Dear Sir or Madam,

When faced with a technical problem for which there are established solutions, technologies or sophisticated products, one only has to find the right supplier and a competent integrator capable of solving the task cost-effectively and reliably.

If, however, a technical problem arises, for which a standard solution – let alone a suitable approach – has not yet been identified, and for the solution of which the latest research results or even new research activities are required, then, Fraunhofer with its many specialized institutes, is the right address.

Fraunhofer IOSB is the first port of call for the fields of
• optronics,
• systems engineering, and
• image analysis.

With its extensive portfolio of competencies, IOSB is Europe's leading center of excellence in these areas.

But scientific and technical skills alone are not sufficient to guarantee the success of an application-oriented research institute. To be a successful innovator also takes an intimate knowledge of the industries and markets for which innovations with commercial value are to be created. Our scientific and technical competencies in the sectors and markets we serve cover the following five business segments:
• Automation
• Energy, water and environment
• Automated visual inspection
• Security, and
• Defense

With the numerous positive results in 2013 we again demonstrated our ability to meet the challenges presented by these fields of activity. All of IOSB's sites have undergone an outstanding commercial and scientific evolution, both in terms of quality and quantity. Personnel levels, budget, and business project volume, as well as economic results have reached record levels. The prospects for 2014 are also highly promising.

An important challenge for 2014 is to establish a professorship for Optronics at the Faculty of Electrical Engineering and Information Technology of KIT. Prof. Dr. Maurus Tacke, who
represented this field at IOSB, commenced his well-deserved retirement on May 1, 2013. He has been succeeded in the management of the field of Photonics and Optoelectronic Systems, comprising the departments of Signatorics, Optronics, Scene Analysis, and Object Recognition by Dr. Reinhard Ebert.

With the Chair of Optronics, the cooperation with KIT will be institutionalized with another faculty important for IOSB in addition to our existing collaboration with Informatics. Although this new professorship has already been under discussion and in preparation for some time, the motto “good things come to those who wait” applies here: As all parties are working towards a common goal, we are hoping to be able to achieve this aim, which is of great significance to IOSB, before the end of this year.

As every year, we want to provide our readers with as comprehensive an insight into the work of our research departments as possible with this annual report. Because of the numerous exciting topics covered by the research and development work carried out by our capable staff, we cannot do more here than offer a brief glimpse into our activities.

Our special thanks goes to our partners and clients in business, in government and in the ministries, and to all the sponsors and advisors of IOSB. The support and cooperation of the federal ministries of Education and Research (BMBF) and of Defense (BMVg) are vital in enabling us to carry out our activities.

Our gratitude also extends to the employees of IOSB and their excellent work. Their expertise, skills, diligence and academic motivation is the cornerstone of our institute's success.

Dear readers, this report aims to provide you with an overview of IOSB, with a few deeper insights into typical projects and examples of our research work. We hope that we have succeeded in striking a good balance that makes for interesting reading and we would welcome your comments.

Karlsruhe, Ettlingen, Ilmenau and Lemgo, May 2014

Prof. Dr.-Ing. habil. Jürgen Beyerer
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREFACE</td>
<td>2</td>
</tr>
<tr>
<td>CONTENTS</td>
<td>4</td>
</tr>
<tr>
<td>THE INSTITUTE IN PROFILE</td>
<td>6</td>
</tr>
<tr>
<td>The Institute in Profile</td>
<td>10</td>
</tr>
<tr>
<td>A RESEARCH FACTORY FOR INDUSTRIAL AUTOMATION</td>
<td>12</td>
</tr>
<tr>
<td>CIT NEW CONSTRUCTION</td>
<td>14</td>
</tr>
<tr>
<td>IT SECURITY LAB FOR INDUSTRIAL CONTROL SYSTEMS</td>
<td>16</td>
</tr>
<tr>
<td>CONTACT OFFICE CHINA</td>
<td>18</td>
</tr>
<tr>
<td>THE INSTITUTE IN FIGURES</td>
<td>19</td>
</tr>
<tr>
<td>IOSB IN FRAUNHOFER ALLIANCES</td>
<td>20</td>
</tr>
<tr>
<td>IOSB IN FRAUNHOFER GROUPS</td>
<td>23</td>
</tr>
<tr>
<td>FRAUNHOFER-GESELLSCHAFT</td>
<td>24</td>
</tr>
<tr>
<td>Locations</td>
<td>25</td>
</tr>
<tr>
<td>NAMES, DATES, EVENTS</td>
<td>116</td>
</tr>
<tr>
<td>ADVISORY BOARD</td>
<td>117</td>
</tr>
<tr>
<td>SCIENTIFIC PUBLICATIONS</td>
<td>142</td>
</tr>
<tr>
<td>VERNISSAGEN 2013</td>
<td>158</td>
</tr>
<tr>
<td>EDITORIAL NOTES</td>
<td>159</td>
</tr>
<tr>
<td>ADDRESSES</td>
<td>160</td>
</tr>
</tbody>
</table>

## BUSINESS UNITS

### AUTOMATION

- **Bernard, T.**: Model-based Optimization of a Complex Biological Production Process 28
- **Schick, A.**: Gesture-based Quality Assurance 30
- **Usländer, T.**: Towards ProVis 4.0: Production Monitoring and Control in Light of Industrie 4.0 32
- **Flatt, H.**: Highly Available Communication 34

### ENERGY, WATER AND ENVIRONMENT

- **Nicolai, S.**: Intelligent Distribution Grid & Energy Storage: SmartRegion Pellworm 38
- **Rauschenbach, T.**: Small Hydropower Plants: Assessment of Climate Protection Potential and Improvement through Smart Technologies 40
- **Chaves, F.**: TRIDEC – Early Warning Systems Architecture 42

### AUTOMATED VISUAL INSPECTION

- **Frühberger, P.**: MicroLab 46
- **Vieth, K.-U.**: GrapeSort – Optical Sorting of Grapes to Improve Quality and the Removal of Foreign Objects 48
- **Taphanel, M.**: CCT Sensor – Towards High-Speed 3D Sensing 50
- **Schwarz, A.**: Directional Reflectance Measurements with a Robot-Based Goniometer 52
- **Höfer, S.**: Thermal Infrared Deflectometry 54
DEFENSE 56

Sprung, D.:
Optical Turbulence – Atmospheric Impact on Imaging and Wave Propagation: Basic Research and Applications 58

Eberle, B.:
First Results of a New Eye-Safe 3D-Laser-Radar APD Line Scanner 60

Tchouchenkov, I.:
Heterogeneous Reconnaissance Data: Task-oriented Acquisition, Distributed Exploitation and Interactive Utilization 62

Hebel, M.:
MODISSA – A Test Bed for “Mobile Distributed Situation Awareness” 64

Middelmann, W.:
Approval of Trial Capabilities: A Real-Time Airborne Multi- and Hyperspectral Sensor System in an Interoperable Environment 66

SECURITY 68

Eisele, Ch.:
AlGaN Detectors for Observation of UV Emitters 70

Grasemann, G.:
MobSC – Mobile Situation Center for the Management of Complex Crisis Situations 72

Streicher, A.:
INTUITEL Intelligent Tutoring Interface for Technology Enhanced Learning 74

Monari, E.:
Patient-Tracking for Epilepsy Monitoring 76

Jakoby, A.:
CyphWay – The One Device for Secure Communication 78

DEPARTMENTS PORTFOLIOS

CORE COMPETENCE Optronics 82

Optronics (OPT) 82
Signatorics (SIG) 84
Visual Inspection Systems (SPR) 86

CORE COMPETENCE System Technologies 88

Energy (NRG) 90
Water and Mobile Systems (WMS) 92
Information Management and Production Control (ILT) 94
Fraunhofer Application Center Industrial Automation INA 96
Systems for Measurement, Control and Diagnosis (MRD) 98
Secure Communication Architectures (SKA) 100

CORE COMPETENCE Image Exploitation 102

Interactive Analysis and Diagnosis (IAD) 104
Interoperability and Assistance Systems (IAS) 106
Object Recognition (OBJ) 108
Scene Analysis (SZA) 110
Video Exploitation Systems (VID) 112
Variable Image Acquisition and Processing (VBA) Research Group 114
Objectives

IOSB’s mission is the same as that of the Fraunhofer-Gesellschaft: Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. With its research the IOSB seeks to further technology-driven innovation; with market analysis it seeks to further application-driven innovation; and in cooperation with partners from research and industry it supports innovation in society and industry.

What makes the institute special is that it combines core know-how in optronics, system technologies and image exploitation with application know-how gained through an extensive dialog with its partners.

Short portrait

Established on January 01, 2010, the Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB grew to become Europe’s largest research institute in the field of image acquisition, processing and analysis. IOSB’s other areas of activity are control and automation technology, and information and knowledge management.

IOSB has four locations in Germany: Karlsruhe, Ettlingen, Ilmenau and Lemgo (highlighted on the map of the Fraunhofer Gesellschaft on page 33), as well as a representative office in Beijing.

The three core competencies of Optronics, System Technologies and Image Exploitation give the institute its distinctive profile. Optronics covers the interface region between electromagnetic radiation and electronic signals. It deals with converting information about the appearance of the environment and the objects it contains into electrical signals and – conversely – electrical signals into optical images.

Image processing covers conditioning and real-time processing of, and automatic and interactive information extraction from images and videos.

System integration, which represents a cross-section of expertise and is essential for responding to difficult, comprehensive issues with integrated solutions, may, at first sight, appear to be our most abstract field of research. System integration covers everything that is required for analysis, gaining an understanding of, modeling, development, and controlling complex systems.
The key of IOSB are fourteen departments and a research group, which represents building blocks the link to the Chair for Interactive Real-Time Systems of the Institute of Anthropomatics at the Faculty of Informatics of KIT. The Competence Triangle in Figure 1 illustrates the share of core competencies contributed by each of IOSB’s departments.

With their various key areas, the departments of IOSB cover the entire process chain from signal acquisition through signal analysis to integration into operational systems. In practical use, systems interact with their environment. This, too, is reflected by the activities of IOSB, which cover all degrees of freedom required for effective system design.

The problems on which IOSB focuses in its research and development work usually require the integration of a range of different scientific disciplines. This awareness forms the basis for the allocation of our departments within the competence triangle in Figure 1. The abundance of our expertise gives us a great bandwidth of achievable goals. While finding solutions to our tasks requires sophisticated technologies to deal with the various subproblems, the creation of value and benefit requires a well-organized interplay of powerful components in a coherent whole.
In order to leverage this potential, profound expertise in automation technology, system architecture, software engineering, network engineering, information and knowledge management, interoperability technologies and, not least, a systematic design of human-machine systems is required. Typical for problems beyond a certain degree of difficulty and complexity is that optimal solutions are not merely automatisms but rather man-machine systems, in which – in addition to hardware and software – the organization into an overall process is crucial.

Convincing examples of systems from IOSB include the image and video analysis system ABUL and VABUL for the LUNA unmanned reconnaissance aircraft, several of which are in use in the German Armed Forces and now also in the Swiss Air Force; the RecceMan® system, which provides efficient interactive object recognition in aerial photographs and has also been taken into operation as a valuable tool by the German Armed Forces; and the control system ProVis.Agent®, which is being used very successfully in automobile production at Daimler AG, in particular in the Bremen and Wörth factories. In industrial quality inspection, large numbers of our sorting systems are working reliably, for example, in glass recycling plants. Our partner Binder+Co was awarded the Austrian State Prize for Innovation for this system.

Complementary to its research and development activities, IOSB has systems evaluation and assessment capabilities. An example is IOSB’s thermal range model software package TRM 4, with which the performance of the overall system consisting of vision device and observer is determined quantitatively. Based on the knowledge of all components and associated human capabilities, this system considers technical features and laboratory measurements to perform assessments. With its neutral evaluation competence, IOSB supports clients in planning and developing components and systems, in concept development and planning of facilities, and in procurement.

Our business units bring together the expertise of IOSB towards the markets. As well as requiring scientific and technology skills, best-of-class solutions need also need in-depth industry knowledge. The five business units are listed alphabetically in Figure 2.
dynamically, they provide specific solutions, services and products tailored to the needs of their specific markets. The departments participate in the business units according to the allocation of their activities to the markets.

Of great importance for IOSB are its close ties with the Karlsruhe Institute of Technology (KIT), which complements its research capabilities. With the Chair for Interactive Real-Time Systems at the Institute for Anthropomatics of the Faculty of Informatics, consulting activities of university chairs at IOSB, membership of university professors in the Board of Trustees, lecturing by IOSB staff and more, cooperation with the KIT is already multi-faceted.

An intensified collaboration with KIT in the research work at the Ettlingen site to sustainably integrate the entire range of IOSB’s activities in the science region of Karlsruhe is also being planned. To this end a Chair in Optronics is to be established at the Faculty of Electrical Engineering and Information Technology of KIT.

