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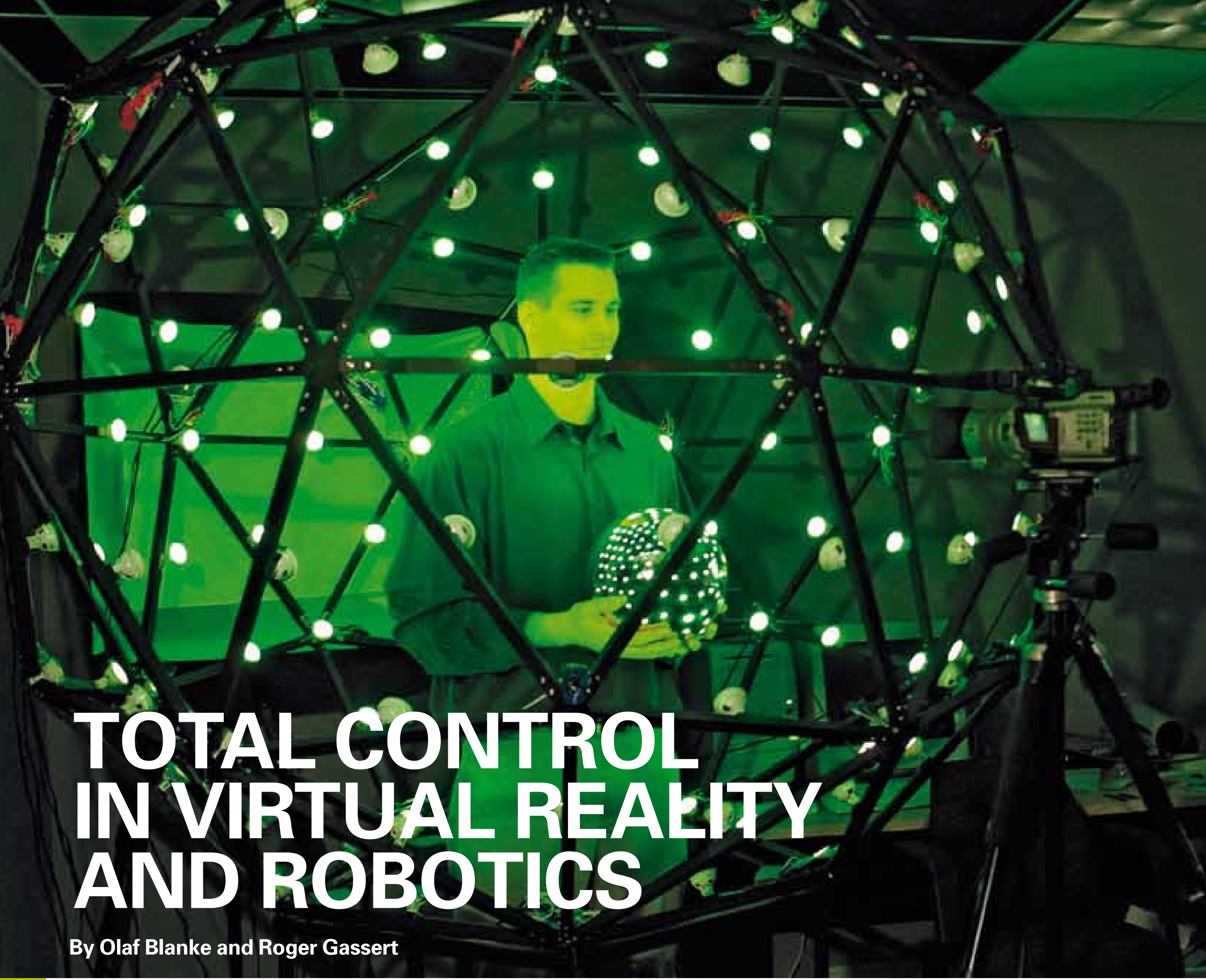

# TOTAL CONTROL IN VIRTUAL REALITY AND ROBOTICS

### By Olaf Blanke and Roger Gassert

Recent developments in virtual reality (VR) and robotics are opening novel technology and neuroscience-inspired avenues for human enhancement of sensorimotor and cognitive function. VR integrates real-time computer graphics, sounds, and other sensory inputs to create a computer-generated world with which humans can interact. Virtual environments are generally presented on large projection screens, head-mounted displays, or other devices including sound systems. The recent addition of robotics in the form of haptic interfaces allows dynamic physical interaction with remote, virtual, and augmented real objects and humans.

