# CINACS International Research Training Group
## Cross-modal Interactions in Natural and Artificial Cognitive Systems

## Motivation

Natural cognitive systems significantly outperform artificial systems in most cognitive tasks. They are more robust and faster. Research on natural systems can inspire and improve the design of artificial ones. Interdisciplinary studies comprising informatics, neuroscience and psychology currently are still rare.

In the CINACS Graduate College we will investigate the principles of cross-modal interactions in natural cognitive systems to implement them in artificial systems. Research will primarily consider three sensory systems (vision, hearing and haptics) and their interactions. We will study multisensory interaction in natural systems with behavioural, electrophysiological and neuroimaging techniques. Different paradigms including cross-modal association learning, sensorimotor control, cross-modal illusions and multisensory language perception will be used to uncover the principles of multisensory processes and multimodal representation.

The research program will aim at understanding the biological mechanisms of cross-modal processing and its role in perception and behavioural control. Furthermore, our goal is to design models, implement algorithms and architectures for more robust artificial multimodal systems which can function like natural systems.

CINACS will combine the relevant methods, in particular behavioural techniques, EEG, fMRI, TMS, multi-electrode recordings, simulation, artefact construction, computer and robot experiments. This combination of approaches is only possible because CINACS comprises the disciplines of neuroscience, psychology, linguistics, computer science, robotics and bio-engineering. From this synergy we expect major advances in the fields of multisensory learning, attention, memory and sensorimotor control.

Furthermore, CINACS offers many innovative aspects.

1. First integrated study program in the field of multisensory interaction and integration.
2. Joint decision about student admission by Hamburg and Tsinghua faculty.
3. Joint supervision by both, Hamburg and Tsinghua professors.
4. Advanced tools for strengthening interaction through virtual presence: eLearning platform, videoconferencing for virtual lab visits.

## Structure of Research Program

**Research area 1:** Mechanisms of multisensory perception and attention.

- Investigation of visual-auditory and visual-tactile interactions in natural systems, in artificial systems and in brain-computer interfaces.
- Biological mechanisms addressed at cellular and systems level; technical solutions implemented in network simulations and in multimodal robot systems

**Research area 2:** Cross-modal learning and association.

- Implementation of problem solving algorithms based on cross-modal information.
- Multimedia content processing through cross-modal association.
- Investigation of cross-modal associative learning in humans with imaging techniques.

**Research area 3:** Multimodal representations for communication.

- Cross-modal interactions in language processing: between sensory processes and content representation, between spoken and written language, and between verbal and pictorial representation modalities.

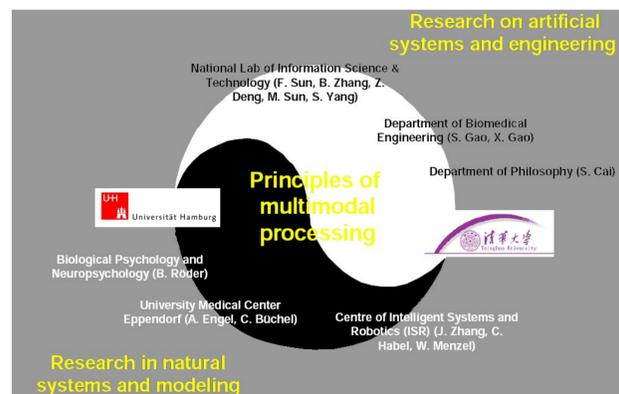## Participating Faculties



**Figure 1:** The CINACS Consortium.

The interdisciplinary program is established between three faculties of the University of Hamburg/Germany and three faculties of the Tsinghua University Beijing/China. This faculties keep leading positions in their particular research field and together establish the CINACS consortium as presented in Fig. 1.

### Department Informatics, University of Hamburg

◇ Center of Intelligent Systems and Robotics (ISR); one of the largest AI competence centers in Germany.
◇ TAMS - Technical Aspects of Multimodal Systems (Prof. Dr. J. Zhang).
◇ NATS - Natural Language Systems (Prof. Dr. W. Menzel).
◇ WSV - Knowledge and Language Processing Group (Prof. Dr. C. Habel, Dr. C. Eschenbach).

### Department Psychology, University of Hamburg

◇ Biological Psychology and Neuropsychology Group (Prof. Dr. B. Roeder).
◇ Strategic development to strengthen cognitive neuroscience.

### University Medical Center Hamburg-Eppendorf

◇ Neurophysiology and Pathophysiology (Prof. Dr. A. Engel).
◇ NIN - Neuroimage Nord (Prof. Dr. C. Buechel).
◇ Cognitive and clinical neurosciences have been identified as the top research priority area.
◇ One of the leading neuroimaging centers in Europe (3T MR, whole-head MEG, high-density EEG, PET-CT, animal-PET).

### Tsinghua National Laboratory of Information Science & Technology

◇ Largest AI research unit in China (Prof. Dr. F. Sun, Prof. Dr. B. Zhang, Prof. Dr. Z. Deng, Prof. Dr. M. Sun, Prof. Dr. S. Yang).
◇ Recently established as one out of five national laboratories.

### Tsinghua School of Medicine

◇ Newly established faculty
◇ Including the Dept. of Biomedical Engineering (Prof. Dr. S. Gao, Prof. Dr. X. Gao), and the leading brain-computer-interface lab from the Institute of Neural Engineering.

### Tsinghua Department of Philosophy

◇ Will soon establish a center for cognitive science research (Prof. Dr. S. Cai).

## Acknowledgements

**Figure 2:** The whole CINACS group at the first summer school in Sep. of 2006 at University of Hamburg