At IOSB’s Ilmenau and Lemgo sites the cooperation with the Technical University of Ilmenau and the University of East Westphalia Lippe has also been strengthened through professorships and is proving highly fruitful.
A research factory is a manufacturing system, which is flexible and resource-efficient as well as adaptive to humans and can therefore be operated intuitively. It is a highly complex system consisting of technical components that even incorporate intelligence. We firmly believe that we will have smart factories soon. The paradigm of “Internet of Things” is making inroads on all areas of daily life: Whether in the home, in cars, or in production, embedded systems are rapidly becoming our daily companions. Coffee makers, toasters, and even plants can “have their own voice” and be responsive. This hidden computer systems, which are connected to the Internet are working to make users’ lives easier. In future production systems the plants control themselves and work pieces are able to advise the production system how they have to be processed. This makes production much more flexible and allowing mass customization. As part of the German government's high-tech strategy the trend of merging production technology with information technology has been termed “Industry 4.0” – the fourth industrial revolution. The technological platform at the core of Industry 4.0 is the Internet of Things (IOT), which largely eliminates the distinction between the virtual and the real world.

Since 2005 we have been working specifically on ICT-based automation technologies to realize the factory of the future. In 2014, as we continue to pursue the same objective, the proven research and demonstration platform “Lemgo Modellfabrik” is evolving into an intelligent factory of the future.
With a consistently modular design concept in terms of mechatronics, automation, and software, the most important characteristics of a Research Factory – such as adaptability, plug-and-play capability and ease of use – are demonstrated with augmented reality methods.

Located on the campus of the Ostwestfalen-Lippe University of Applied Sciences, the Research Factory will be both demonstration facility and learning environment for students of industrial and electrical engineering as well as of computer science. Small and medium-sized producing companies will have the opportunity of benefit from a batch production and training their personnel.

On a floor area of 2000 m², intelligent automation solutions will be explored, developed and tested here. **The research factory for Industry 4.0 technologies is an initiative of the Fraunhofer IOSB-INA and the OWL University of Applied Sciences**
A WESTPHALIAN SUCCESS STORY: RESEARCH CENTER CIIT IN LEMGO IS EXPANDING

It is a success story made in OWL. Industry leaders from the world of electrical engineering are partnering with research institutions. Dedicated private investors provide the necessary capital. The CENTRUM INDUSTRIAL IT (CIIT) in Lemgo is the home of the Fraunhofer Application Center for Industrial Automation and Germany’s first Science-to-Business center in the field of industrial automation. Built in 2010 on the campus of OWL University, the research center is now, four years later, being extended to twice its former size.

The CIIT has globally established itself as a high-tech research center. Technology companies and research institutes, who carry out research work in the field of IT-based automation, here work under a single roof. Adjacent and connected to CIIT’s existing premises right on the campus of OWL University, a new building is being erected, increasing the total area to 10,000 square meters. The new building is to be inaugurated in mid-2015. The Fraunhofer Application Center for Industrial Automation (IOSB-INA) can now significantly expand its floorspace. The CIIT partners, too, are getting more space for work and research. Flexible project areas that are available for short- and medium-term rental will also be available.
On March 20, 2014 around 150 invited guests celebrated the groundbreaking ceremony for the CIIT extension. Among the guests was Svenja Schulze, Minister for Innovation, Science and Research of North Rhine-Westphalia, which presented the CIIT with the “Place of Progress” award for exceptional cooperation between industry and science. This award is presented to institutions in North Rhine-Westphalia that unite economic, ecological and social innovation and enable progress for society. Minister Svenja Schulze praised the long-term interdisciplinary cooperation within the CIIT. “Science and industry are pulling together here – permanently, head to head and under one single roof. A venture from which both benefit”, said Schulze in her speech.

The extension also symbolizes the growth of the network that has developed around the CIIT. Numerous research projects, dual degree opportunities, graduate school and the award of a prize for young researchers demonstrate the fruitfulness of the close cooperation between industry, research institutes and universities in Lemgo.
IOSB establishes an IT security lab for industrial control systems in 2014, which specializes in net-working and the application of Internet technologies in the factory of the future (Industrie 4.0). This IT security lab combines IOSB’s expertise in automation, control and IT security. It thus enables IOSB to provide its customers with tailored solutions from a single source. In order to support consulting and development services, the IT security lab provides IOSB’s customers an opportunity to carry out security investigations around new security technologies for networked industrial control systems. Particular aspects of this lab are the protection of networked cyber physical systems (CPS) by applying security technologies promulgated by the »Internet of Things« community.

IOSB experts focus on the analysis of security threats, the identification of vulnerabilities in production networks, and the development of solutions that allow the operator to observe the security state of its assets (security monitoring, gaining overview of the situation). This IT security lab comprises its own industrial automation systems with integrated equipment from different manufacturers. Security research and the testing of new security technologies and products can be carried out in an integrated real environment. Security investigations are executed in the classical multi-level IT system automation pyramid ranging from the field
device level up to manufacturing execution systems (MES) and enterprise resource planning (ERP), as well as in networked CPS environment possibly relying upon virtualized, distributed data storage systems. The latter case tends to be a typical Industrie 4.0 environment, which typically relies upon cloud technologies, implemented as private or public cloud or both. Here, security, privacy and trust aspects need particular attention. Furthermore, the secure local automation systems at IOSB Karlsruhe are connected to further labs residing at other locations of IOSB (Lemgo, Ilmenau) so that multi-site supply chain settings can be demonstrated. As it is set-up as a high security lab it allows the IOSB scientists to study special attack techniques and dangerous malicious programs. Further the development of new methods to identify vulnerabilities (penetration testing, vulnerability testing) is carried out.

The IT security lab for industrial control systems is well connected nationally and internationally and leverages close cooperation networks between experts from academia and industry. The IOSB activities are involved in the high-tech strategy of the federal government (Industrie 4.0) and in standardization processes for Industrial IT security technology.
Many German companies have discovered China as an attractive market for itself. However, these companies often need local partners also in applied research. Due to a long-term cooperation with several research institutes and industrial partners in China, Fraunhofer IOSB established a representative office in Beijing as early as in 1996.

The focus of the representative office is the initiation of research activities focused in the areas of environment and energy. Especially in the field of water supply and water resource management Fraunhofer IOSB is involved in many R&D projects in China.

2013 was one of the most successful years since the establishment of the representative office. Under the presence of prime minister of the state of Thuringia Christine Lieberknecht and minister Christoph Matschie the underwater vehicle “C-Watch” was delivered to the Chinese customer, China Agriculture University (CAu) in May 2013. A second vehicle will be transferred to the Nanjing Hydraulic Research Institute in 2014.

As part of the funding program „International Partnerships for Sustainable Technologies and Services for Climate Protection and the Environment“ (CLIENT), the research project „HAPPI“ (Small Hydropower Plants: Assessment of Climate Protection Potential and Improvement by Smart Technologies) could be successfully started. As a third major water project, the EU project INAPRO (innovative model and demonstration based water management for resource efficiency in integrated multitrophic agriculture and aquaculture system) could be initiated.

Offside the water sector, an industrial project with Volkswagen Group China and Fraunhofer IWU has to be mentioned, addressing several issues in electric mobility. Beyond, a consulting project in the field of cable harness production started together with the Beijing Research Institute of Telemetry (BRIT).

Furthermore, the exchange of scientists between China and Germany could be strengthened: Nine Chinese visiting scholars of the China Agriculture University and the Yellow Sea Fishery Research Institute could be welcomed to Germany within the EU personnel exchange fund „Marie Curie Actions“.

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The Thuringian Minister President Christine Lieberknecht, Professor Thomas Rauschenbach (Fraunhofer IOSB-AST) and Professor Li as well as Science Minister Christoph Matschie (from right) at the handover of “C-Watch” in Beijing.
The development of IOSB continues to be positive and we are expanding organically. Especially pleasing is the substantial growth in our returns from private enterprise in 2013.

Aside from the peak in 2012, which was due to exceptional investments, the IOSB grows steadily.

In addition to our permanent staff we also engaged 175 student assistants and interns.

* The diagram does not include research and business activities concerning defense.

Annotation:
The chart "business expenses 2009" shows only the figures for IITB without FOM.
Carmakers, their suppliers, and those equipping the automotive industry, represent a decisive economic factor in Germany. Significant changes to the entire concept of mobility are ultimately being driven by global trends, such as dwindling natural resources, an increasing need for mobility, urbanization and megacities. In addition, German carmakers and their suppliers are facing increasingly tough competition as the trend towards low-cost vehicles takes hold.

The Fraunhofer Alliance pools the expertise of 18 institutes, who collectively provide the German automotive industry with a competent single-source partner for its research and development needs. The complementary effect achieved by combining the individual institutes’ key areas of research, makes it possible to generate rapid, integrated and sustainable innovations along the entire process chain of vehicle manufacturing – from the planning stage right through to the finished vehicle. The Alliance tackles the challenges posed by environmental policies (reducing fuel consumption and CO₂; electromobility; cutting material consumption) while taking full account of commercial imperatives (ongoing pressure to cut costs).

Fraunhofer Embedded Systems Alliance

Deputy Spokesperson of alliance:
Prof. Dr.-Ing. Jürgen Jasperneite

Contact at IOSB:
Prof. Dr.-Ing. Andreas Wenzel
Fraunhofer Energy Alliance

In the Fraunhofer Energy Alliance eighteen Fraunhofer Institutes join their expertise in energy technologies and energy research, with the aim to give research and development from one hand to industry and energy economy.

The alliance co-operates with the Fraunhofer networks Microenergy Technology, Wind Energy, Direct-Ethanol-Fuelcell and Smart Grids.

The Alliance’s work is chiefly focused on: Renewable energy sources (solar energy, biomass, wind power); energy-efficient technologies (fuel cells, combined heat and power (CHP) systems and gas delivery, building-service technologies, power electronics); buildings and components (low-energy-houses, building energy technology); smart grids (p.e. systemtechnological grid integration of distributed generators; electrical energy storage and micro-energy systems (lithium battery technology, fuel-cell systems) and energy management solutions.

Fraunhofer Food Chain Management Alliance

The Fraunhofer »Food Chain Management« Alliance is a platform that merges the expertise of 12 Institutes. It aims at introducing latest scientific know-how in new products and solutions of this field by means of mutual projects.

Food Chain Management has an enormous economic significance. Therefore new approaches in food safety, microelectronics and logistics, which can easily be integrated in the entire food chain and exhibit an added value as high as possible at low costs are the main objective.

The alliance acts as a competent contact partner and problem solver, both for industrial partners and SMEs as well as institutional funding organizations on a national, European and global level.

Fraunhofer Vision Alliance

The Fraunhofer Vision Alliance combines the expertise of institutes in the field of automated visual inspection and image processing.

The main office in Erlangen serves as the initial point of contact for customers. This office is also responsible for the coordination of joint projects. The institutes cooperating in the Vision Alliance offer services relating to applications of innovative sensors, from terahertz radiation over the visual spectrum and infrared to x-ray, the associated handling, and the evaluation of the sensor data. Their work focuses particularly on optical sensing and automated inspection processes for quality assurance.
Fraunhofer Water Systems Alliance

In the Fraunhofer Water Systems Alliance (SysWasser) eleven Fraunhofer Institutes have been pooling their expertise in the research and development of effective water infrastructure systems and technology.

The alliance's objective is to take sustainable solutions for water catchment, infrastructure, and wastewater treatment and adapt them for use in practical applications on a national and international level, taking into consideration the relevant social, economic and environmental implications.

The use of an integrated, systemic approach linking the energy, waste management and agricultural sectors will contribute towards a more efficient and environmentally compatible usage of water as a life-essential resource.

Fraunhofer Space Alliance

Bringing together 13 institutes, the Fraunhofer Space Alliance conducts applied research in the field of industrial space technology. Weather forecasts, navigation, real-time transmission for satellite TV or global Internet access – space industry applications and services have become an indispensable part of daily life, underpinning the importance of space technology for a modern industrialized society. In the Fraunhofer Space Alliance, the institutes pool their technological expertise in order to provide the industry and funding agencies such as the European Space Agency (ESA) and the European Commission with a central contact.

Fraunhofer acts as systems provider, developing a wide range of top-quality components, integrating them into an overall system and delivering that system to the customer. The sheer technological variety of the participating institutes enables the Fraunhofer Space Alliance to offer its customers a unique range of services. Its business units are Communication and Navigation, Materials and Processes, Energy and Electronics, Surfaces and Optical Systems, Protection Technology and Reliability and Sensor Systems and Analysis.
**Fraunhofer Information and Communication Technology Group**

As the largest ICT research group in Europe, the Fraunhofer Information and Communication Technology Group serves as a one-stop shop for industrial customers and media enterprises. The strengths of the member institutes are pooled strategically and marketed jointly. This network makes it possible to translate application-oriented research into customized, integrated solutions for a specific sector:

- tailored IT solutions
- competent consulting on technological issues
- pre-competitive research for new products and services

Regular economy summits unite the right partners from industry and research. The Fraunhofer Information and Communication Technology Group evolves strategies and visions for medium-term priority research areas, providing its member institutes with assistance in the transfer of technology and the marketing of their research activities. The ICT Group also publishes the economy magazine »InnoVisions«, which is available at the kiosk.

**Fraunhofer Group for Defense and Security**

This group has been formed by Fraunhofer institutes as a means of coordinating their research activities and defining common goals in the area of »Defense and Security«. The chief objective of the group is to agree on common strategies vis-à-vis government funding agencies and to promote collaboration with these institutions and with the defense industry. Furthermore, the members of the group intend to align their research strategies with the requirements of the projected unification of European defense and security policy.

