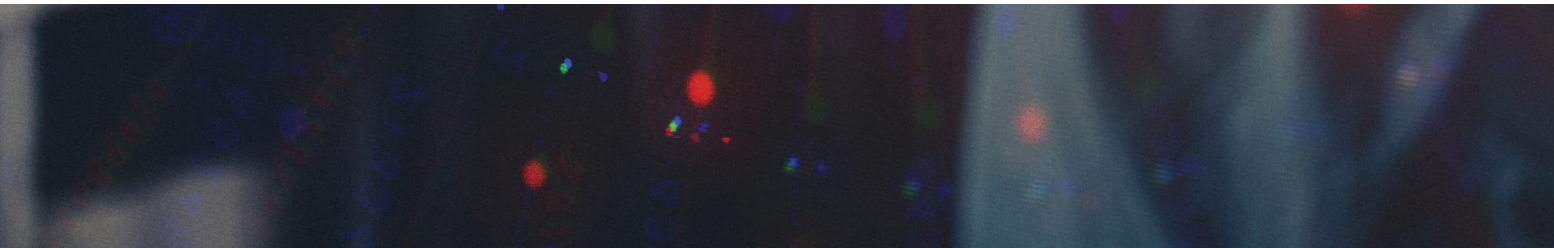
Strenge, B., Schack, E., Vogel, L., Krause, A. F., Sionti, M., & Schack, T. (2017.12.01). Personalized Cognitive Assistance (and ethical system development). Congleton, U.K.: Pan European Networks retrieved on December 2017 from http://edition.pagesuite-professional.co.uk/html5/reader/production/default.aspx?pubname=&edid=a58adf4a-936e-4f21-af25-7a4dd3c5b9ba

Universität Bielefeld

Neurocognition and Action

The Neurocognition and Action (NCA) research group



Personalised cognitive assistance

Since 2005, the Neurocognition and Action (NCA) research group at Bielefeld University, Germany, has analysed human memory structures and now applies these findings to the next generation of user-adaptive assistance systems.

The NCA group employs researchers from a diverse range of fields such as cognitive psychology, sports and movement science, biology, neuroscience, computer science and engineering. This interdisciplinary approach allowed them to establish software for assessing long-term memory structures and predicting human errors for a given task; for example, using specific high-tech machines, building birdhouses from wood, or doing exercises at home.

The required data is gathered by a semi-automatised survey. Using a special app created by the NCA group, users are asked to judge whether they think different pairs of actions belong together during the task execution. Subsequently, the software calculates the person's memory structure for each task. Based on this structure, researchers assess whether the person will know what to do in a given situation or not.

Fig. 1 Special software from cognitive sciences (lower left) enables the prediction of human action errors (upper left) for individualised user assistance, e.g. using intelligent smart glasses (right)

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, e.g. 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) the NCA closely co-operates 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 practising 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 are combining 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.

Job-related cognitive training

In many instances, people with cognitive disabilities face difficulties in organising work-related tasks autonomously. Some may fail to conduct all relevant tasks to prepare a coffee machine, while others may mix-up specific sequential tasks during their daily work. Based on our extensive previous research, we ascertain that mental representations play an important role in planning and executing complex actions and movements. In the joint project Adaptive Cognitive Training (ACT) between the NCA group and the von Bodelschwingh Foundation (Bethel), one of the largest healthcare centres in Europe, we investigated the memory structure of different work-related tasks by deploying the Structural Dimensional Analysis of Mental Representation (SDA-M) and found significant differences between the instructors and the handicapped trainees.

ACT uses this cognitive assessment to identify differences in the memory structure on an individual level. To support the learning process, we developed an adaptive training terminal to analyse the cognitive structure automatically and provide an adaptive feedback. The terminal provides individualised training advices and helps to identify unstructured working tasks. Depending on the trainee, the training can include self-instruction or imagery training. Furthermore, instructors use the terminal to address trainees in a more targeted way and intervene earlier. The regularly repeated cognitive diagnostic assessment makes changes and progress for the instructors and the trainees visible and enriches the learning progress. The terminal can easily be applied to different kind of tasks and complex movements, which makes it to a useful tool for accompany learning and working processes in rehabilitation, sport or other fields.

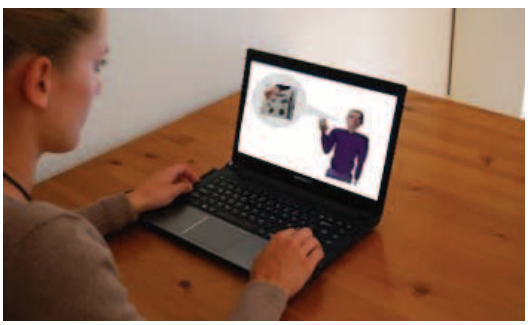


Fig. 2 The adaptive learning training terminal provides structural analysis and feedback, based on individual training advices

The personal trainer chair

It is estimated that in the next forty years, every third person will be at least 65 years old, and the number of 70-year-old persons will be twice as high as the number of newborn children in Germany. This demographic challenge requires the development of assistive technologies to support elderly people to live a self-sufficient life in an age-appropriate way. In the context of the KogniHome project, the Personal Trainer Chair (PTC) was developed to support and motivate daily exercise of all family members in a smart-home environment. It is designed to be a ubiquitous interaction system: by combining mental diagnostics, marker-free motion tracking and natural interaction, the system seamlessly integrates into the living room and provides a motivating and fun exercise tool, a relaxation mode and entertainment through gamified activities.

