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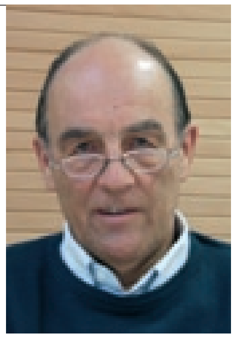

PRESENCIA - Presence Research Encompassing Sensory Enhancement, Neuroscience and Cognition, with Interactive Applications – IST 2001-37027

PRESENCIA ist ein Projekt aus dem Bereich "Presence Research" („Gegenwartsforschung"/„Gegenwartserleben") mit einem Gesamtvolumen von 20 Millionen Euro. Es verbindet Neuro- und Kognitionswissenschaften und soll verbesserte Stimulationsmöglichkeiten sensorischer Systeme und interaktive Anwendungen untersuchen. Die TU Graz (Institut für Elektro- und Biomedizinische Technik, Abteilung für Medizinische Informatik) ist für die erstmalige Kopplung von BCI-Technologie mit Virtual Reality (VR)-Technologie verantwortlich. Ziel dabei ist das Navigieren in einer virtuellen Welt mit Hilfe von „Gedanken".

PRESENCIA is one out of 10 projects of the European Commission initiative on "Presence" research funded altogether with € 20 Million for the years 2002 to 2005.

Objectives of "Presence" research

The objective of this initiative is to develop a coherent multilevel theory of presence, which explores the cognitive and affective roots of sensory perception. Knowledge in this area should contribute to the design of innovative media systems that offer richer experiences than any current combination of IT-based media and communication technologies.

Reaching the objectives of the presence initiative, requires systematic and interdisciplinary scientific investigations to discover what are the salient parameters and clues that contribute to the experience of presence when human beings participate in a mediated environment. Such an experience can be demonstrated by interactive systems that allow humans to escape the boundaries of space and time for such purposes as communicating, learning, entertainment, commerce, and remote actions.

What is "Presence"?

Presence, the sense of "being there", is the experience of projecting one's mind through media to other places, people and designed environments. Appropriate presence technologies combine to create an illusion of "non-mediation" – the closest possible approximation to a sense of physical presence, when physical presence there may be none.

The initiative is timely because of two developments: On the one hand, recent discoveries in cognitive neuroscience make it possible to acquire a better understanding of the human aspects of presence. On the other hand, the breakthroughs at the level of the enabling technologies such as broadband access, computing power and displays make it increasingly possible to build systems based on this understanding.

Background and Analysis of "Presence" Research

There has long been a tendency to increase the fidelity of representations of reality by pushing the limits of established technology. This tendency was reflected in a pixel-pushing, or "resolution" approach to media design, supported by technological advances in the areas of networks, computing power, electronic displays and human-system interfaces. There are lessons from the past that illustrate the limits of the pixel-pushing approach to media design. The RGB color gamut was developed as an add-on to black and white television, colour tv has not changed much in 30 years and isn't based on a correct theory of human colour perception.

The pixel-pushing approach to increased fidelity and high resolution multimedia led to systems that are increasingly digitized in form and increasingly "sophisticated" but the human cognitive aspects have not been sufficiently taken into account. Taking the lessons of the past, and going for an alternative approach, means that if these perceptual aspects were now taken into account we could have media that were better, or cheaper, or that could generate new experiences.

Sound is very important for presence; the human voice contains in its acoustic structure a wealth of information on the speaker's identity and emotional state. Humans perceive this information with remarkable ease and accuracy. The quality of sound from tv sets and high-end speakers is unconvincing to our ears: the acoustical source signal has been "processed" and re-engineered to fit the available technology channel, and as a result sounds are almost void of the information source content which the human ear would need to be tricked into believing there are really present.

With internet and other forms of digital access, the consumption of media-related information is at a historical all-time high. As a result the enabling technologies are increasingly sophisticated, especially when it comes to compression for the sake of maximising resolution. What pixel-pushing technologies lack in their consideration of human characteristics could serve as an opportunity for an alternative approach to the design of interactive communication systems – less in the sense of maximising throughput and more in providing what the user needs or wants – to be useful to convey a greater sense of presence.