The group aims to maintain its traditional combination of research fields with civil and military applications, because it represents a valuable source of innovation and technological progress, to the benefit of all parties. It will continue to exploit this factor as a competitive advantage in both markets. The member institutes of the group, which engage in both civil and defense research, thus have an important role to play in the transfer of knowledge. They ensure that any significant breakthrough in research funded by non-military sources will be used to benefit defense technology, and vice versa.

**Fraunhofer Group for Production**

The Fraunhofer Group for Production is a cooperative venture by a number of Fraunhofer Institutes, created with the aim of collaborating on production-oriented research and development in order to be able to offer customers in the manufacturing, commercial and service sectors comprehensive single-source solutions derived from the pooling of the wide-ranging expertise and experience of the individual institutes. The Fraunhofer Group for Production makes use of the latest findings in industrial engineering and information science to offer a range of services that covers the entire product life cycle or value chain.
Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

At present, the Fraunhofer-Gesellschaft maintains 67 institutes and research units. The majority of the more than 23,000 staff are qualified scientists and engineers, who work with an annual research budget of 2 billion euros. Of this sum, more than 1.7 billion euros is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft’s contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 percent is contributed by the German federal and Länder governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

International collaborations with excellent research partners and innovative companies around the world ensure direct access to regions of the greatest importance to present and future scientific progress and economic development.

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer. Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies, and helping to train the urgently needed future generation of scientists and engineers.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry and in society. Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur.

more at:
www.fraunhofer.de
Locations of the Fraunhofer institutes in Germany

more at:
www.standortkarte.fraunhofer.de
BuSineSS unit
technology. Industrial ICT has to fulfill high standards, which result from competitive production costs, high equipment availability, required product quality and guaranteed delivery times. Mechanical engineers, computer scientists and automation experts must therefore cooperate more closely than ever to meet future requirements. That is what the team of the Automation Business Unit stands for.

To date, ICT in production technology has been based on the architectural model of the automation pyramid. Owing to increasing ICT support on all hierarchical levels of the factory, however, there seems to be a new trend according to which the information flow in factories follows a new “reference model of industrial information technology”. This model takes account of three dimensions of information flow, namely vertical and horizontal integration, and integration spanning the entire life cycle of production equipment.

When it comes to enabling shop-floor-related ICT systems to communicate consistently within the three aforementioned dimensions, for example, it is necessary to connect them systematically with the systems of the digital factory (life cycle dimension) and with automation technology on the control and field levels (vertical integration). To this end, it is indispensable to use unified, general syntax and semantics.

Specifically, the activities of the Automation Business Unit focus on the following areas:

1) Production monitoring and control technology and MES: Monitoring and control systems become increasingly important for transparent and safe production. We consider control technology to be a fundamental part of today’s manufacturing execution systems.

2) Adaptive information technology: Adaptivity is one of the key requirements for the factory of the future – not just in physical terms, but increasingly in terms of software, too. Our current activities in the field of Secure Plug&Work are ground-breaking in this respect.
3) Industrial Smart Grids: We deal with the challenge of energy management in manufacturing operations. To this end, our specialists make use of the principles of smart grids, including the integration with the smart grids of energy providers. We combine our expertise in energy management and suppliers’ energy data management with long-term experience in monitoring production plants on behalf of energy consumers.

4) Process intelligence and quality improvement: We use state-of-the-art monitoring and control technology as well as condition monitoring to improve plant performance and availability in the process and manufacturing industry.

5) Industrial communication: It is our vision to create an internet for machines and “things” in general in manufacturing, making real-time information available on all levels of a distributed automation system in the required quality and allowing devices to be integrated on the basis of standardized Plug&Work principles.

6) Robot systems: This area focuses on activities relating the control of autonomous and partly autonomous robots and vehicles, acting as individuals, in groups and in cooperation with human beings.

Equipment / laboratory facilities

- Model factory at the Fraunhofer Application Center Industrial Automation (IOSB INA) in Lemgo
- ProVis test bed
- Automation test bed including PLCs, communication, and monitoring and control systems
- Tools for online fine planning and scheduling for discrete manufacturing (ProVis.APS)
- OPC and OPC UA simulation
- AutomationML™ test center
- Virtual commissioning laboratory including PLCs, WinMOD, and Delmia Automation
- Test installation to demonstrate interoperability and adaptivity
- Design and simulation tools for engineering and testing micro-electronic IPs in the field of real-time communication
- Network-based data loggers for process and system diagnosis
- Autonomous robot platforms
- Intelligent Energy Systems research platform at the sub-institute of Advanced System Technology (IOSB-AST)
- ICT energy laboratory at the sub-institute of Advanced System Technology (IOSB-AST)

References / product highlights

- ProVis.Agent® integrated monitoring, control and reporting system for car body, paint and assembly shops of the Bremen and Wörth plants of Daimler AG
- Integration platform in the press shop of the Bremen plant of Daimler AG
- ProVis.Agent® monitoring and control system for Thyssen Krupp Steel AG, Duisburg
- Various interoperability tools based on CAEX and OPC UA
- ProDaMi: suite containing data mining tools for decision support in manufacturing
- Condition monitoring for Bayer Technology Services GmbH, Leverkusen
- PROFINET single-chip solution for Phoenix Contact, Blomberg and Siemens AG, Nürnberg
- Various projects relating to Industry 4.0
MODEL-BASED OPTIMIZATION OF A COMPLEX BIOLOGICAL PRODUCTION PROCESS

The production of bulk and fine chemicals based on renewable resources has gained increasing importance in recent years as “white biotechnology”. Surfactants which, for the most part, are currently manufactured industrially from petrochemical raw materials, are a potential product of the use of biotechnological production methods. One known example of microbial surfactants is rhamnolipids from the bacterium Pseudomonas aeruginosa. Rhamnolipids can be produced on the basis of renewable resources such as vegetable oils or sugar. They are characterized by their good environmental sustainability and biodegradability and excellent surfactant properties. A significant reason as to why biotechnologically produced rhamnolipids cannot yet compete with synthetic surfactants on the market is the relatively low product yields. Approaches used so far to optimize the production of biosurfactants are largely based on heuristic processes, particularly with regard to the rhamnolipid creator Pseudomonas aeruginosa. The aim of the project was therefore to attain optimized process management strategies by using an interdisciplinary combination of advanced process control, biological process technology and molecular biological methods in order to make it possible to produce surfactants from renewable resources in an economical and sustainable way.

Results

Figure 1 shows the reactions and interactions for forming Pseudomonas aeruginosa (biomass) and the products mono-rhamnolipid and di-rhamnolipid. The biomass is in large part formed from glycerol and fatty acid. Nitrogen is also required for its formation along with the trace elements phosphorus, sulfur and iron. As shown in Figure 1, the sunflower oil that is added is cleaved into glycerol and fatty acid by using lipase as a catalyst. Lipase, in turn, is formed by using glycerol, fatty acid and nitrogen and under the catalytic effect of the biomass. Mono-rhamnolipid is also formed from glycerol and fatty acid under the catalytic effect of the biomass. A part of the mono-rhamnolipid reacts with glycerol and fatty acid to make di-rhamnolipid. As a by-product, polysaccharide is formed from glycerol and fatty acid.

State variables of the model are firstly the concentration of biomass, sunflower oil, lipase, glycerol, fatty acid, mono-rhamnolipid, di-rhamnolipid, polysaccharide, nitrate and carbon dioxide. Another state variable is the concentration of C4-HSL (HSL = homoserine lactone), which is a measure of quorum sensing. The bacterium Pseudomonas aeruginosa uses quorum sensing to control the secretion of the rhamnolipids.

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By using the chemical equations and the reaction kinetics, a non-linear dynamic model of the process has been developed. In total, the model consists of 11 common, highly non-linear and coupled differential equations. The model contains 38 parameters, 8 of these parameters were determined experimentally, 22 parameter values were taken from literature or from databases or derived from balance equations. The remaining 8 parameters were fitted based on measured timings of the bioprocess. A specific numerical sensitivity analysis was also performed to obtain a prioritization of the parameters. The results of the sensitivity analysis were clearly visualized using a Hinton diagram. By using this approach, five parameters out of the 38 parameters were identified as having the greatest influence on the defined quality indices when varied. The selected parameters were then optimized in the form of an algorithm, which minimizes the deviation of the simulated processes from the measured data. Based on the model, optimized process control strategies were investigated to significantly increase the rhamnolipid production rate. As can be seen in Figure 2, the model-based oil supply strategy results in a significantly higher product formation.

**Funding**
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**Project Partners**
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**Literature**
GESTURE-BASED QUALITY ASSURANCE

Intuitive interaction for industrial environments

Next-generation human-computer interaction offers intuitive control even for complex systems. In this project, we applied our vision-based gesture recognition technologies to a challenging industrial application area. Together with the BMW Group in Landshut, we improved their quality assurance process for painted bumpers by directly marking errors with gesture interaction. This saves production time while simultaneously reducing errors and improving working conditions.

Task
Quality assurance is an integral part of production as it ensures that products meet company standards and customer expectations. Like most elements of current production systems, quality assurance is tightly integrated into the IT infrastructure, and every finding must be documented. While various systems are linked with sophisticated data exchange interfaces, the human-computer interface is often less than perfect, as it forces workers to use mouse and keyboard to insert data into input masks. This is not how humans naturally interact and therefore suboptimal.

The BMW Group noticed that there is potential for improvement regarding the interaction between workers and computers, in particular in industrial environments. As a test case, they chose one of their factories in Landshut where painted bumpers are produced (Figure 1). After production, these bumpers are visually inspected by workers to ensure the expected high quality. Their findings must then be entered into a terminal that cannot be accessed from the actual inspection area. Even though this terminal already uses modern touchscreen technology, there are several drawbacks: Workers must leave their workplace to go to the terminal. This costs valuable production time and requires that workers shift their focus from their actual work. Furthermore, workers must remember the precise location of errors, which can lead to imprecise input, in particular in cases of multiple errors. Therefore, the BMW Group decided to apply the human-computer interaction technologies of the Fraunhofer IOSB to their quality assurance process to allow for a more direct control through intuitive gestures.

Result
The Fraunhofer IOSB develops technologies for SmartRooms – intelligent environments that perceive their interiors and react to people. The goal is to provide natural and intuitive ways of interacting with computers, for example through gestures. These technologies were applied to the use case of the BMW Group to improve the quality assurance process.

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The current system perceives both workers and bumpers in real-time. In particular, it recognizes gestures and relates them to the currently inspected bumper. If an error was found, workers can now simply point at them, in much the way they would when interacting with a colleague. The system recognizes and interprets these gestures and automatically records the pointed-at error locations in the quality assurance system. If no errors were found, a simple swipe gesture over the bumper documents it as error-free. This improves the quality of the documentation because workers can precisely point at the errors in front of them. It also saves time because workers are not required to leave their inspection area.

Project description
The system is based on the technologies developed in the SmartControlRoom at Fraunhofer IOSB. Two depth sensors placed near the ceiling view the whole inspection area from above. This ensures that the inspection process is not disrupted by additional hardware that is in the way of workers. The sensor data is then combined into a coherent 3D reconstruction and both workers and bumpers are detected (Figure 2). The bumper recognition is based on a CAD model and can be applied to arbitrary parts by simply changing the model. Gesture recognition gives information about the arms in 3D and gestures can be directly linked to the bumpers. This enables workers to simply mark error locations by pointing at them. To allow for a seamless integration into the existing quality assurance system ANABEL, our system was designed as a gesture device that acts as an additional input modality (Figure 3). Both the installation of the hardware and the integration into the existing system did not disrupt the current process, but smoothly blended into the existing environment.

A prototype system was installed in the BMW Plant Landshut for an evaluation period of two months. The reactions of the workers were positive as they saw a direct improvement of their work. In addition, they enjoyed the system, as gesture interaction can be much more pleasant and enjoyable than traditional interfaces.

1 Quality assurance process at BMW Plant Landshut.
2 3D reconstruction and gesture interaction.
3 Integration into the quality assurance system.

Customer
This project was commissioned by the BMW Plant Landshut.

Project execution
Two departments united their expertise for this project. Alexander Schick (IAD) implemented the vision-based gesture recognition and object tracking. Todor Dimitrov (ILT) integrated these modules into the quality assurance system of the BMW Group. Dr.-Ing. Olaf Sauer supported this project during all phases, from acquisition to completion.

Literature
The advent of the “Internet of Things and Services” in automation technology and industrial production has shifted the technological discussion towards the use of Internet technology in all its facets, ranging from Internet protocols, data description languages (for example XML in the form of AutomationML) to service-oriented architectures (SOA, probably in the form of OPC-UA) or lightweight Web services for online interaction with “smart” devices, such as sensors, actuators, or so-called cyber-physical systems (CPS) in general.

This trend – in Germany promoted by the Industrie 4.0 initiative – will also affect those functions that are commonly classified as Manufacturing Execution Systems (MES). The Fraunhofer IOSB production suite ProVis contains an MES core component, which provides monitoring and control functions for discrete manufacturing processes. This has been successfully deployed, operated and maintained for more than 25 years at the car and truck manufacturing plants of Daimler AG in Bremen and Wörth. It also monitors and controls soaking pit plants of ThyssenKrupp Steel Europe AG in Duisburg. Due to its architecture, based on an agent-based software platform, it is already well positioned to migrate towards the arising technological trends dominated by Internet technology.

