PROFESSOR THOMAS SCHACK AND DR KAI ESSIG ON THE REQUIREMENTS NEEDED FOR NEW COGNITIVE INTERACTION SYSTEMS

New cognitive interaction systems

Established ten years ago, the Neurocognition and Action-Biomechanics (NCA) research group at Bielefeld University, Germany investigates the movements of biological organisms, humans and technical systems in natural and artificial environments, with a special focus placed on human movement and its adaptivity. To this end, the biological basics, the neurocognitive organisation and the kinematic and perceptual parameters of human motor functions are analysed using modern research methods.

Within the Faculty of Psychology and Sport Sciences, the group primarily represents the disciplines of sports psychology, motor control, and biomechanics and is dedicated to research, particularly in the areas of modern diagnostics and corrective intervention techniques, mental training, visual perception, neurocognitive organisation of movement, media-based movement-learning, action dynamic testing and sport anxiety. Moreover, the group works in close co-operation with other faculties and institutes of the university, primarily with the Faculty of Biology and the Technical Faculty (in the areas of cognitive robotics, machine learning, object and action recognition, and virtual (VR) and augmented reality (AR)). The aim of this interdisciplinary co-operation is to analyse the basic mechanisms of human behaviour and movement organisation with the goal of future implementation on technical platforms (e.g. smart glasses, VR/AR setups or robots).

Cognition and action lab (Coala) infrastructure

To learn about the building blocks of motor performance and its adaptivity in our memory and underlying brain structures, the Neurocognition and Action-Biomechanics research group has established different research lines. State-of-the-art research methods are used to investigate the cognitive-perceptual organisation and kinematic parameters of human motor functions. In order to conduct experimental studies on kinematic, cognitive and perceptual processes in human motor action we established the Cognition and Action Laboratories (Coala), a cluster of seven well-equipped labs. This structure provides the environment to investigate, develop and evaluate new techniques and methods for future cognitive interaction technologies under the involvement and participation of the future target groups (e.g. researchers or elderly people).

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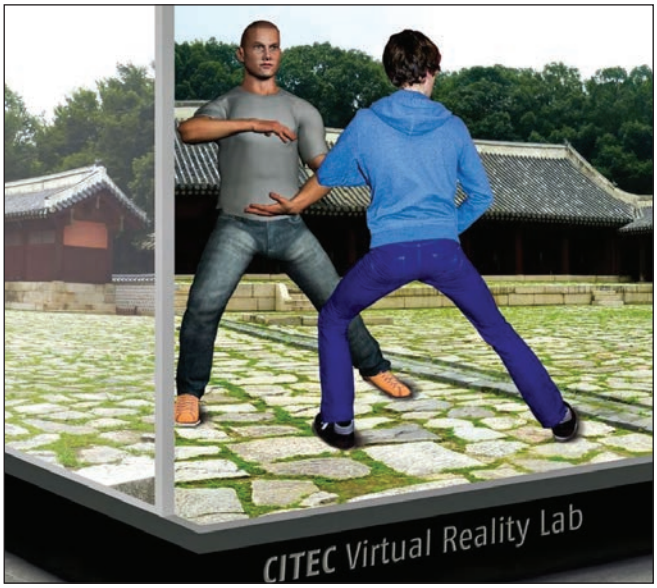

Intelligent Coaching Space: in a teacher-trainee scenario, the virtual coach supervises the acquisition of action sequences (e.g. in golf or Tai Chi) by verbally instructing participants, signalling the movements with gestures, and assessing changes of mental representation during skill learning to provide feedback

Cognitive interaction technology

To facilitate smooth interactions with humans, a robot or virtual avatar should be able to establish and maintain a shared focus of attention with its human partner or instructor. Furthermore, the system should be able to identify problems in actual action processes in order to react when mistakes are made, as well as to deliver situation and context-dependent assistance in a 'natural' way by using speech, gestures and demonstration. Finally, it should be tailored towards the requirements of the target groups and should provide unobtrusive and intuitive support while operating along in a largely unnoticed and restriction-free manner.

To address the specific research questions arising from these requirements we work closely with 30 other research groups in the Cluster of

Excellence Cognitive Interaction Technology (CITEC) at Bielefeld University, which is funded as a part of the German Excellence Initiative (DFG), and offers the infrastructure to allow respective research topics to be approached from an interdisciplinary perspective. This enables us to translate our findings from studies of human movements (e.g. how structured mental representations can arise during skill acquisition and how the underlying processes can be replicated) into theoretical models that can guide the implementation of corresponding features on cognitive system architectures.

As an example of future cognitive technologies that we are currently working on, below is a brief outline of two of our recent projects (ICSPACE and ADAMAAS), which illustrate our overall approaches as well as the resulting system capacities.

Intelligent Coaching Space (ICSPACE)

The understanding of the neurocognitive architecture of actions based on empirical research is an important step in applied fields such as the mental coaching of athletes in high-performance sports or rehabilitation. On the other hand, a fundamental aspect of the growing field of cognitive systems, particularly in relation to its central goal of action support, is to be able to identify user and context-specific problems in the execution of action sequences. Based on this information, the actual visual focus, and the detected objects in the environment, the system should then be able to provide adequate feedback, i.e. by displaying situation and user-specific help comments and hints.

In the large scale project 'Intelligent Coaching Space' (funded by CITEC and headed by Mario Botsch, Stefan Kopp and Thomas Schack) we closely co-operate with other groups in developing a form of intelligent assistance of human performance from a research perspective, without losing focus on possible practical applications.

Coaching a trainee at different levels of skill interaction while they are practicing and learning a motor task has been shown to be important. In this context, our research on action representation will be extended to contribute to intelligent coaching by using action representation as a scaffold for teaching and learning. In this direction, we will combine motion analysis with coaching strategies such as task-oriented feedback and guidance of attention at different levels of interaction. ICSPACE has contributed and will continue to contribute not only to investigations concerning the link between representation and attention, but also to higher-level objectives such as adaptability and deep assistance.

ADAMAAS: intelligent glasses provide assistance for activities such as baking a cake, making coffee, repairing a bicycle, or even practising yoga

ADAMAAS

In the ADAMAAS (Adaptive and Mobile Action Assistance in Daily Living Activities) project, which recently received funding from the German Federal Ministry for Education and Research, we focus on the development of a mobile adaptive assistance system in the form of intelligent glasses that provide unobtrusive and intuitive support in everyday situations.

The system will identify problems in ongoing action processes, react to mistakes and provide context-related assistance in textual, pictorial or avatar-based formats superimposed on a transparent virtual display. The technical platform is provided by the eye-tracking specialist SensoMotoric Instruments (SMI; see: www.smivision.com). This project integrates mental representation analysis, eye tracking, physiological measures (pulse, heart rate), computer vision (object and action recognition) and augmented reality with modern diagnostics and corrective intervention techniques.

The major perspective that distinguishes ADAMAAS from stationary diagnostic systems and conventional head-mounted displays will be its ability to react to errors in real-time, to provide individualised feedback for action support, and to learn from expert models as well as the individual behaviour of the user.

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