Telepresence: Transforming Transparency

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Abstract

The same sensorimotor and brain systems responsible for our sense of bodily boundaries and our sense of spatial location are also remarkably adaptable to include non-biological elements within the perceptual-motor loop, provided reliable, real-time sensorimotor correlations can be established. When we interact with virtual or remote environments using intuitive interaction devices, isomorphic to our sensorimotor abilities, the real-time, reliable and persistent chain of user action and system feedback will effectively integrate the technology as a phenomenal extension of the self. Yet the true added value of telepresence technologies is not its cognitive disappearance but its ability to transform reality into an augmented environment our bodies and brains are better equipped to deal with. In this way, telepresence technologies become 'mind tools' - enhancing our perceptual, cognitive and motor abilities, and profoundly changing our perception of self in the process.

Introduction

Interactive systems that allow users to control and manipulate real-world objects within a remote real environment are known as *teleoperator* systems. Remote-controlled manipulators (e.g., robot arms) and vehicles (e.g., NASA's Mars Exploration Rovers) are being employed to enable human work in hazardous or challenging environments such as space exploration, undersea operations, or hazardous waste clean-up. They also allow for transforming the temporal and spatial scale of operation, as is the case with for instance minimally invasive surgery. In teleoperation, the human operator directly and continuously guides and causes each change in the remote manipulator. Sensors at the remote site (e.g., a stereoscopic camera, force sensors) provide continuous feedback about the slave's position in relation to the remote object, thereby closing the continuous perception-action loop that involves the operator, the master system with which she interacts locally, and the remote slave system. In the context of telerobotics, telepresence is closely associated to the sense of *distal attribution*, the externalisation of the self to include remote tools that phenomenologically become extensions of one's own body, even if they are not physically part of it.

Whereas teleoperation systems enable the manipulation of remote real-world environments and objects within it, virtual environments (VEs) allow users to interact with synthetic or computer-generated environments. In its most well-known incarnation, VEs are presented to the user via a head-mounted display (HMD) where visual information is presented to the eyes via small CRTs or LCDs, and auditory information can be presented using headphones. Importantly, the HMD is fitted with a position tracking device which provides the necessary information for the computer to calculate and render the appropriate visual and auditory perspective, congruent with the user's head and body movements. Haptic information, although not yet usually included in present-day VEs, can be added through the use of for instance an exoskeletal glove or arm, acting both as sensor and actuator.

Telepresence (in relation to teleoperation) and virtual presence (in relation to VEs) both address the psychological phenomenon of *presence* – the sense 'being there' in a mediated environment, or a "perceptual illusion of non-mediation" as Lombard and Ditton (1997) defined it. Perceived transparency of the medium is crucial, i.e. a sense of direct perceptual stimulation and potential for action, without an awareness of the remoteness in time or space of the simulated or reproduced realities.

Forty Part Motet

Recently, I visited the Liverpool Tate art gallery, which had on display an audio piece entitled *Forty Part Motet* by media artist Janet Cardiff. Here was a reproduction of a choir singing a piece by Thomas Tallis, one of the most influential English composers of the sixteenth century. His *Spem in Alium nunquam habui* was originally written to mark the fortieth birthday of Queen Elizabeth I in 1575. It is a choral work for eight choirs of five voices, and Cardiff assigned every single one of the forty voices to a different audio speaker, set at an average head height and spaced around the exhibition hall in such a way that participants could listen to different voices and experience different combinations and harmonies as they wandered through the artist's installation.

The experience of walking amidst a virtual choir while they were singing was a novel and compelling one, but that is not the point. When the choir was silent, I sat down on a

bench in the centre of the gallery and was talking with a friend about what we had just heard, with other people talking behind us in the background. Until at some point I turned around and suddenly realized that there were *no people there at all*! Apparently, the artist had also recorded some of the conversations choir members had had during the intervals in practicing, which tricked me into the 'perfect' presence of simply assuming there were people there, behind me. As such, the experience was initially of a trivial, uninteresting nature, precisely *until* I became aware of the mediated nature of the experience, *until* I acknowledged the role the technology had played in engendering my sense of presence for that brief moment in time – an interesting paradox when thinking of Lombard and Ditton's definition.