The ProVis production suite

In its current version, the ProVis suite provides the following functions and classifies them according to their architectural position (see figure):

- **ProVis.Kernel**: The kernel provides functions to convert several input/output formats and protocols (Integra, OPC, OPC-UA, MMS, etc.) and to send manufacturing information about the current and next shift to the relevant manufacturing equipment. It also contains a dedicated engineering tool.
- **ProVis.Agent®**: This core component includes functions to monitor all production-relevant data in real time and to process and aggregate these data, for example to provide status information about production facilities and to generate shift-specific reports. All of these functions are driven by a flexible, configurable production time scheme.
- **ProVis.Visu®**: This is the visualization component for all production-relevant data and all inferred information. Visualization can be configured either manually with a graphical editor or using templates and an automatic data import mechanism such as AutomationML.
- **ProVis.Paula**: This component allows users to retrieve aggregated information through a highly-configurable, modular Web-based analysis and reporting tool. It can be used, for example, to efficiently calculate key performance indicators (KPIs) and to get a quick overview of current and estimated shift-specific piece numbers and related disturbances in the production process.
Emerging Trends

Following current market trends and customer needs additional requirements shall be fulfilled by MES:

- MES shall automatically support vertical integration to shop-floor level based on engineering principles, such as plug-and-produce.
- MES shall integrate universal engineering tools based on standard data exchange formats, such as AutomationML.
- MES shall be open and support horizontal integration of components and functions – possibly provided by multiple software vendors – through standardized interfaces.
- MES shall support various communication interfaces according to international and enterprise-specific standards.
- MES shall be scalable and enable decentralized self-organization of production systems.
- Information produced by MES shall be provided to users in tailored form through role-specific interfaces, including mobile devices and innovative gesture-based interaction.
- MES shall be connected to a Digital Factory Repository and shall rely upon its production plant information.
- MES shall integrate energy monitoring and energy management functions that are, on one hand, dedicated to the production site itself and on the other linked to the energy management systems of energy suppliers inside or outside the enterprise to pave the way towards Industrial Smart Grids.
- MES shall incorporate facility management services related to the production site building and infrastructure, for example to optimize the use of energy resources such as electricity, heat or compressed air.
- MES shall support simulation functions to allow its use as a production assistant.
- MES shall be enhanced with flexible resource scheduling functions as currently provided mainly by separate systems, such as ProVis.APS, the Advanced Planning and Scheduling Systems for Shop-Floor Production of Fraunhofer IOSB.

However, all of these additional functions will be used and accepted by automation and production technicians only if industrial core requirements such as security, robustness, reliability and real-time capability are guaranteed. An in-depth look at these requirements and trends quickly reveal that a “ProVis 4.0” that takes on board trends and paradigms of “Industrie 4.0” will comprise an open, scalable, secure, and flexible development and engineering platform and that this platform shall provide MES core functions as standard services. Furthermore, it shall support and leverage multi-vendor production systems-of-systems. Fraunhofer IOSB will perform this development work as an active partner in various standardization bodies (IEC, VDI, DIN).

References:

ProVis Production Suite:
http://www.iosb.fraunhofer.de/servlet/is/18359/

Industrie 4.0:
http://www.iosb.fraunhofer.de/servlet/is/24313/

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Literature

HIGHLY AVAILABLE COMMUNICATION

Seamless Redundancy solutions for networked technical systems

In the course of the fourth industrial revolution, production processes are increasingly automated. This means that machine modules and even individual devices are connected with each other and exchange data constantly. The aim is to develop intelligent factories, in which information about the current process, maintenance intervals for individual devices, and product status is available at any given time in addition to the usual process control. In short: The factory is to be completely transparent.

Due to the ever-increasing volume of data and network connectivity in technical systems the role of communication technology – which is responsible for smooth data transmission – has grown. The main requirements for data transmission in automation technology networks
consist of fast, reliable and time-synchronous communication. It is also important that no data is lost. Reliable cabling and topologies are essential. The most common solution is the ring topology, in which data is transmitted through two separate, independent lines, so that a transmission is guaranteed even if one line is damaged. In this type of ring topology, two data packets normally arrive at the recipient. These packets must undergo a redundancy check, which deletes duplicates. Redundancy mechanisms must be provided by the network at all levels of the factory – from the field level to the control center – to ensure the required uninterrupted process operation.

To provide a redundancy platform for highly available communication in Ethernet networks, which use various different topologies, two redundancy protocols have been defined in standard IEC 62439-3: PRP (PRP: Parallel Redundancy Protocol), and HSR (High Availability Seamless Redundancy). Several vendors have already brought solutions to market that are based on PRP or HSR. Research projects are now facing the challenge of developing a solution that can be used for both protocols. In a BMWi-funded project with Berlin-based company Yacoub Automation GmbH, IOSB INA has tackled this challenge. The aim was to create a redundancy solution that can be switched between standard Ethernet devices to integrate them into PRP/HSR networks. According to the requirements, IOSB INA has developed a RedBox (redundancy box) that can be integrated in an HSR network as well as a PRP network, or can connect networks of both types with each other. With this solution users can use the RedBox flexibly according to their requirements. These protocols were implemented on an FPGA platform. The time-critical parts of the implementation have been realized completely in hardware. To avoid the usual costs for the implementation of a network component with the described functionality, a low-cost FPGA variant (Altera Cyclone IV) was combined with a high-performance switch ASIC (Marvell FireFox). These two components are linked through an MII interface and provide four ports for connecting end nodes. In measurements on sample configurations (PROFINET controllers and devices, Meinberg master clock, etc.) interoperability with other manufacturers’ RedBoxes and support for time synchronization standard IEEE 1588 could be identified.

To further develop the solution and gain a market advantage, IOSB INA and Yacoub Automation GmbH have decided to initiate a follow-up project, the aim of which is to make the RedBox useable in hazardous areas. This adds several new requirements for the hardware: A RedBox for hazardous areas must be optimized to ensure a very high level of safety, which should be maintained even in the rare event of a malfunction. It must not ignite even if several technical faults occur in the device at the same time. Furthermore, its energy usage must be optimized to meet the stringent requirements for approval for use in hazardous areas. By complying with current safety standards for explosion-protected areas, the solution of IOSB INA can be used in many other industries and application scenarios.

Literature
modeling, and systems analysis to knowledge-based process optimization with a wide range of methods and sophisticated algorithms. An example for this is the energy market solution EMS-EDM PROPHET® that supports utility companies and system operators with varied and complex tasks in a liberalized market environment. In the fields of water management as well as environmental information and early-warning systems our business unit offers customized ICT applications for the private and public sectors. The objective is to provide integrated solutions that are flexible and can also adapt to individual constraints, such as those of service oriented architectures (SOA) and standard interfaces of the “Internet of Things and Services”. Beside the close collaboration with industry, the business unit sees itself as a technology driver for future topics of intelligent energy systems and Integrated Water Resources Management (IWRM) in numerous national and international research projects.

Markets

The target groups of the business unit Energy, Water and Environment range from utility companies through communal water suppliers to governmental institutions, with a current focus on the German and European market. This business unit draws on international research projects and projects with industrial partners in Portugal, China, Mongolia and Turkey, as well as on European research projects in the fields of environmental risk management, early warning systems and environmental monitoring. In the medium term the importance of international markets for this business unit will grow. Impulses are expected not only from Asia and the Middle East, but also from the USA, where a contract for the optimization of the hydropower plants at the Columbia River was acquired from Bonneville Power Administration (BPA) in 2012.

The market of innovative environmental information systems is served by the product suite WaterFrame®, which is installed in many German federal states (Länder) for communal and governmental use. WaterFrame® is being extended according
to customer needs to support standards of the Open Geospatial Consortium (OGC) compliant with the requirements of European spatial data infrastructures (INSPIRE). It is complemented by WebGenesis® for knowledge- and Web-based information systems.

The business unit’s portfolio is complemented by its know-how in the field of maritime system technology, which is specialized in the guidance of underwater vehicles for automated inspection of underwater infrastructures and for water quality monitoring.

Laboratory and test facilities

ICT Energy Lab: energy and energy data management, virtual power plants, operational management of island and area networks
Intelligent energy systems research platform: micro grids, operational management strategies, storage management, automated metering, intelligent distribution networks, electric mobility
Maritime systems research platform: 250 m³ water volume, lorry access capability, energy and data interface, rail system for object placement
Environment sensor network INSENSUM: air, ground and water monitoring, open interfaces as well as mobile applications according to the Sensor Web Enablement (SWE) initiative of the Open Geospatial Consortium (OGC)

Product highlights

• EMS-EDM PROPHET® – energy and energy data management
• HydroDyn – network simulation solution for water and gas
• WaterDemand – water supply forecasting
• WebGenesis® / WaterFrame® – environmental information system for government agencies (environmental portal, specialized information offers, information systems for ground water, surface water and drinking water)
• Thematic information system for the Integrated Rhine Program

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• natGAS AG
• Nanjing Hydraulic research Institute
• Spacebel, Belgium
• Stadtwerke Bielefeld GmbH
• Stadtwerke Marburg GmbH
• SWE Energy GmbH & SWE grid GmbH
• TenneT TSO GmbH
• The German Federal Institute of Hydrology (BfG)
INTELLIGENT DISTRIBUTION GRID & ENERGY STORAGE: SmartRegion Pellworm

The policy objectives of the energy transition in Germany are very ambitious: thus, 80 percent of the electricity power needs by 2050 should come from renewable energy sources. The North Sea island Pellworm already reached this value and is therefore a suitable place as a pilot region for a power system with energy storages and an extremely high proportion of distributed power generation from biomass, photovoltaics and wind. All these components need a sophisticated control and management system connecting distributed generation, energy storages and a flexible demand. In addition, cross-disciplinary topics such as heat generation can continue to play an important role.

Goals

The project “SmartRegion Pellworm”, sponsored by the BMU and BMWi, is one of the projects of the lighthouse “battery storage in distribution grids” of the funding initiative “energy storage” of the federal government and includes as a central element the building up and operation of such a smart grid. Hybrid storage is used to map the different fields of application of storage systems. In addition to two stationary storage facilities with different technologies (li-ion battery and redox-flow battery) there are also unidirectional storage systems, e.g. electric storage stoves, heat pumps, and the biogas plant on the island.

Within the framework of this project comprehensive analysis of present and future business models of hybrid storage systems are performed for market, grid and local supply.

The experience gained during realization and operation should feed into the analysis of transferability of the Pellworm approach to other distribution grids and the investigation of business models.

Realization

The task of Fraunhofer IOSB Advanced System Technology (AST) includes the question of the optimal operational management of hybrid storage systems for various use cases. Therefore an extensive analysis of measurement data of the energy system is being conducted, and all relevant electric and thermic components are being modelled and integrated in optimization models of the particular operational management strategies.
Based on examined business models all objective functions of the relative operational management will be created. Thereby, both financial and technical restrictions of the energy system must be regarded, including data from customers and feed-in, current grid condition and also exogenous influences, such as meteorological data and different special conditions, such as feed-in management. A special challenge is the combination of different, partly opposing objective functions for operational management. Mapping of various chronological levels of operational management is possible because of a multi-stage optimization approach.

The core of the operational management solution is the energy management system EMS-EDM PROPHET®. Here the implementation of the operational management strategies in the form of optimization models takes place. During the startup phase the basic functions of the operational management solution are tested. These functions build the basis for the complex operational management strategies in the demonstration phase.

**Evaluation**

Evaluation of various relevant parameters of the energy system, with and without being actively influenced by the different operational management strategies, provides an essential statement of functionality of the operational management strategy. Through different scenarios the operational management was evaluated using quality factors. The presentation of all proportionate influences of the requirements of the business models and the specifications of the grid management attracts special attention during the analysis. Another main focus of the analysis will be the detailed view on the behavior of the complete system in special situations.

**Literature**


Research objectives
The German-Chinese research project HAPPI (Small Hydropower Plants: Assessment of Climate Protection Potential and Improvement by Smart Technologies) aims to develop an evaluation method for planning, construction, and operation of small hydropower plants, focusing on at least three main aspects: first, ecological effects, such as the protection of climate, nature and water, i.e. impacts on flora and fauna, landscape and watercourses, and land use; second, economical effects, such as cost-efficiency, network infrastructure and proximity to customers, realization periods, and location and constructional optimization; and – last but not least – social effects, such as improved infrastructure, employment, influence on the development potential of rural settlement, poverty reduction and resettlement.

Work packages
Together with six partners, three of which are small and medium-sized enterprises (SMEs), Fraunhofer IOSB defined 15 working packages to achieve the following research objectives: environmental sustainability analysis (1), climatic sustainability analysis (2), socio-economical

sustainability analysis (3), hydrological modeling and CO₂ balancing (4), hydraulic system and location optimization (5), geotechnology and structural hydraulic engineering (6), control and management strategies (7), energy management strategies (8), financing strategies and operator models (9), monitoring system (10), integrated planning guide (11), automatic cascade operation (12), ex post evaluation of the sustainability aspects (13), feasibility evaluation (14), and participation processes and capacity building (15).

