## *ZESS Compact*

The Centre for Sensor Systems (ZESS) defines itself as an interdisciplinary centre with scientists from the engineer´s and natural sciences, which comprises, under combining method knowledge from the mechanical, electronical, physical, chemical and computer science fields, the following three spheres of competence:

- *Novel Sensor Principles and Sensor Development,*
- *Sensor Information Processing and*
- *High Level Information Extraction and System Integration.*

By basic research and application-oriented development in these fields ZESS does not only contribute to solve selective actual problems, it provides also the basis for interdisciplinary joint projects in cooperation with the industry and other research institutions. In this process the research and technology transfer in both industrial applications as well as in university teaching is always in the foreground.

**Sensor systems**

The parking assistant system in the car, the motion detector of an outdoor lighting, the light barrier in the lift, these are only three of the mostly known sensors used in the everyday life – however, but a quite exciting field of sensor systems / sensor research includes much more. Multi sensor systems now play in industrial as well as in everyday areas an increasingly important role: In home automation, when the stove detects whether a cooking pot is on the plate, the vacuum cleaner, which removes all alone and independently the dust. In medicine, long-term ECG can be carried out now with an ECG shirt, where the sensors are incorporated into the cloth. Sensor and assistance systems support surgeons in demanding operations. Aircraft- and satellite-based positioning and exploration systems afford not only in small, handy navigation systems valuable help in practical everyday life, they provide in crises and disasters vital information for effective management on the coordination of rescue and assistance.

**High-level Postgraduate Education**

As a confirmation of the scientific success ZESS was granted in 2003 financial support for the establishment of the International Postgraduate Programme (IPP) Multi Sensorics by the German Academic Exchange Service (DAAD). This programme is open to students with master and diploma degree of all engineering sciences, mathematics, chemistry and physics. The participants work on their own scientific topics and write within three years their doctoral Dissertation. Under the new program, "Research Schools" the state of NRW also

launched at the University of Siegen in the winter semester 2008/2009 the new Research School "Multi Modal Sensor Systems for Environmental Exploration and Safety (MOSES)"

**Equipment:**
ZESS provides on a floor space of about 1.500 square meters (office and laboratory space) modern equipment for the three main research topics.

---

*Novel Sensor Principles and Sensor Development*

---

For investigation and development of novel sensor principles and sensor hardware, ZESS provides laboratories and measuring places for performance checks and compliance tests:

- High speed precise gantry platform
- Calibration equipment with translational and rotational positioning units for verifying, testing and calibrating navigation sensor elements (IMU, INS, Gyro, Accelerometer, high end inclination sensors)
- 3 axes coordinate moving platform on heavy granite table
- Laser interferometry-based guidance (LIG) system for accurate sensor positioning
- Laser vibrometer for non-contact measurement of vibration velocities
- Electromagnetic shakers with forces up to 600 N
- High speed camera for motion analysis
- Robotic research lab with setups for analysing dynamic sensor effects
- Turning roll test bench for axisymmetric symmetrical components
- Acoustic camera with 48 microphones for noise detection and localization
- EMV-measuring equipment

Additionally we can provide setups (optionally equipped with high-speed and high-precision analogue data acquisition devices up to 8 GHz) for:

- New camera developments, camera modules/image sensors with different interfaces (VIS, NIR,)
- Depth cameras based on ToF sensors from different manufacturers (single sensors and multi sensor arrangements, PMD devices, mono- and binocular RGB-D sensors)
- Thermal infrared cameras
- THz camera systems
- Optical developments (stabilized tables, spectral radiometry, confocal microscope, laser power measuring facility, dark room for calibration and experiments)
- Chemical experiments (wet laboratory and a chemical laboratory with fume hood)
- Medical experiments (robotic research lab with medical robots, X-ray room)
- Radar experiments (laboratory with direct roof access for free-space measurements and test site with different microwave Signal generators and Spectrum/Signal Analysers and various $K_u$- and X-Band Radar transmitter and receiver up to 750MHz (analogue bandwidth)

together with:

