepresence. The imagery presented to the distant viewer is a 3-dimensional representation of live events that may take place at a very significant distance, and several technical solutions have been used to achieve the goal of practical stereoscopic viewing. With the exception of autostereoscopic devices, most systems require external viewing devices (shutter or polarizing glasses). The freedom of unconstrained looking at volumetric, 3-D renditions of objects ("pseudo-holographic" images) makes autostereoscopic viewing platforms particularly suitable for medical telepresence applications. Another, and from the medical point of view – critical – advantage derives from the fact that even in protracted use, the autostereoscopic viewing systems do not induce the disturbing physiological side effects (vertigo, nausea, spatial disorientation) that are frequently caused by the external viewing devices such as helmets or shutter/polarizing glasses.

Two major drawbacks seriously affect the current practical applications of medical telepresence. The first relates to the continuing inadequacy of the devices allowing physical interaction with the image of the remote object. While under some circumstances (e.g. telerobotic surgery) the remote robotic devices may produce adequate force (but not tactile) feedback at the operator site, essentially none of the currently used systems are capable of rendering haptic element that is sufficiently convincing. Hence, even if the visual components of medical telepresence are reproduced with the extreme degree of volumetric precision, appropriate interaction interfaces permitting engagement with the rendered environment need to be developed. Haptolingual devices (Wicab Inc.) based on an ingenious application of the fundamental aspects of sensory and brain physiology may offer a very promising route for the development of a broad range of pseudo-tactile and force-feedback interfaces. Significantly, haptolingual devices allow integration of bi-manual input (essential in medicine where most tasks involve the use of both hands) that is not available in other force-feedback devices that have a realistic potential for medical uses.

Access to adequate bandwidth represents the second major problem that currently affects effective implementation of medical telepresence. Although we have demonstrated that, depending on the mission requirements, adequate results can be obtained using telecommunications platform as simple as POTS (Plain Old Telephone System), the minimum capacity of a T1 line is required for a satisfactory experience of medical telepresence. Higher bandwidth capacity offered by fiberoptic, multiplexed T1 or DSL, and, ultimately, Internet2 connections permit full implementation of 3-D visualization, synchronized bi-directional voice communication, and associated transmittal of additional data (such as tactile or force-feedback, simulation device control input/output data, etc.)

Medical telepresence offers a new and very exciting alternative to the currently practiced methods of "medicine at a distance." Unquestionably, it is a new field with all imperfections typical of any new area of endeavor where science, technology, and practical applications mix and interact. We have explored several aspects of medical telepresence demonstrating the practical usefulness of the concept. Further studies of medical telepresence based on the simultaneous use of human patient simulation, autostereoscopic 3-D displays, high resolution 2-D visualization systems, and a sophisticated mix of telecommunication platforms are planned. The goal of these studies and practical demonstrations is to explore the concept of simultaneous advanced medical team training at the remote locations in Europe, North- and South America, and in Africa. The results will provide further verification of medical telepresence as a readily accessible tool in the practice of medicine at a distance.