Perspectives
In addition to tapping the ecological benefits and optimize the use of the unexploited energy potential of hydropower – especially in China – HAPPI aims to achieve economic benefits through know-how-transfer, patents and the export of engineering services and facility delivery. Goals of the project are the development and application of new policies for small hydro power plants with a focus on socio-economic and ecological sustainability and taking into account climate change and land use. Further aims include the development of advanced planning guidelines for hydroelectric power plants (selected optimal power plant sites, civil engineering and hydraulic optimization, support with obtaining regulatory approval), a new application of control and energy management strategies for small hydro power plants (individually and in coordination) and the integration of small hydropower plants in regional and national power distribution grids. Processing the results will therefore focus on the following goals:

- Employment of models for location evaluation and design of energy-optimized hydropower plants from a hydrologic, hydraulic, ecological and economic perspective
- Coordinated control of SHP and integration into the power grid
- Application of dimensioning processes for an optimized structural design of hydroelectric installations in largely modular architecture
- Implementation of ecological design concepts at for dams, hydraulic conduits and the application of fish-friendly power plant technology on inland waterways
- Training in the use of the developed quality management tools and assurance of health protection and occupational safety at the construction site
- Consulting services for developing marketable company structures for the operation and cost-effectiveness of utility companies
- Development and application of financing and operator models tailored to the legal and social circumstances in China.

Project description
Name: Small Hydropower Plants: Assessment of Climate Protection Potential and Improvement by Smart Technologies; Work packages: project management (consortium manager), controlling and management strategies, energy management strategies, automatic cascade operation
Life span: 01.02.2013 – 31.01.2016, Tags: Small Hydropower Plants, China, automatic cascade operation, energy management strategies, multiple criteria optimization

1. Oldest small hydro power plant in China with German technology from the 1920s.
2. HAPPI model regions in China (red and blue dots).

Partners
Advanced System Technology (AST) Branch of Fraunhofer IOSB,
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Literature
TRIDEC – EARLY WARNING SYSTEMS ARCHITECTURE

Tsunamis wreak havoc and cause enormous economic damage with a high loss of lives in coastal regions. To be effective a tsunami early warning system must be able to acquire and react to sensor signals within few minutes. Existing warning systems require extensive software engineering to incorporate new sensors and data sources as well as models to compute the likely propagation of the tsunami.

What issues are to be solved

The integrated EU FP7 project TRIDEC focused on new approaches and technologies for intelligent geo-information management in collaborative, complex and critical decision processes in earth management. The key objective was to develop a software architecture for a tsunami early warning system to equip existing and future Tsunami Warning Centers around the Mediterranean Sea. The TRIDEC architecture had to facilitate the integration of new sensors and models, and to support real-time processing of data streams. The typical data sources not only include sensors on land and sea, but also unconventional sensors, such as streams of tweets with eyewitness accounts. The early warning systems have to integrate data sources from multiple nations of the Mediterranean region and be customizable for decision-makers with local or specific emergency plans and defined warning dissemination processes. At the same time scientists need to be able to improve the underlying rules, models and computations without relying on extensive help from IT experts.

Description of the solution

All components of the TRIDEC architecture were conceived, designed and implemented to be suited to integrate a multitude of heterogeneous services and software tools, data and information sources. From the domain experts’ point of view this means that they can leverage all relevant information in order to provide adequate and timely support to decision-makers.

Description of methods and processes

The main objective of TRIDEC presented a number of challenges, such as the task of examining, adopting and adapting a large number of state-of-the-art systems and components as well as contributing to a diversity of emerging innovative ICT technologies. Some challenges concerned the integration of existing warning systems (system-of-systems architecture) and the design of a scalable and resilient communication infrastructure based on a message-oriented middleware (MOM). Another set of challenges was concerned with the management of large and dynamically increasing volumes of data and information as well as data fusion processes and

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the management of metadata on different semantic levels. Further effort went into the design and implementation of Decision Support Services, including an ontology based on the SSN Ontology of OGC and W3C, federated Semantic Registries for registering (over MOM) metadata about crisis-relevant objects, a workflow and rule engine, a rule editor for Decision Tables, and a number of standards-based interfaces for connecting all these different components.

Further IOSB projects on Early Warning Systems

EO2HEAVEN (Earth Observation and Environmental modeling for the mitigation of HEAlth risks) was co-funded by the European Commission under FP7, Grant Agreement 244100. IOSB led the work on the architecture of a Spatial Information Infrastructure, which formed the basis for warning systems in the area of environmental impact on health. Case studies investigated the effects of air pollution in Saxony and Durban and the risk of cholera outbreaks in Uganda. See www.eo2heaven.org.

INCA (Integrated Nowcasting through Comprehensive Analysis) was co-funded by the European Commission with the InterReg IVb Programm. IOSB developed an early landslide detection and warning system (ELDEWAS) that incorporates dynamic nowcasting data and merges them with static geological data for certain regions (for Burgenland in Austria for instance) in order to gain short-term predictions for the danger of landslide events. See www.iosb.fraunhofer.de/?40945

Figures and technical data

TRIDEC (Collaborative, Complex and Critical Decision-Support in Evolving Crises)
Coordinator: Geoforschungszentrum Potsdam
Duration: 9/2010-10/2013
Budget: ≈ 8.9 million €

Principal/partner
TRIDEC was co-funded by the European Commission under FP7 (Seventh Framework Programme), Grant Agreement 258723

Project execution
Dipl.-Inform. Ulrich Bügel
Dr.-Ing. Siegbert Kunz
Dipl.-Inform. Jürgen Moßgraber
Dipl.-Inform. Felix Riedel
Dipl.-Inform. Manfred Schenk
Dr. Kym Watson
Dr. Andrea Zielinski

Literature

assurance and/or increasing productivity in real time that come into play when “seeing” is the solution of choice. “Seeing” in this context refers not only to what the human eye is capable of, but also includes the entire electromagnetic spectrum from UV to IR as encountered in the natural and technical world. The technical solutions offered cover a broad service portfolio, ranging from feasibility studies to process developments, practical validation up to and including demonstrators and productive systems that can be used at the customer’s site.

Markets

“Seeing” relevant information forms the basis for our solutions. In a technical respect, this generally comprises image acquisition using line scan or area array cameras and image analysis in real time. Whether the task is to rapidly monitor a large number of moving parts while sorting bulk goods (in order to separate desirable parts from undesirable ones), detect changes in the reflective properties or the texture of a surface (which are indicative of product defects or process defects) or classify objects or object groups (to detect divergences from specifications), we are able to offer tailored solutions to our partners and customers.

Whenever the task is to “sort” large quantities of parts (e.g. bulk goods) in the material flow and in real time or verifying the compliance of complex individual parts with specifications – whether in terms of color, shape or other “visible” properties – our solutions are put into practice. The solutions we develop are used in recycling glass or enriching minerals to the same extent that they are used in sorting tea, coffee and other foods.
In the field of surface inspection, we not only detect changes in the structure, but also convert sensor data using photometric stereo or deflectometry into 3D data in order to reach conclusions relating to part topography. These methods are used to evaluate both glossy and mat surfaces. Sometimes “taking a look inside parts” or simply “seeing through them” is helpful when it comes to recognizing constituents or divergences. If light can be used to make them visible or the materials being searched for have specific reflective properties, we find them. We also offer solutions for special problems such as “seeing” vibrations from far away, “seeing” in an adverse environment (e.g. in deep-sea environments) or recognizing objects for identification purposes.

**Equipment, lab and test facilities**

- Sliding tables with a variety of lighting facilities for image acquisition
- Experimental systems for sorting bulk goods (each equipped with a camera and blow-out unit) in various configurations as a belt sorter, channel sorter, sorter with chute and free-fall sorting
- Measurement stations for inspecting surfaces, e.g. photometric stereo or deflectometry
- Measuring devices for 3D inspection
- Test systems for transparent materials
- Multispectral workbench
- Lab equipment for characterizing materials
- Microscopic image acquisition stations
- Test lab with lighting technology
- Fully-automatic BRDF measuring station
- Experimental systems for underwater inspection

**References / product highlights**

- **Binder+Co AG**: Systems for sorting recycling glass; recognizes heat-resistant glass containing lead
- **SALUS Haus GmbH & Co. KG**: Systems for sorting tea and herbs; color, size and debris sorting
- **PETKUS Technologie GmbH**: Sorting of seed
- **Uhlmann GmbH**: Blister inspection
- **GREIWING logistics for you GmbH**: Sorting system for plastic granulates
- **Zwiesel Kristallglas AG**: Inspection of glass lenses for occlusions and air bubbles
- **Eti Maden General Directorate**: System for sorting materials (colemanite)
- **De Beers UK Limited**: Systems for finding diamonds
MicroLab

Microscopic inspection systems are getting more and more important in assuring quality of industrially produced goods. With its newly built up microscopy laboratory (MicroLab) Fraunhofer IOSB is taking a new approach. Various microscopes are combined with standard automation components, such as robots, positioning stages and illumination components, to realize automatic industrial inspection. MicroLab is equipped with versatile optical microscopes which provide a wide range of sensors for combined usage. Currently MicroLab contains a macroscopic device with different illumination components, a research microscope with UV illumination, a white-light interferometer and a 3D reconstructing autofocus system, which also can be used for roughness measurements.

Automation
The key role in automation in MicroLab is played by a six-axis industrial robot. The robot, which is connected to a central control unit that interacts with additional sensors, places various specimen onto the microscopic devices in an exactly defined position. The inspection system therefore exactly knows about the overall condition of a currently running inspection process. It can intelligently influence this running process to optimize throughput, for example using all inspection devices in parallel. It can also prioritize specific specimen, giving it a decisive advantage over industrial assembly lines, which can handle goods only sequentially.

General applications
MicroLab deliberately uses standard industrial automation components. These can be combined at will to realize customer-driven inspection systems for visual inspection and quality assurance analysis. The different sensor components with their diverse properties can be used to examine the properties of a large number of different specimens, such as completeness of electronic components or roughness of iron, steel or other industrially produced materials. The combination of multiple microscopes brings inspection tasks to a new level, allowing specimens to be inspected by multiple sensors with a range of characteristics within one automation process. The gathered information can then be used as input for multi-sensor fusion. To provide a clearer idea of microscopic dimensions, figure 2 illustrates these using a real-life example. Inspection of a technical sample can be seen in figure 3.

The microscopic devices are further used to acquire ground truth information. This is extremely important when constructing new sensor components in order to back up the measurement results. Another reason our customers like the MicroLab concept is its modular construction. It is quite easy to integrate components of MicroLab into existing quality assurance systems. The long-term knowledge of IOSB in the field of image processing is of high value in the context of...
MicroLab. Established methods of image processing, ranging from image fusion to photometric stereo, are transferred to the microscopic dimensions. The integration of such established methods is the basis of providing modular microscopic inspection systems for industrial purposes.

**MicroLab in research and education**

MicroLab, with its multiple sensors, delivers great possibilities for research and education. Over the past year several research projects were conducted with the help of MicroLab equipment. One highlight was the implementation of a novel approach for instrumenting a microscope with gaze-based interaction.

Finding important regions and focal planes within a microscopic process can be seen as a visual search task. Our research combined advanced image processing algorithms – highly encapsulated and easy to use – with a state-of-the-art human-machine interface to realize the operators' tasks, such as focusing, image analysis, and synthetic image enhancement driven by gaze-based interaction. Figures 4 and 5 show the installation together with the developed graphical user interface.

As the depth of field becomes quite small at higher levels of magnification it is important to compute a synthetically enhanced image that has all visually selected focal planes in focus at once. To achieve this, the software creates a depth map in the background which, together with the recorded image series, provides the input for the image fusion algorithm. Figure 6 gives an overview of the overall fusion.

**Outlook and future**

Although conceived only recently, MicroLab has already established itself as a contact point for a wide range of applications. Within the last year it was used to measure a variety of technical surfaces, such as CMOS sensors. It was also used to gain detailed reflectance information to better understand properties of industrial materials and to reconstruct bidirectional reflectance distribution functions (BRDF). Furthermore, the automation component has been integrated into the overall system, and methods of interaction with microscope devices have been developed and implemented. MicroLab will be presented at CeBIT 2014.
GRAPESORT – OPTICAL SORTING OF GRAPES TO IMPROVE QUALITY AND THE REMOVAL OF FOREIGN OBJECTS

Drinking and enjoying a glass of wine is usually taken for granted. For a winemaker, it is by no means a matter of course to produce quality wine, considering climate change and the variability of weather. Recently, differences in grape ripeness of up to 40 degree Oechsle (°Oe) have been recorded on a single grape vine. This presents a challenge: Grape harvesting is becoming increasingly automated, and although improved continuously, the machines used cannot assess grape quality in the way that a human harvester can. Selection of machine-harvested grapes by their degree of ripeness has therefore become an issue, together with the separation of foreign objects, which have a negative influence on the wine’s flavor.

Task
Grape sorting machines from a handful of companies have already been on the market for a few years. These are able to remove foreign objects, such as leaves, stems, and bugs. Some are also able to detect botrytis – a mold that affects both white and red grapes. These machines have not established themselves in the wine community because their sorting quality, software and hardware operation, and cleaning procedures do not meet wine makers’ requirements.

Due to these drawbacks we applied for a ZIM (The Central Innovation Program – Zentrales Innovationsprogramm Mittelstand) research project of the BMWI (Federal Ministry of Economics and Technology – Bundesministerium für Wirtschaft und Technologie).