The PTC provides a closed-loop sensorimotor learning, interaction and training system. Neurocognitive diagnostic tools developed in our research group enable the SPC to identify user-specific problems in the execution of action sequences based on measured memory structures. The PTC will then adapt the training routines and provide adequate feedback. Monitoring the emotional and motivational status will be used to ensure long-term motivation by proper goal setting. A biofeedback based relaxation mode facilitates an integrated radar sensor to measure vital data and uses a virtual reality setting to help smart home inhabitants to relax after a long work day.

Fig. 3 The Personal Trainer Chair prototype

Smart glasses as a cognitive assistance device

The information about user's memory structures and task knowledge has also been transferred to intelligent technical systems, so that they can adapt to individual expertise. In a current project at Bielefeld University's Cognitive Interaction Technology Excellence Center (CITEC), smart glasses are used to assist users in different activities. The so-called 'ADAMAAS' glasses use augmented reality and eye tracking technology to show helpful illustrations and virtual 3D animations overlaid with real world objects to provide assistance exactly at the time and place where the user needs it. In order to reduce unwanted distraction from the task due to visual clutter, a cognitive diagnostics component predicts in which action steps this assistance is actually required.

Researchers from the NCA group are currently testing the glasses with handicapped people in an educational programme, with senior citizens, and in an industrial assembly setting. While the current research focuses on a handful of specific activities to optimise the system's accuracy and user experience, the potential future applications are theoretically almost unlimited. The scientists believe that in a few years intelligent smart glasses like the ADAMAAS system from Bielefeld can be widely used as a cognitive assistance device during our daily life. Just like a universal remote control for hi-fi devices in the living room, intelligent smart glasses could easily be programmed to assist in new activities. NCA Professor Thomas Schack expects such next-generation assistance systems to "help people develop further and live a more satisfying life" by enabling them to engage in new activities.

Fig. 4 ADAMAAS: Intelligent glasses provide assistance for activities such as baking a cake, preparing coffee, repairing a bicycle or even practicing yoga

Fig. 5 ADAMAAS: the bird house assembly

Ethical aspects of system development

Ethical, legal and social implications (ELSI) are an important aspect of new technological developments. In many cases German research funding bodies require systematic analyses of these aspects to avoid unforeseen consequences for the society. This is especially important when target groups comprise people with above-average vulnerability such as handicapped or elderly people. NCA researchers recently developed an innovative approach to meet these requirements.

The approach of working on ELSI aspects will be presented especially for the ADAMAAS project, where a threefold method is used: 1) qualitative investigations and context of use analyses to identify user requirements, 2) participatory design, and 3) a functional-analytical approach to consider ethically relevant criteria.

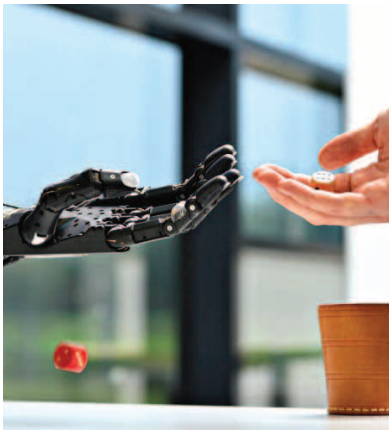
Ad 1) Qualitative investigations and context of use analysis methods, such as interviews, contextual inquiry and a systematic development of user models (Personas) are used to identify and address user-specific concerns and requirements.

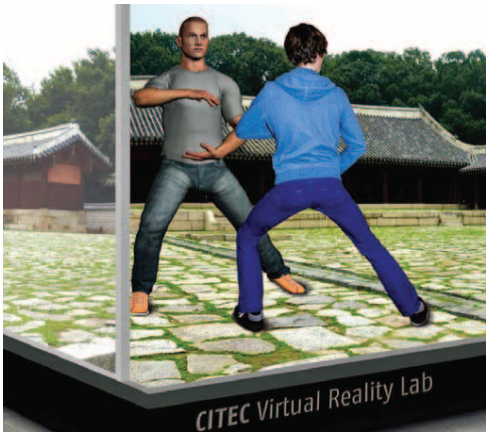
Ad 2) Participatory design is realised by interdisciplinary workshops (with researchers, practitioners and representatives of potential user groups) and feedback platforms for prospective stakeholders. By this means a technical system is developed which meets the expectations of target groups (e.g. handicapped people) by optimising usability and functionality. For example, using plain language occurred as an important issue for people with special needs.

Ad 3) A flexibly applicable methodology called Agile Worth-centred System Engineering (AWOSE) was created to incorporate ethically relevant criteria in development. In a first step MEESTAR (Manzeschke et al. 2015), a multi-dimensional model for the ethical evaluation of socio-technical arrangements, is applied. MEESTAR helps to identify and assess ethical issues on an individual, organisational and social level, as well as according to a standardised set of dimensions, such as privacy, participation or safety. Each potential issue's severity is evaluated according to a four-level scale that ranges from "completely harmless" to "should be opposed from an ethical viewpoint". As a result, detailed information about relevant ethical issues regarding the socio-technical system are gained. To ensure that ethical issues are not only identified, but systematically considered during research and development, the second phase of AWOSE integrates approaches from value-sensitive design and worth-centred development (cf. Cockton, 2006) into an agile process. The special artefacts from this methodology combine project management tools and engineering methods to guide the regular prioritisation of development tasks as well as systematic choices among design alternatives with respect to ethical implications.

Besides the threefold way of working on ELSI aspects additional expertise is used in the process of ethical evaluation of the emerging technical system. External experts are invited for reviewing how ELSI aspects are considered and to discuss central legal and social questions in the development of this assistive technology. Hereby additional environmental and Nature-related aspects were taken into account as an important fact of viewing the use of new assistive technologies.

Based on that complex approach finally a comprehensive list of ethical guidelines for the application of ADAMAAS was worked out which also serves as a reference for other advanced technical assistance systems.





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