VR has already played an important role in augmenting cognition and influencing anxiety and specific phobias such as acrophobia and arachnophobia. A crucial advantage over more classical phobia treatments is the well-controlled, unlimited, and systematic exposure of humans to fearful objects, situations, and control stimuli. VR has also been used to study the interaction with virtual humans, especially in social phobia patients with intense and persistent fear of social performance situations (Klinger et al., 2005). Yet, the efficacy of VR with respect to clinical treatments needs further investigation. The application of VR to neuroscience is likely to have great potential, as this allows linking principles from psychophysics and cognitive psychology (Sanchez-Vives and Slater, 2005; Tarr and Warren, 2002) with neuroimaging in ecologically valid and complex experimental conditions.

The power of VR in neuroscience was recently demonstrated integrating not

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only objects, scenes, or other people, but also the participant's own body in the VR environment (Lenggenhager et al., 2007; Slater et al., 2008). Using principles from cognitive psychology, this work amalgamated the body of the user with his (or any other) virtual body resulting in more powerful states of immersion. Projects of merging high-resolution EEG with such experimental VR setups are currently under way to unravel the associated brain mechanisms. We believe that such complete, controlled, repeatable, and predictable immersion of the user in virtual worlds will allow usage of VR-based enhancement to the full potential in health, disease, and technology.

Bringing robotics into the equation promises further improvements in experimental control over virtual environments, by allowing dynamic physical interaction with augmented real and virtual objects and humans. The emerging field of neuroscience robotics combines these technologies with functional brain imaging modalities such as fMRI (Gassert et al., 2006). This combination promises the ability to assess and manipulate bodily states of the user while measuring the associated brain activity. Neuroscience robotics are already a powerful tool in defining the neural mechanisms of human sensorimotor control and guide diagnosis, assessment, and rehabilitation of motor function (Takahashi et al., 2008). The same technology will allow measurement of cortical reorganization while healthy subjects perform procedures for sensorimotor and cognitive enhancement using multimodal feedback.

We hope that the knowledge gained from such studies will pave the way toward user- and patient-specific enhancement and treatment protocols, specifically stimulating preserved functions and brain areas for faster and longer-lasting enhancement and recovery. The behavioral and neural signals need to be analyzed, manipulated, and interfaced, ideally non-invasively, and in real-time so that subjects and machines can interact in entirely novel ways (Andersen et al., 2004; deCharms, 2008) to bring sensorimotor and cognitive enhancement to its full potential. This result may sound like science fiction, but the joining of VR, robotics, and systems neuroscience is already an emerging reality for the enhancement and manipulation of sensorimotor and cognitive neural mechanisms.

Who would reasonably deny usage of a motor performance enhancement drug for stroke patients, or a memory enhancer for patients with Alzheimer's disease? The same reasoning does not seem to apply to the augmentation of mood, attention, memory, and motor performance in healthy individuals (Farah, 2002). We do not address the impact or ethical dilemmas raised by VR and robotics-based enhancement, but are well aware that such procedures may raise a number of unprecedented issues.

## REFERENCES

**Andersen, R. A., Burdick, J. W., Musallam, S., Pesaran, B., & Cham, J. G.** (2004). Cognitive neural prosthetics. Trends Cogn Sci, 8(11), 486-493.

**deCharms, R. C.** (2008). Applications of real-time fMRI. Nat Rev Neurosci, 9(9), 720-729.

**Farah, M. J.** (2002). Emerging ethical issues in neuroscience. Nat Neurosci, 5(11), 1123-1129.

**Gassert, R., Moser, R., Burdet, E., & Bleuler, H.** (2006). MRI/fMRI-compatible robotic system with force feedback for interaction with human motion. Mechatronics, IEEE/ASME Transactions on, 11(2), 216-224.

**Klinger, E., Bouchard, S., Legeron, P., Roy, S., Lauer, F., Chemin, I., et al.** (2005). Virtual reality therapy versus cognitive behavior therapy for social phobia: a preliminary controlled study. Cyberpsychol Behav, 8(1), 76-88.