IOSB’s tasks in the research project are:
- Analyzing grapes using hyperspectral imaging in the wave band of 400 to 2500 nm
- Implementing results of the analysis in the sorting machine
- Sorting grapes by different ripeness parameters, such as degree Oechsle, acidity, and nitrogen content
- Removal of foreign objects, such as bugs, stems, wire fragments, leaves, and wood
- User-friendly graphical user interface

IOSB’s project partners focus on:
- Definition of sorting criteria and preparation of grapes for sorting tests
- Laboratory analysis of the grapes
- Wine-making from the sorted grapes, and wine tasting
- Improvement of air-based sorting unit, and reduction of air consumption
- Improvement of material transport
- Hygienic design

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Description of project status quo

Grapes of types Pinot Noir, Pinot Blanc, and Riesling have been used during the harvest season of 2012 to acquire short-wave infrared (SWIR) hyperspectral image data and red-green-blue (RGB) images. Hyperspectral image data yield a full spectrum within the SWIR band for each pixel, i.e. from 1000 to 2500 nm. Following preprocessing the data was analyzed using multivariate data analysis. The aim was to correlate the hyperspectral data with the laboratory data provided by the project’s wine experts, Hochschule Geisenheim. Based on the analysis, characteristics were selected for use in classification. To achieve good classification results during the 2013 harvest season, the software was adapted and the sensor hardware was matched to the task. The resulting hardware consisted of two line scan cameras that were used in parallel: one sensitive in the visible range, the other in the infrared range. The latter was equipped with a special filter. In addition the incident light was extended into the visible range to correspond with the measured wave band.

In preparation for the experiments in October 2013, the software was extended with a function for recording sorting results and to offer several possibilities of teaching it the different grape qualities, especially using only the visible spectral range or a mixture of visible and infrared spectrum.

In October 2013 many experiments on both red and white grapes to detect foreign objects, mold, and ripeness degree were performed with the adapted sorter prototype at Hochschule Geisenheim University (see Figure 2). In addition, a large corpus of hyperspectral data in the range from 400 to 2500 nm was acquired for further analysis with the aim of improving the sorting system that will be used in the next harvest season in 2014.

Intermediate results

We achieved very good results in the removal of foreign objects and botrytis-afflicted grapes, both red and white. Regarding quality parameters such as degree of ripeness a classification was possible but the degree of discrimination has yet to be improved.

Funding

This project was financed by The Central Innovation Program (Zentrales Innovationsprogramm Mittelstand) research project of the Federal Ministry of Economics and Technology (Bundesministerium für Wirtschaft und Technologie).

Partners

The application for the ZIM research project was submitted in cooperation with Hochschule Geisenheim University and two industrial partners: ARMBRUSTER Kelterei-Technologie GmbH and Ingenieurbüro Waidelich.

Project execution


Literature


CCT SENSOR – TOWARDS HIGH-SPEED 3D SENSING

Microscopic 3D sensing is an established tool in quality control. However, there is still a lack of inline-capable measuring devices. Due to speed limitations most of the available 3D sensors are for laboratory use only. One type of 3D sensor, which uses the chromatic confocal principle, is already available as high-speed version with more than 50,000 measurements per second. However, it is a point sensor which requires a 2D scan to cover an object surface. The step from point to line scan sensor is technically challenging, especially if the measurement speed should remain the same. Within this project a multispectral camera approach was developed, which has the potential of enabling cutting-edge measuring speeds. Thus, the chromatic confocal triangulation (CCT) sensor is well suited for inline applications.

Task
The technical problem in a nutshell: The chromatic confocal principle for 3D measurements encodes different surface heights by unique wavelengths. The optics of chromatic sensors split up a white light source into its monochromatic wavelengths. Additionally, each wavelength is focused at a different distance from the sensor. If an object surface is located within the measurement range, a single wavelength is focused while the others are out of focus. The measurement itself is carried out by spectral analysis of the reflected light using a spectrometer. The reflected light spectrum shows a characteristic peak at the wavelength that is currently focused. Due to the confocal optics, wavelengths which are out of focus are blocked. The 3D information is obtained by mapping the peak wavelength to the corresponding height value.

A technical problem arises by changing over from a point sensor to a line scan sensor. Each measuring spot requires its own spectrometer and this causes a huge gain in data traffic. Typically, a spectrometer necessary for a point sensor consists of 1000 pixels. A line scan sensor with 2000 measurement spots causes data traffic of two million pixels per measurement (2000 pixel per spot times 1000 pixel per spectrometer). This amount of data causes a bottleneck and significantly slows down the measurement speed. The way to enable high-speed measurements is to avoid high data traffic.

Results
At the Fraunhofer IOSB a solution has been developed by replacing the spectrometer with a multispectral camera. Compared with an ordinary RGB color camera, a multispectral camera consisting of more than three spectral channels equipped with customized filters. The task of the spectrometer within the chromatic sensor principle is to measure the wavelength of monochromatic light. The developed multispectral camera uses six optimized interference
filters for this task. At the CONTROL 2013 fair an implementation of the camera with a filter wheel was demonstrated. With six filters the number of pixels per measurement drops from two million down to twelve thousand, using the same numbers as in the previous example.

The purpose of this multispectral camera is to speed up chromatic confocal line scan sensors. A new optical sensor design was developed, which is optimized for 3D line scan sensing. This chromatic confocal triangulation (CCT) sensor, in combination with the developed multispectral camera shows promising results. With this concept microscopic high-speed 3D sensing becomes feasible.

Project description
To realize a multispectral camera with custom transmission characteristics the technology of interference filters was used. The spectral transmission characteristic of interference filters can be controlled by adjusting layer thicknesses. Each filter consists of a stack of thin films with alternating high and low refractive index. Based on a physical model of the 3D measurement system the filters of the multispectral camera were optimized by finding the best-suited thin film filter stacks. In cooperation with the Fraunhofer Institute for Surface Engineering and Thin Films IST the filters were manufactured and mounted on a filter wheel. Additionally, CCT sensor optics were set up to proof the concept for 3D sensing. Current research focuses on shrinking the filters to pixel size to avoid the slow filter wheel. With these competences the Fraunhofer IOSB will have the ability to set up a 3D sensor with cutting-edge measurement speed. According to the state of the art in camera technology a microscopic 3D sensor with more than 50,000 measurement lines per second becomes feasible. Typically, a measurement line consists of 2000 adjacent measurement spots.

Project execution
Dipl.-Ing. Miro Taphanel, Prof. Dr.-Ing. Thomas Längle

Literature
DIRECTIONAL REFLECTANCE MEASUREMENTS WITH A ROBOT-BASED GONIOMETER

Optical reflections on surfaces are of great interest for a wide range of applications. There are many technical and scientific examples of the use of reflections. Automated imaging-based inspection and machine vision systems can find defects or conspicuous features, for example by detecting change of optical reflectance compared to fault-free work pieces. Because the human eye is very sensitive, slight changes in reflection from optical paints and coatings are readily spotted by customers. Remote sensing needs detailed knowledge of the reflectance of natural materials for a meaningful examination of hyperspectral satellite data. Furthermore, computer science uses surface reflectance models to design realistic 3D scenes.

The magnitude of optical reflection from surfaces of opaque and transparent objects is influenced by the surface material’s optical properties and actual geometrical structure (roughness and granularity). Absolutely flat surfaces reflect light directionally, like a mirror, whereas mat surfaces scatter light into all directions. Real surfaces reflect the incident light more or less around the ideal reflection direction. The form of this reflection lobe depends to a large extent on the light’s incident angle, but also – because of dispersion – on its wavelength.

Task

Reflections on surfaces are characterized with the help of the Bidirectional Reflectance Distribution Function (BRDF), which describes the amount of reflected light in each direction as a function of the incident angle and wavelength of the light. The measurement of the BRDF characteristics with high spatial and spectral resolution presents a major challenge. This task is best performed with an automated setup to achieve the necessary precision and reproducibility. Some national institutes of metrology, such as the Physikalisch-Technischen Bundesanstalt (PTB) in Brunswick have constructed such a setup and use it for highly accurate BRDF measurements of reference standards. Other setups are available in other institutions (e.g. ONERA, Toulouse) or can be bought from commercial companies (e.g. surface optics, USA). All setups are optimized for special purposes and have some limitations in certain cases, i.e. in their spectral range, measurement spot diameter or sample type. Commissioned by the Wehrtechnische Dienststelle 52 and with financial support from the German MOD a robot-based BRDF goniometer was developed and built at the IOSB to perform measurements in the visible and infrared spectral range. The lighting unit was designed such as to be able to also measure the retro reflex signal from the sample.
Optical setup

With the goniometer at the IOSB the BRDF of samples can be measured automatically. The setup consists of two main parts: an industrial robot from KUKA, mounted headfirst on a framework and a height-adjustable turntable directly under the hanging robot. A movable mechanical semi-circular guide rail integrated in the table carries the lighting unit. The angle of the semi-circular guide rail is controlled by the robot to obtain the required incident angles between 0° and 90°.

The sample is fixed on the turntable, which is also controlled by the robot. All incident azimuth angles can be realized by turning the table, on which samples of different sizes and thicknesses can be mounted. Because the sample is in a horizontal position, bulk solids and liquids can also be measured.

At the end of the robot arm an optical sensor (e.g. a photo diode or camera) is mounted to detect the reflected light. During the measurement the robot moves the sensor around the sample along a hemispherical plane such that the sensor traverses all required reflection angles. At each measurement position the robot stops and reflection data are collected. Because the correct mechanical adjustment of all components is indispensable to guarantee accurate measurement values, the robot was calibrated absolute mechanically to reach a repeat positional accuracy of 0.1 mm.

The complete measurement procedure is controlled by two PCs. One of these controls the movements of the robot, the turntable and the semi-circular guide rail; the other controls the lighting unit and the sensor and handles the measurement data. All angles, changes and adaptations of the measurement procedure can be realized easily with parameterized software.

The illuminating light source is a thermal emitter (e.g. a halogen lamp). Alternatively, lasers with different wavelengths can be used. Calibration is done with the help of reference standards such as a Spectralon plate.

Results

With this goniometer setup BRDF measurements in the visible and near-infra-red (NIR) spectral range have been successfully performed. The reflectance distribution of highly reflecting, glossy and mat samples has been measured and characterized precisely.

To visualize the optical material properties measurement results can be presented in different ways: BRDF and reflection lobe in 2D or 3D.

Project execution
Dipl.-Ing. (FH) Michael Kremer,
Dipl.-Inform. Dipl.-Ing. (BA) Martina Richter,
Dr.-Ing. Dipl.-Phys. Alexander Schwarz

1 BRDF goniometer with robot, turntable and sample.
2 Spatial reflectance distribution of a sample.
3 Roof of a car.
THERMAL INFRARED DEFLECTOMETRY

New insights into specular surfaces

Deflectometry is a reliable method of contact-free, optical measurement of a surface shape. It provides highly accurate surface slope information, which is the measurement parameter that most closely resembles the human perception of specular surfaces and, as such, enables an objective evaluation.

A simple deflectometric sensor can be assembled with off-the-shelf components. It consists of a monitor, which displays a series of code patterns, and a camera that observes the reflection of these patterns in the test surface. The visible distortion of these patterns characterizes the shape of the surface. As a consequence of this working principle, the conventional deflectometry is limited to specular surfaces such as mirrors, polished surfaces, or glossy coatings, which exhibit a reflection primarily in the visible light spectrum.

One way to partially overcome this restriction is to use longer wavelengths, since the optical properties of materials are usually wavelength-dependent. The long-wave infrared (LWIR) spectrum in particular has beneficial properties for deflectometry, notably a higher reflectivity of most surfaces. This effect is especially pronounced with metals and enables the deflectometric inspection of raw metal or machined metal parts. In visible light unpolished metals usually exhibit a dull reflection, which blurs the image, whereas in the LWIR spectrum they display near mirror-like reflectivity.

Other materials that benefit from the change of spectrum are transparent materials such as glass or several plastics [2]. In the visible spectrum interference effects, such as multiple inner reflections or a visible background behind the translucent object, prohibit an undisturbed deflectometric measurement. In the LWIR spectrum, however, many of these materials appear opaque so that the predominant primary reflection allows for a deflectometric measurement of the surface. While cameras for this spectrum are readily available, the suitable technology for creating the necessary code patterns is not.

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The Variable Image Acquisition and Processing (VBV) Research Group of the Fraunhofer IOSB in cooperation with the Vision and Fusion Lab (IES) at the Karlsruhe Institute for Technology (KIT) is developing such methods of pattern generation that are necessary for deflectometry in the LWIR spectrum. The developed methods range from static patterns and arrays of thermal elements to spatial and temporal variable patterns generated with laser light [1]. The novel pattern-generation techniques necessitate the adaptation of the coding methods from the visible to the thermal infrared spectrum. Promising results have been achieved by using a powerful laser to generate large-scale, dynamic patterns. The laser creates heat patterns on a projection surface, which then serves as the pattern display for the deflectometric code sequence (Fig. 1). This setup allows for the deflectometric inspection of raw metal surfaces, which are difficult to handle with optical inspection methods in the visible light [3].