To me, this experience illustrated a number of points. For one, it showed how presence research is not just about engineering clever technology, but is as much about human psychology, and the interaction of bottom-up sensory information (the voices of people from the high-quality speakers, at an appropriate volume, and from appropriate directions) and top-down cognitive processes (my assumptions about the media art piece having finished, the assumed presence of other people). But more importantly perhaps, the experience hammered home the point of just how much we take everyday presence for granted. And how, if we would somehow succeed in engineering 'perfect' presence, this may ironically not be detected as something extraordinary. If this perfect simulation is anything like the relatively uneventful lives most of us lead most of the time (I'm quite happy to say), we will not question the reality of what we experience, for what would be the reason? We are only aware of our sense of presence in relation to media systems precisely because it is *not* a perfect representation, not only because we usually detect the limits of current technology, but also, and more positively, because the experience we are provided with is often an unusual one – a *transformation* rather than a replication of reality.

In the event of 'perfect' presence, we may only become aware of the mediated nature through the use of our *media schemata*, our experience and thought cues, judging the likelihood of certain occurrences, for instance (IJsselsteijn, 2004). As with stage magic, or other particularly unlikely (often enervating or dramatic) events, we will tend to doubt our own perceptions ("I couldn't believe my eyes!"). In fact, good presence technologies will have a lot in common with stage magic or sleight-of-hand - covering up the media form factors, attracting little, if any, attention to *how* the media technology accomplishes its feats, and leaving its audience wondering how their eyes can be so convincingly deceived when, clearly, what they see *cannot* be real, or can it?

It seems fair to say that the experience of presence is a complex, possibly multidimensional perception, formed through an interplay of raw multi-sensory data, spatial perception, attention, and motor action, all coupled through a constant dynamic loop of sensorimotor correspondence. What makes presence research unique is that it studies the experience of being in a place or being with someone as it is *mediated* through technology. This is what sets it apart from psychology in general or from research into spatial cognition or consciousness in particular, as a large part of the research focuses on the media conditions under which presence may or may not occur, how to measure this experience if and when it occurs, and how to optimise media accordingly. Thus, the presence research area, by its very nature, requires hybrid, multidisciplinary scientific work. Pure engineering or pure psychology, although each is valuable in its own right, would not bear immediate relevance upon the relation between mind and media in the same way that presence research does.

The level of sophistication of current media systems has the unexpected effect of making us aware of just how much we take our everyday experience of presence in our physical surroundings for granted, as was reiterated by my experience at the Liverpool Tate. In fact, many philosophical and psychological ideas on the nature of perception and experience become more tangible when confronted with the experience of 'being' in a simulated or distant environment. In this way, media technology may help us understand the mind, much like cyclotrons help unravel the nature of matter (Biocca, 2003).

What am I?

Our sense of self-localisation is very much determined by our point of view - the locations of our sense organs - as the essay '*Where am I?'* by Daniel Dennett (1978) entertainingly shows. However, the fact that this sense is highly plastic, and continuously able and prone to adapt to altered sensorimotor contingencies only becomes apparent when these dependencies are changed, sometimes radically. This is the case, for instance, when we consider the amazing adaptation processes that occur in the body-image of people with one or more lost or amputated limbs (Ramachandran & Blakeslee, 1998). A less dramatic and perhaps more obvious example of the negotiability of our body-image is of course the lifetime growth and development of our own bodies, which requires a continuous re-mapping of our bodily boundaries based on the continuous correlations between motor action and sensory feedback. Although body-image adaptations across the lifespan can afford to take their time, it is the relative speed of these sensorimotor adaptations that enables us to experience man-made technology as, quite literally, part of ourselves - be they a blind person's cane or an advanced telerobotic arm. It allows us to feel part of an environment, not just as a passive observer, but as an active participant, changing the perceived environment through our actions, including head and eye movements, in a continuously updated real-time perceptual-motor loop.