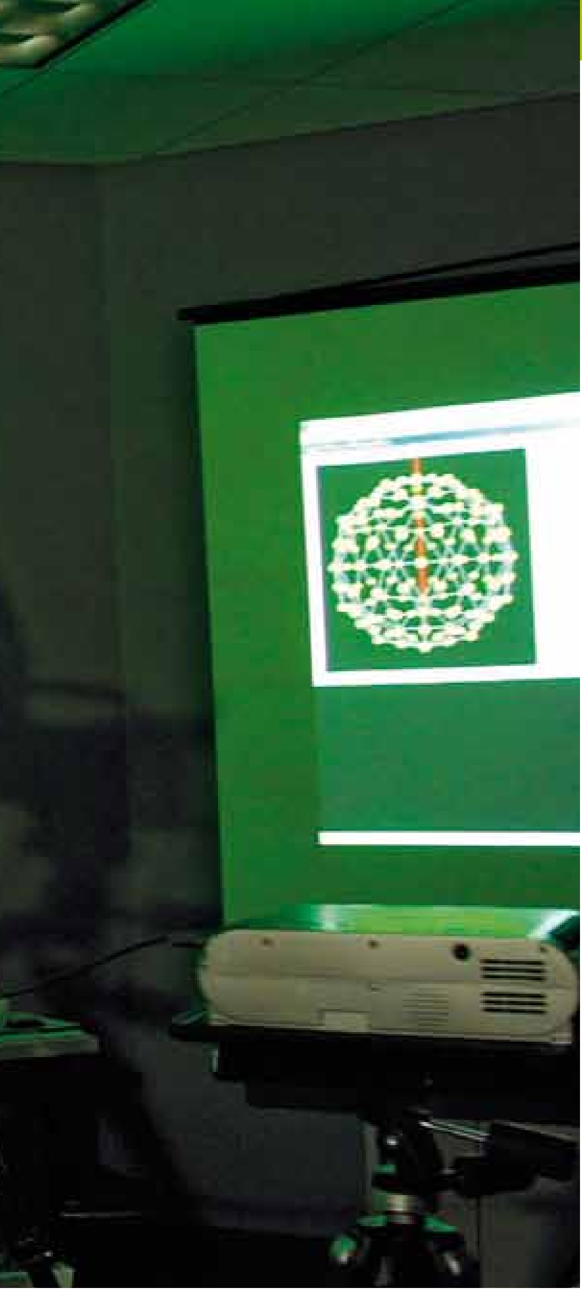
**Lenggenhager, B., Tadi, T., Metzinger, T., & Blanke, O.** (2007). Video ergo sum: manipulating bodily self-consciousness. Science, 317(5841), 1096-1099.

**Sanchez-Vives, M. V., & Slater, M.** (2005). From presence to consciousness through virtual reality. Nat Rev Neurosci, 6(4), 332-339.

**Slater, M., Perez-Marcos, D., Ehrsson, H. H., & Sanchez-Vives, M. V.** (2008). Towards a digital body: the virtual arm illusion. Front Hum Neurosci, 2, 6.

**Takahashi, C. D., Der-Yeghiaian, L., Le, V., Motiwala, R. R., & Cramer, S. C.** (2008). Robot-based hand motor therapy after stroke. Brain, 131(Pt 2), 425-437.

**Tarr, M. J., & Warren, W. H.** (2002). Virtual reality in behavioral neuroscience and beyond. Nat Neurosci, 5 Suppl, 1089-1092.



**Roger Gassert**'s research interests are in rehabilitation- and medical robotics, haptics, assistive technology and neuroscience. Using a combined approach of robotics, psychophysics and cognitive neuroscience, his group develops and clinically evaluates robotic systems to train hand function after stroke, and explores the neural mechanisms of human sensorimotor control and their reorganization with age and after focal brain injury. His work lead to the first fMRI-compatible haptic interfaces allowing safe and gentle interaction with human motion during functional MRI. Roger Gassert is an Assistant Professor of Rehabilitation Engineering at ETH Zürich, and Academic Visitor at the Ecole Polytechnique Fédérale de Lausanne and Imperial College London [www.relab.ethz.ch/]. Roger Gassert and Olaf Blanke collaborate on the integration of cognition, neuroscience, robotics, and virtual reality.
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