Current research focuses on the use of static patterns, which represent a simple way of code pattern generation but require a more sophisticated evaluation of the data. In addition, an adaptation of the methods and algorithms for the evaluation and 3D reconstruction of deflectometric data developed at the Fraunhofer IOSB for the LWIR spectrum is required. With a complete processing chain for the acquisition and evaluation of deflectometric data in the thermal infrared spectrum, the deflectometry can be extended to a whole range of new surface materials. Its ability of inspecting raw metal surfaces enables its application in earlier stages of a manufacturing process and can save costs due to an earlier detection of defects before further processing.

Literature


The IOSB’s core competency lies in research into optronic systems for human and computer vision, real-time processing and analysis of imagery, and full-motion video as well as the necessary information and communication technology for the use of images in network-enabled operations.

Of special significance for the German armed forces is our research and technology work in the following areas:

- Design, evaluation and protection of existing and future optical and optronic sensor systems: daylight and night vision, hyperspectral sensing, laser-based sensors and protection against laser threats.
- Warning sensors, propagation of light through the atmosphere, signatorics for reconnaissance and protection, concepts for and evaluation of camouflage, concealment and deception.
- Network-enabled interoperable real-time processing and analysis of imagery for purposes ranging from wide-area imaging reconnaissance to target detection in weapon platforms, including human-system-integration.
- Computer assisted object and situation recognition and image-based methods for object tracking and target handoff.
- System architectures for networked simulation and generation of terrain and building models for simulator-based training.

The research and technology activity of business unit Defence is carried out in three tiers:

- To support the ability of the German ministry of defence (GMOD) and its subordinate authorities for analysis and evaluation of defence-related technologies the IOSB conducts basic research that is funded by the GMOD in the long term.
- Based on this research the institute conducts technology projects of the GMOD with a medium-term horizon and specific objectives.
Finally projects with the defence industry lead to solutions for the forces. These projects are carried out in close coordination with the GMOD to ensure the independent role of the IOSB as consulting entity for the government.

International cooperations based either on bilateral agreements, with contracts from the European Defence Agency (EDA), or common research activities in the context of NATO’s Science & Technology Organization (NATO STO) are continuously flanking our national defence research work.

To the extent that military security classification does not prevent this, the R&T in business unit Defence is incorporated into the IOSB’s applied research for civil purposes performed by the other four units in order to achieve the highest benefit for all application areas.

Equipment, and lab and test facilities

- Environment simulation (e.g. for camouflage assessment)
- Adaptive optics
- Bidirectional reflectance analysis of materials
- Airborne platform for imaging radiometrics (AirSIG)
- Observer performance evaluation
- Assessment of visual and infrared imaging systems
- Optronic countermeasures
- Femtosecond laser lab
- Human-computer interaction for image analysis (eye gaze, gesture)
- Testbed for network-enabled imaging reconnaissance
- Federation of simulators
- Distributed Network Battelab (DNBL)
- SAR simulation (CohRaS®: Coherent Ray-tracing based SAR-Simulator)
- Reconnaissance and surveillance with mobile sensor swarms
- Serious gaming for image analysis training
- Airborne multisensor platform (VIS, LWIR and hyperspectral)

Reference solutions

- ABUL – Full-motion video exploitation system for reconnaissance and surveillance (air, land, and sea)
- RecceMan®: Interactive recognition assistance for aerial and satellite imagery reconnaissance
- iZexrep for reporting in image-based reconnaissance
- SAR-Tutor for image analysis training
- Computer-Aided Interactive Performance Evaluation Tool CARPET for camouflage assessment
- OMSIS: Onboard Infrared Ship signature Management system
- Digital Map Table
- CSD – Coalition Shared Data Server and clients for interoperable data and information distribution
- Prediction tool for thermal imaging based on a Thermal Range Model (TRM 4)
- Environment measurement system for characterization of atmospheric effects
- GERTICO: Infrastructure for federated simulators
Atmospheric phenomena like diffraction, refraction, aerosol scattering and absorption, and turbulence influence wave propagation of electro-optical and imaging systems. Basic research at the Signatoric department of the Fraunhofer IOSB is focused on optical turbulence in the lower atmospheric boundary layer, quantifying the impact of the turbulent atmosphere on wave propagation. Optical turbulence may result in a strong degradation in imaging quality, making tasks such as detection, classification and identification difficult or even impossible. Because the atmosphere experiences turbulence almost continuously, correction procedures for compensation of turbulence are investigated.

This report gives an overview of the basic research and applications dealing with atmospheric corrections regarding the influence of optical turbulence on electro-optical systems as part of the ATLIMIS (Atmospheric Limitations of Military Systems) project.

Optical turbulence is described by the structure function parameter of the refractive index of air, $C_n^2$, and is caused by temperature and humidity fluctuations in the atmosphere. These are created by thermal (interaction with the earth surface by heating and cooling) and mechanical forces (wind shear) or evaporation.

**Project description**

The basic research focuses on field trials investigating the spatial and temporal resolution of optical turbulence in the lower atmospheric boundary layer, in which most of the electro-optical systems are operated. These experimental trials, with time periods from several weeks up to several years, are performed in different climatic conditions, including deserts, moderate...
central European, arctic, and sub-tropical. Regarding the influence of the earth surface, typical land covers, including sea surfaces at different temperatures, various rural agricultural sites, and urban areas are investigated. Besides these experiments under typical atmospheric conditions, the project focuses on the long-term experiment VerTurM (Vertical Turbulence Measurements) in which the vertical distribution of the optical turbulence up to a height of 400 m is investigated with various complementary instruments. This long-term experiment has been set up on the site of the WTD 91 (Technical Centre of Weapons and Ammunition of the German Armed Forces) in Meppen (north-western Germany) since June 2009. A diel cycle of the vertical distribution of the optical turbulence for one typical day in summer is presented in Fig. 1. A high variability of optical turbulence can be identified. Measured vertical profiles are analyzed with respect to the meteorological conditions. Diurnal and seasonal effects are investigated. Regarding standard meteorological data a prediction model of the vertical distribution of turbulence should be derived regarding standard meteorological data and therefore the efficiency of electro-optical systems in the lower atmospheric boundary layer should be improved. Results from existing models (e.g. Tatarskii, Fig. 2) deviate strongly from the measurements, especially at stable atmospheric conditions at night.

All measured optical turbulence data are stored in a database maintained at the Signatorics department. Here the measured turbulence data can be combined with the performance properties of electro-optical systems, allowing the operating instruments to be characterized regarding specific measurement sites and times (meteorological conditions).

The results of the experimental work on optical turbulence are also used for model validation and for the correction, improvement and prediction of performance of electro-optical and imaging systems.

For practical applications software tools are developed to compensate turbulence for use of the data in imaging systems. Using adaptive optics, systems are implemented for measuring and correcting fast wavefront distortions (Fig. 3). The project also covers laser applications for urban environments.

Sponsor

The research and application on optical turbulence are part of the project ATLIMIS (Atmospheric Limitations of Military Systems, No. EUR1M/9A265/AF170), commissioned and sponsored by the WTD91 (Technical Centre of Weapons and Ammunition) of the German Armed Forces and embedded in the business segment defense.

Project execution

Dr. rer. nat. Karin Stein, Dr. Detlev Sprung, Dr. Peter Grossmann, Erik Sucher

Literature


In a non-cooperative environment, imaging 3D laser radar sensors offer a unique potential compared to passive sensors regarding tasks like surveillance, detection of small objects, reconnaissance, classification, protection, obstacle avoidance, positioning, terrain modeling, depth sounding, autonomous navigation, automatic object recognition, and object tracking. Employing scanning laser systems it was proven that laser radar sensors offer the capability of automatic data evaluation. Their outstanding performance is owed to the fact that laser range depth resolution is independent of the sensor’s distance to the target. In contrast to passive sensors, for which there exist no reliable object recognition algorithms, the main difficulty in introducing operational laser radar systems is owed to the lack of adequate sensors.

Two-dimensional scanning systems suffer from the drawback of spatial resolution, when, for a given field of view (FOV), a high image update rate is necessary. Tasks demanding reliable resolution of small objects, especially at long ranges in real time, can be fulfilled only by sensors consisting of detector arrays. The detector is the heart of an imaging 3D sensor system and ensures sufficient frame rates and a high spatial resolution for tasks such as detection or classification.

Increasing efforts have been made throughout the world to develop 3D detectors based on one- or two-dimensional arrays. Detector development focuses on avalanche photo detectors (APD) operated in the Geiger mode (GAPD) or in the linear (non-Geiger) mode. GAPDs offer the advantage of higher sensitivity, but there are also some negative effects using GAPDs in laser radar: First, dark counts generated by thermal noise can cause false alarms. Second, GAPDs experience a dead time in which the detector element does not work after detecting a photon. The dead time typically varies from 10 ns to 1 μs and depends on the detector material and on the design of the quenching electronics. Thus usually only one echo can be detected in Geiger mode. In linear mode multiple successive echoes can be detected within a short range.

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Here we present first results for a recently developed 3D imaging laser radar sensor, working in the short-wave infrared (SWIR) band at 1.5 µm. It consists of a novel Cadmium Mercury Telluride (CMT) linear detector array with 384 x 1 APD elements at a pitch of 25 µm, developed by AIM Infrarot Module GmbH. The APD elements were designed to work in linear (non-Geiger) mode. Each pixel is capable of providing time of flight measurement, and – due to its linear detection mode – allowing the detection of three successive echoes. The digital read-out integrated circuit (ROIC) was designed to offer a principal depth resolution of 60 cm. Using additional electronic processing on the ROIC a depth resolution of 15 cm was attained. The ROIC delivers the time-of-flight (TOF) data for the whole flashed area all at once; for test purposes an intensity mode is available. The maximum read-out rate is 4 kHz.

The 3D laser radar system was set up in a laboratory from which the surrounding environment could be accessed. The sensor head, consisting of 3D sensor and laser source as well as a SWIR camera to monitor the laser beam, were mounted on a horizontally scanning rotation stage. This scan direction was attributed to the fact that the 3D sensor was mounted with the detector line in the vertically direction. Trying to realize an FOV of around five degrees for the present test purposes, we chose a commercial SWIR lens with an f-number of 100/1.4 as receiver optics for the 3D laser range camera. To suppress background radiation, a bandpass filter of 80 nm width was mounted in the back of that lens.

In the absence of a kilohertz-laser system we used a Q-switched 20 Hz OPO laser from Quantel (Big Sky CFR 400 Laser Series) with an output power of 70 mJ at the wavelength of 1.57 µm. The transmitter optics, developed by EADS Deutschland GmbH Cassidian, was designed to fit the linear FOV of the receiver. The whole experimental set-up was operated by a home-build computer control unit, which controlled triggering of 3D camera, laser and scanning unit, as well as providing data recording and real-time visualization of the measured range data. During data acquisition each of the three echoes was visualized in real time on the monitor of the control computer.

Literature
A system of this kind needs special mechanisms for interoperability. In addition to interlinking, the cooperation of systems and users with various competencies at a technical, logical and semantic level play a vital role to achieve a consistent workflow.

To provide a solution to these problems a distributed experimental system-of-systems for video-based reconnaissance was set up at Fraunhofer IOSB. Closely cooperation with potential users and participation in realistic exercise scenarios assure quality and applicability of the whole system group as well as the single system components.

The so-called ExBA group of interlinked systems, then, is a heterogeneous system-of-systems consisting of a range of different sensors and of components for sensor management, communication and analysis, interactive visualization, and automated and manual processing of data and information. This solution offers standardized interfaces to other systems, which can be integrated into the reconnaissance workflow.

Department IAS has developed a system called AMFIS for managing and evaluating heterogeneous sensors, which can be stationary or mounted on heterogeneous sensor carriers in a homogenized ground control station within a complex parallel reconnaissance application. For this purpose a distributed modular architecture was developed, allowing a quick and efficient adaptation of the system to varying demands or the need for special sensors. The parallel control of different sensor carriers was integrated and tested on the ground, in the air and on water. To achieve technical and semantic interoperability, the system contains communication components for transferring reconnaissance data in STAnAg 4609 as an integrative system interface and supports additional information exchange systems, such as XMPP and Coalition Shared Data (CSD), which is a STANAG 4559 implementation.
Department VID has developed ABUL, a modular system for assisting the exploitation process for unmanned aerial vehicles. Thereby, ABUL provides real-time optimized features for online surveillance and reconnaissance as well as functionalities valuable for offline reconnaissance tasks. Key features of the system include video processing algorithms for stabilizing and improving the video image, for detecting moving and stationary objects, and for generating geo-referenced mosaics or stereo images etc. ABUL is flexible in adapting to different sensors and data. Interoperability is a main focus of the development. STANAG 4609 video data with encoded metadata is processed in real time. Interface to the CSD enables dissemination of the exploitation products.

The software for Digital Situation Table (DigLT) was developed by department IAD to connect heterogeneous reconnaissance, tactical and spatial data from multiple sources, such as ZGeoBw, OpenStreetMap and CSD, and allows role-based visualization and interaction. Since the different roles in ISR use different hardware, the software also supports mobile devices, normal PC workstations, digital situation table and video walls. These devices support different modes of interaction, such as touch input with finger, mouse and keyboard, and 3D gestures. The software can specifically adapt the spatial data for the resolution of the display of the device used without a delay. The result is a visualization optimized for every device and its interaction with the spatial data.