"Presence" research requires systematic scientific investigations to discover what are the salient parameters and clues that contribute to a meaningful experience of presence when human beings interact with a mediated environment. How the brain translates tacit sensory stimuli into symbolic knowing (a coherent and meaningful mental representation of the world outside) is still not understood. The state-of-the-art offers fragmented research findings which give new insights into the specialization and organization of the human visual brain and sensory-motor intelligence.

"Presence" Research Targets

"Presence" research covers an inherently broad area of interdisciplinary work. Collaboration means combining scattered fragments of knowledge from various disciplines into a field which is only at the very beginning. The background state-of-the-art and vision documents for "Presence" research have been developed in consultation with experts by the EU funded PRESENCE RESEARCH WORKING GROUP.

Some of the research targets that were agreed to be important are provided below (Fig. 1):

- Brain processes & the sensory-motor system
  Can we enhance presence through understanding multisensory integration? How? Can we identify the various brain functions and the user states that modify or determine presence? Rever-

sibly, can we understand consciousness through presence in a virtual environment?

- Cognitive parameters & representation systems for presence
  Can we identify the salient determinants of presence and explain their interaction? What are the salient perceptual cues that facilitate correct semantic recognition for object representation? What are the best metrics for assessing quality of service in presence technologies?

- Designing optimal experiences (e.g. "creative flow")
  Immersive experiences tend to be of short duration, with users having to learn to adjust to the system instead of the reverse. Can we create a rich coherent perceptual experience of presence adapted to the diverse needs of the environment, the user and the application?

- Telepresence
  Can we radically improve the way we convey multisensory information at any time, to anyone, on the move close by or at a distance; time and space becoming irrelevant? Can we design a multimedia system that captures 3D holographic omnipresence, that transmits and reproduces non-verbal communication, group mood and eye contact?

- Haptic presence, moving the sensory-motor system through communication networks
  Is there an implicit "touch language"? Can presence research create sensory rich environments that feel like interacting with "real matter" (using force feedback, and gaining greater degrees of freedom than today's haptic interfaces)?

These challenges need to be addressed through a combination of study and experimental work.

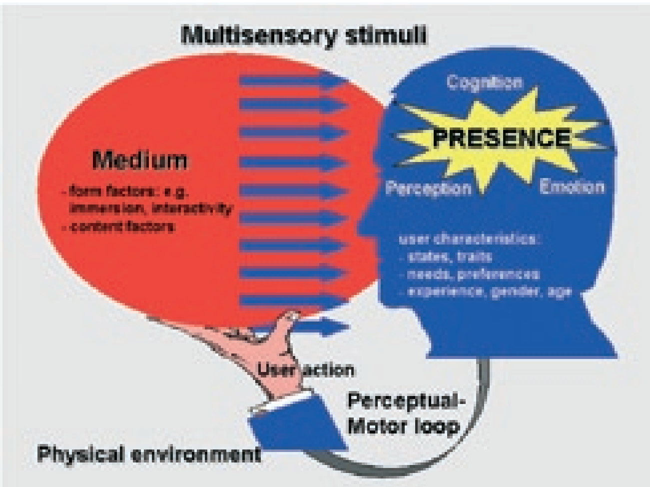

Fig. 1 Components of "Presence" research

Objectives of PRESENCIA

- A neural and physiological characterisation of presence: To execute psychophysiological and brain imaging studies that provide a characterisation of the physiological and neuronal signatures associated with switches between different presence states. The key goal is to implement functional magnetic resonance imaging (fMRI) experiments, using event-related designs, where the presence state (or switches in state of presence) is indexed by (i) phenomenological report from subjects (ii) a change in bodily state indexed by independent psychophysiological markers.

- Neurophysiological and behavioural studies: To execute electrophysiological and behavioural experiments, with the goal of understanding the pattern of electrical brain activity when animals have to choose their behaviour under conditions of changing environmental cues. How does behaviour change, and what pattern of neuron firings are associated with these changes?