Thus, the perceptual-motor mappings involved in answering the question of spatial location - *Where am I?* - are also powerful enough to integrate technologies for

remote sensing and operation into our mental representations of what we consider to be our own bodily boundaries - *What am I?* Naive definitions of 'self' as everything contained within our bodily boundaries, and 'non-self' as the world outside our own bodies become much less obvious when we regard the intimate dependencies and co-adaptation we can experience when technology starts working as a transparent extension of our own bodies and minds. As cognitive scientist Andy Clark convincingly argues in his wonderful book '*Natural Born Cyborgs*' , what 'I' am is not defined by the outer limits of the 'biological skin-bag'. He states: "For our sense of self, of what we know and of who and what we are, is surprisingly plastic and reflects not some rigid preset biological boundary so much as our ongoing experience of thinking, reasoning, and acting within whatever potent web of technology and cognitive scaffolding we happen currently to inhabit" (p.45).

Thus we learn that our relationship with technology is a two-way adaptive process - we adapt the technologies to fit our needs and abilities (a process known as *user-centred design*), but at the same time, our brain adapts itself to the technology, so that the technology becomes part of our extended self – the biological self and all non-biological tools and toys we employ to enhance our performance and pleasure. Dennett (1996) calls these "Mind Tools" as they are not only the result of intelligence but also the endower of intelligence in the sense that they transform problems previously beyond our capabilities into problems our brains are equipped to deal with. Good tools and toys have in common that they enable and challenge the brain to do what it does best - pattern recognition, modeling simple dynamics in the world, and manipulating objects in the environment (Hutchins,1995).

Beyond the Window

This is the basis of what in the domain of human-computer interaction is known as *transparency* - technologies that become so well matched to our abilities, needs, habits, preferences, and limitations that they become, for all practical purposes, invisible-in-use (Winograd & Flores, 1986; Norman, 1998). Just as the act of writing a letter takes very little explicit 'human-pen' interaction, so too should fluent interactions with computers make the computer itself disappear into the background as one of many tools that have the ability to scaffold and leverage our cognitive potential. As Marc Weiser (1991) noted, "the most profound technologies are those that disappear". Of course, it is not the *physical* disappearance of the computer as such that is important here, but its *cognitive* disappearance. That is, whenever people learn to use a tool sufficiently well, they cease to be aware of it. A transparent interaction shouldn't feel like a human-computer interaction anymore, but rather like a human-product or human-task interaction. The focus should be on interacting *through* a computer instead of interacting *with* a computer. Indeed, this would truly engender an 'illusion of non-mediation', to borrow Lombard and Ditton's (1997) phrase. Yet, too much of the current generation of computer tools still require skills and resources that do not come naturally to human users – demanding attention, obstructing the flow of the task, tripping the user up, continuously stressing the mediated nature of the interaction. Computers may have become *ubiquitous* or *ambient*, intelligence certainly has not.

Transparency is, of course, at the heart of presence engineering. Whenever we can design media technology that will not be obtrusive, heavy, cumbersome, and quite literally in-your-face, but will instead be user-sensitive and well-fitted to our sensory capabilities, needs, habits, and rhythms of life, such a technology is more likely to support a rich flow of content through a transparent form. Like a window, the interface should disappear, for the true added value is not in the glass itself, but in the outside world onto which it offers access. Unlike a window however, presence technologies needn't stop at mere replication of what is already there. The human-machine symbiosis has a great potential for sensory, cognitive, and motor enhancements, or *intelligence augmentation* as Biocca (1996) calls it. Thus, in addition to improving the human-machine bandwidth and interactive flow towards transparent immediacy, we also need to explore the exciting potential of presence technologies to transform rather than replicate reality, including our own bodies, enabling us to perceive, think, act, and enjoy ourselves in new, unforeseen ways, such that we may, someday, even *prefer* to be telepresent.

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