- Clean room on class 1000
- SMD soldering equipment (reflow ovens, etc.)
- 3D scanner (structured light) and 3D printer for rapid prototyping of miniature sensor enclosures
- Automated spraying system for graphene based thin-film nano-sensors

## *Sensor Information Processing*

Research in the field of sensor information processing are supported by setups for high performance sensor data simulation, collection and handling. Most of it is to study signal processing techniques for efficiently acquiring and reconstructing data by finding solutions to underdetermined linear systems (compressed sensing):

- Mono- and binocular RGB-D sensors
- AMCW and pulse-based ToF cameras (also to study various sensor effects such as multi-path, motion artefacts etc.)
- THz cameras
- Thermal infrared cameras
- optical infrared stereo cameras for 3D-Posetracking
- Long-range ToF imaging system mounted on a rotary table
- Turning roll test bench for axisymmetric symmetrical components

In addition there are measurement setups for:

- Real-time data recording of new sensor systems (mainly camera modules/image sensors with different interfaces)
- sensor fusion and 3D scene reconstruction (also on mobile devices)
- Imaging with Synthetic Aperture Radar Imaging
- Radar Detection and Tracking

And spectroscopy setups:

- Chemiluminescence/emission-sensor system based on a spectrometer and a back-illuminated CCD camera
- Raman-sensor system based on a cw Nd:YAG laser
- Various CARS-systems based on pulsed pico/nanosecond a Nd:YAG laser and a broadband dye laser

And Sensor Network test platforms (IMU, pressure, temperature, magnetic, light detection sensors, power balancing electronic etc.):

- Embedded vision nodes (2D/3D, multi-modal sensor nodes
- Autonomous mobile systems (indoor/outdoor, air and ground robots)

Several in-house workstations and high performance compute-servers are used for simulations and verification of algorithms.

## *High Level Information Extraction and System Integration*

This area is supported by following facilities:

Equipment for wearable computing / wearable sensing:

- Smart glasses such as Google Glass various Head Mounted Displays (HMDs)
- Clinically-Validated wearables for long-term biophysical measurements
- Miniature and wearable RGB-D sensors
- System-on-chip platforms for wearable and real-time sensor data analysis

Robots for illustrating computer vision algorithms

ToF-based and other depth cameras for online range image fusion and scene reconstruction (also on mobile devices)

Setup for interactive visual analysis:

- To extract scene lighting and material parameter (Inverse rendering)
- To perform online range image fusion and scene reconstruction (also on mobile devices)
- To investigate super-resolution techniques for imaging beyond the diffraction limit
- To visualize high dimensional multi- and hyperspectral sensor data (e.g. from confocal Raman microscopy)

High performance workstations, specifically equipped with multiple GPUs for large scale optimization problems such as training deep neural networks

“Industrie 4.0” arrangement (test field) with:

- PLC based control system,
- Sensor-Actor Network,
- High precise Pick&Place Robot,
- Distributed Signal processing,
- Image processing,
- Industrial communication structure,
- IoT communication support,
- Database management,
- Secure edge computing,

- Cloud / mobile computing,
- Engine test facility and
- Multi-machine management

**Cooperation:**
In the context of joint projects of the BMBF and the EG ZESS usually has cooperation with industrial partners. For projects that are carried out independently of public funding, a free contract drafting is possible, taking into account in particular the confidentiality requirements of the industrial partners. For clearly specified requirements, a timeframe and budget can be specified at the beginning. Otherwise, a feasibility study is common practice. Utilization or patented legal aspects are covered by a contract in detail. Further to this kind of settlement, the time-restricted cooperation of specialist staff of the cooperation partner is possible. Other service aspects are the realization of problem analyses and consultations as well as the verification of performance data (expert´s reports).

**Seminars:**
Industrial seminars and lectures are offered to the following subjects:

- Optical measuring technique (general)
- 2D/3D – measuring technique
- Multisensory- und image processing
- Signal processing and simulation techniques
- Communication Engineering (general)
- Kalman-Filter technique
- Stochastic models and information theory (general)
- SAR (Synthetic Aperture Radar)
- Mechatronics and robotics
- Embedded Systems (practical applications)
- FPGA design with Verilog/VHDL
- Workshops for electronic design and precision Engineering