- Neurophysiological based interaction methods: To develop a Human-Computer-Interface (HCI) based on a real-time neurophysiological device to be constructed in the project that participants can consciously control and utilize to navigate through a virtual environment. The same device will be used to portray the neuro-physiological state of a people communicating in a shared virtual reality (VR) environment.

- Measurement techniques for presence: To construct robust measures of presence that can assess presence in relation to many different display and interaction media. The measurement techniques will follow from the theory to be developed during the project.

- A theory of presence: To develop a theory of presence that characterises presence and attempts to explain how and why the presence state changes in response to changes in display and interaction parameters, and across different media, and including the role of perceptual and cognitive factors, including attention. This theory will be elaborated in response to real data accumulated in pursuance of the other and tested against the execution of experiments in different media.

Partners of PRESENCIA

Department of Computer Science, University College London, UK
(Project coordinator: Mel Slater)
Institute of Neurology, University College London, UK
(Local coordinator: Ray Dolan)
Instituto de Neurociencias, Universidad Miguel Hernandez-CSIC, Spain
(Local coordinator: Maria V. Sanches Vives)
Institute for Biomedical Engineering, University of Technology, Graz, Austria
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(Local coordinator: Christoph Guger)
Department of Education in Technology and Science, Technion – Israel Institute of Technology, Israel
(Local coordinator: Miriam Reiner)

Contribution of TU Graz to PRESENCIA

The Institute of Biomedical Engineering, Department of Medical Informatics, is responsible for Working Package (WP) 4 with the goal to combine the first time the brain-computer-interface (BCI) technology, developed in Graz, with VR technology (Fig. 2). One goal of WP 4 is to realize the navigation through a virtual environment by mental activity (through thoughts). A partner within this WP 4 is the company "g.tec" in Graz, specialized to design and construct real-time biosignal processing systems (BCI systems). In detail the following has to be investigated:

- Mode of BCI operation: The brain signals can be analysed and classified continuously (asynchronous mode) or in predefined time intervals after a cue-stimulus (synchronous mode). Which mode is more suitable for VR control?
- Feature extraction: Two types of features will be studied. On the one hand adaptive autoregressive parameters (AAR) estimated by a Kalman filter and on the other hand real-time computation of Discrete Wavelet Packages (DWT) calculated by the lifting-scheme. Special effort is given to optimise these features e.g. by use of the Genetic Algorithm. What are the best features for VR control?
- Feature classification: Here a great variety of classifiers will be investigated as e.g. Linear Discriminate Analysis (LDA), Support Vector Machines (SVM), Hidden Markov Models (HMM) etc. Is there an optimal classifier for VR control?
- Dimension of VR control: A two-dimensional control is based on the discrimination of two brain states or two brain patterns, whether a 3, 4 or more-dimensional VR control is feasible has to be investigated. Can we realize a higher dimensional VR control?

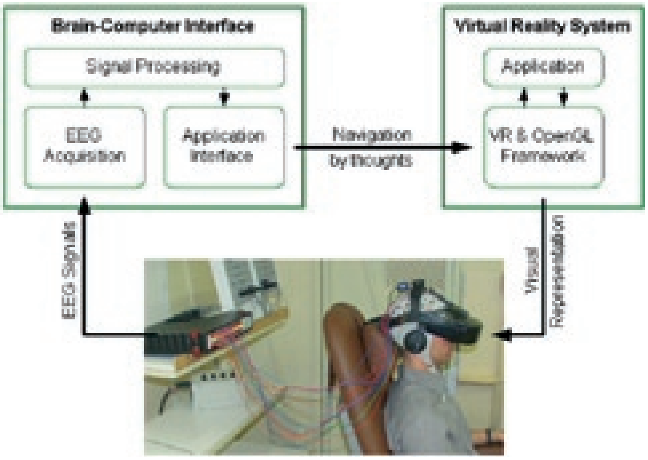

Fig. 2: Control of virtual reality (VR) by a Brain-Computer Interface (BCI)

For the realization of the project the interdisciplinary team at the Department of Medical Informatics consisting of psychologists, bio-medical engineers and telematic experts will be responsible. For the experiments a new 64-channel EEG system and several BCI prototy-pe systems are available. In addition, a head-mounted display with a head position tracker will be installed to realize the VR environment.