The information hub in ExBA is a CSD Server. The CSD stores and disseminates data based on a standardized interface, metadata model and data formats. The other ExBA systems store and retrieve data from the server over client applications. Systems from other vendors and providers that respect the standards (STANAGs) the CSD is based on can easily be connected to ExBA through this concept. This allows the integration of ExBA functionality into a bigger surveillance and reconnaissance architecture. By sharing information within ExBA and with other units and organizations, situation awareness can be enhanced.

The ExBA was successfully tested within the scope of the “Unified Greding” experiment. The integrative system reconnaissance data was provided by the AMFIS sensors and by external sensor carriers and were broadcasted live to the ABUL video exploitation system and to the map-based visualization with DigLT. The data was then evaluated, used for situation representation and analysis and archived. All relevant primary data as well as reconnaissance results were stored in standardized formats in a CSD server.

Fraunhofer IOSB thanks the WTD81 for financing research and support in the “Unified Greding” experiment.

1 Interactive image exploitation.
2 A distributed experimental system-of-systems for video-based reconnaissance (ExBA).

Project execution
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MODISSA – A TEST BED FOR “MOBILE DISTRIBUTED SITUATION AWARENESS”

In the near future, vehicles will be equipped with a variety of sensors, computers, and communication systems, for example to implement driver assistance functions. On the civilian market, this development is largely driven by a growing interest in safety and comfort. Additionally, the military has an increasing demand for situation-awareness capabilities in their vehicles. These trends have become well established in the scientific community. However, current research on these topics is often hampered by the lack of an adequate, configurable testing and demonstration platform.

Task
A versatile research vehicle is needed that provides testing and analysis functionalities for a wide range of sensors and various operating scenarios. Depending on the investigated scenario such a vehicle can even play different roles, for example a leader or follower in a convoy, a single vehicle in traffic, or a command and control vehicle. Example applications for its sensors are obstacle detection and avoidance, traffic monitoring, acquisition of 3D data, change detection, as well as target location, target tracking, target designation and target handoff between vehicles. It is even possible to simulate a network of multiple vehicles and their interaction.

The MODISSA platform
MODISSA (Mobile Distributed Situation Awareness) is the IOSB’s realization of an experimental platform for hardware evaluation and software development in the above contexts of automotive safety, security, and military applications. It is based on a Volkswagen van VW T5 that has been equipped with a broad range of sensors and contains hardware for complete raw data capture, real-time data analysis, and immediate data visualization on in-car displays (Figure 1). The VW van carries several sensors on a roof rack, and a power supply as well as operational electronics inside. The sensor configuration can be adapted to the needs of the respective study. The electronics, including several PCs, are located in a rack behind the driver’s seat. A row of passenger seats behind it is arranged for people operating the system or watching real-time processing demonstrations. The power for the sensor system is provided by four high-capacity Li-ion batteries that are stored in a box in the back of the van. This power system has sufficient capacity for several hours of independent operation.

Control of the sensors and data acquisition are performed by PCs in a rack inside the van. Three types of PCs are included: A control PC, several recording PCs, and a powerful process-
ing PC. For georeferencing and time synchronization, an Applanix inertial navigation system is built into the van. Its IMU (Inertial Measurement Unit) is mounted on the same mounting plate as the main sensors to minimize errors caused by the plate’s elasticity. GPS antennas are positioned on the roof near the front and back of the vehicle.

The sensors are mounted on plates fastened to two cross bars of a standard roof rack. The current sensor configuration includes two rotating Velodyne laser scanners, an omnidirectional camera, and two cameras on a pan-tilt unit (one visual-range camera and one microbolometer infrared camera). The laser scanners are located ahead of both roof rack bars over the front corners of the vehicle roof, and are positioned on a wedge with a 25 degree angle to the horizontal, sloping to the front outside at a 45 degree angle. This configuration guarantees a good coverage of the roadway in front of the car and allows scanning of building facades alongside and behind it (Figure 2). A vertical plate between the laser scanners serves to shield these from mutual direct laser radiation. The omnidirectional imaging system is directly fastened to the roof rack bar near the back of the vehicle, and the pan-tilt unit is located in the center of the vehicle between the rack bars to reduce interference with the two laser scanners.

Conclusion and Outlook
An initial version of the MODISSA platform has been realized. Currently implemented applications include data acquisition and interaction paradigms with the sensors, such as looking around through the roof-mounted omnidirectional sensor with a head-mounted display when sitting inside the car. We are currently realizing more encompassing applications on the MODISSA platform, such as pedestrian detection, target detection and target handoff applications, as well as wide-area 3D model acquisition.

1 The MODISSA platform enables mobile sensor data acquisition, sensor data analysis and mobile demonstrations.
2 Mobile 3D model acquisition with the MODISSA platform. The data acquired with two Velodyne laser scanners (red and green for visualization) constitute highly accurate 3D representations of the vehicle’s vicinity. 3D data can be accumulated for wide area models and can be fused with imagery acquired with the camera sensors of the MODISSA platform.

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APPROVAL OF TRIAL CAPABILITIES:
A REAL-TIME AIRBORNE MULTI- AND 
HYPERSONIC SENSOR SYSTEM IN 
AN INTEROPERABLE ENVIRONMENT

Modern mission characteristics require the use of advanced imaging sensors in reconnaissance. In particular, high spatial and spectral resolution imaging provides promising data for a variety of tasks. These include the classification and detection of objects of military relevance, such as camouflaged units or improvised explosive devices (IEDs). Especially in asymmetric warfare with highly mobile forces, intelligence, surveillance and reconnaissance (ISR) needs to be available close to real-time. This demands the use of unmanned aerial vehicles (UAVs) in combination with downlink capability and the integration in an interoperable environment.

System overview
In cooperation with OHB System-AG and GEOSYSTEMS GmbH the Fraunhofer IOSB developed a multi- and hyperspectral sensor system, which is integrated in a wing pod for ease of installation and calibration. It is designed for the real-time acquisition and analysis of hyperspectral data. The main component is a Specim AISA Eagle II hyperspectral sensor, covering the visible and near-infrared (VNIR) spectral range with a spectral resolution up to 1.2 nm and 1024 pixel across track, leading to a ground sampling distance below 1 m at typical flight altitudes. The push broom characteristic of the hyperspectral sensor demands an inertial navigation system (INS) for rectification and georeferencing of the image data. Additional sensors are a high-resolution RGB (HR-RGB) frame camera and a thermal imaging camera. For online application, the data is preselected, compressed and transmitted to the ground control station (GCS) by an existing system in a second wing pod. The final result after data processing in the GCS is a hyperspectral orthorectified GeoTIFF, which is filed in the ERDAS APOLLO geographical information system. APOLLO allows remote access to the data and offers web-based analysis tools. Furthermore, the system is integrated in a Coalition Shared Database (CSD). Collected data and achieved results can be put in CSD for exchange with other units.

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System benefits
Capturing hyperspectral data in spectral bands of visible light as well as near- and mid-infrared opens up new opportunities for differentiating materials. Different materials, such as minerals and vegetation, possess different spectral absorption and reflection bands. They can be identified using these spectra. This can be used for automatic target detection or the creation of land cover maps containing not only types of use (i.e. man-made objects, vegetation) but gives information about the specific material. In the case of environmental monitoring, important factors include vegetation state (damaged forests), or material properties (environmental pollution).

The field trial
Within the context of the opening of the “Zentrum für Interoperabilität, NetOpFü und Simulation” (ZINS, Center for Interoperability, Network-Centric Warfare and Simulation) at the WTD 81 in Greding, a military scenario simulating the evacuation of an embassy was performed. In preparing the evacuation, routes had to be planned to allow safe access to the embassy. Our system’s task was reconnaissance of the surrounding area for mission preparation, in particular the creation of maps as well as the detection of possible sources of danger. Before the actual evacuation took place, a complete dataset of the whole base area was collected. The data were transferred to the ground control station during acquisition, giving a first impression of the situation around the embassy.

In post processing, the radiometric and geometric correction on hyperspectral data was carried out. Target detection algorithms were used to identify possible sources of danger. A group of camouflaged targets could be identified in the southern part of the base. An image, highlighting these targets and giving their position was created. Furthermore, hyperspectral classification algorithms were used to create precise and up-to-date maps, which can be used for route planning. All results were put into the CSD so that they could be accessed by all participating units.

Literature
Considering that new technologies are being discussed in controversial manner with respect to conflicting aspects of security needs and the need for freedom, particularly if they are associated with surveillance, IOSB pursues the notion of “Privacy by Design”, which requires that privacy criteria are already accounted for during the design of the system. Furthermore the protection of industrial installations and production capabilities against cyber-attacks in the context of the “Industry 4.0” paradigm is an uprising task for which IOSB has already set up working groups and projects.

The range of services spans from studies (e.g. for evaluation) to the realization of experimental systems or prototypes and in individual cases up to and including system development. In typical projects the security researchers of Fraunhofer IOSB support customers in their efforts to improve their competitive position, addressing challenges previously thought too difficult with new product generations featuring innovations from the cutting edge of research.

**Markets**
The business unit Security serves customers from the private and public sector. The former includes, among others, security technology providers, security service providers and operators of properties with critical security profiles. IOSB serves official bodies at the federal, state and municipal level in the public sector, particularly official bodies and emergency services, which aim to identify and evaluate new technologies in order to fulfill their duties.

IOSB is available as a partner for specialized small and medium-sized companies for the development of product innovations and considers itself to be a research resource for companies, which would also like to benefit from new scientific results without maintaining their own research department. Scientists from the business unit Security often take on demanding sub-tasks in large projects on behalf of large companies. System integrators integrate IOSB developments in their systems, for example based on licenses.

**Mission**
The business unit Security focuses on the security needs of people, companies and official bodies, which wish to protect against natural and intentionally planned hazards, and comprises a broad range of interlinked competencies that deal with sensor sphere optronic aspects as well as multimodal surveillance robotics (on land, at sea and in the air), the development of ultra-modern analytical methods, the support of interoperable standards for the real-time exchange of information for risk detection and management as well as assistance in the situational analysis and human machine interaction in situation centers.
Prior to or after acquisition of their contracts, security service providers and IOSB discuss the possibilities for further increase in the efficiency and/or effectiveness of their work by means of using new technologies; if necessary, IOSB involves industrial partners for commercial development and 24/7 support of the systems. Providers of novel high-tech products, which want to offer their own customers assurance with respect to their performance claims, commission IOSB with lab evaluation and benchmarking tests, on the basis of which absolute and/or relative conclusions relating to performance can be drawn. IOSB experts offer consultation to companies or official bodies, which are preparing large invitations to tender for security systems, particularly when it comes to the issue of relevant new technologies. This particularly includes the evaluation of technologies with respect to their suitability for certain objectives.

Companies that intend to resort to publicly funded research projects in order to enhance their portfolio receive assistance by IOSB when it comes to identifying suitable funding programs and preparing a proposal. During the course of a project, IOSB acts as a research partner. Furthermore IOSB finds funding programs and suitable partners from industry for users in search of new technologies for their fields of activity.

In a technological respect and according to the overall research proposition of Fraunhofer IOSB, methods and systems for image exploitation are a core area, which are for example developed for property surveillance in both indoor and outdoor areas. With its competencies, IOSB handles the entire chain from sensor-sphere data acquisition, sensor carriers and their automatic control for surveillance missions, analysis on an automatic or human-machine basis, multi sensor fusion, and situation analysis up to and including the use of information acquired in this manner for higher-level management support. System design in compliance with privacy protection is an explicit topic of research and part of the consulting portfolio of the business unit Security.

Equipment, laboratory and test facilities

- Comprehensive laboratory equipment for capturing the entire image processing chain, from sensors through analysis to interoperable information exchange
- Innovative, powerful sensors, such as eye-safe gated viewing lasers, two-color infrared sensors, multi- and hyperspectral sensors, and remotely-sited laser vibrometry systems
- Distributed test setups for multi-camera tracking and privacy-compliant video analysis in public spaces
- Multimodal sensor platforms: Experimental robotics on land, at sea and in the air, and associated ground control stations (stationary and in vehicles) for mission planning and control in heterogeneous deployment networks
- A “Smart Control Room” lab as a “perceptual room”
- Mobile Control Center – a truck-based experimental platform for on-site situation management support

References and product features

- Fraunhofer IOSB as strategic partner for security research and technology of the German federation of security services (BDSW)
- Armasuisse / Swiss Confederation: uAV-based systems for border surveillance
- Various event organizers: Providing security at major events with IOSB sensors and sensor carriers
- Fraunhofer-wide management and coordination of large scale project SENEKA – sensor network with mobile robots for disaster management
- Federal Ministry of Education and Research (BMBF): Systems for water quality monitoring
- Federal Ministry of Education and Research (BMBF): Video assisted systems for detecting conspicuous movement patterns, attacks and assaults, and abandoned luggage
- European Union (EU): Systems for identifying victims of natural disasters and searching for missing persons
- European Union (EU): Systems for offshore monitoring (detection of illegal border crossings and, smuggling of people, weapons, and drugs)
- European Union (EU): Systems for the protection of critical infrastructures and utility networks
Detectors commonly used in industrial applications are based on silicon (Si) or silicon carbide (SiC). When very high sensitivity is required, photomultiplier-based systems present a possible alternative. Often, additional optical filters are needed to meet spectral requirements. The sensitivity of these detectors usually decreases constantly under heavy illumination due to degradation of detector or filter materials.

Since March 2011 detectors based on aluminum gallium nitride (AlGaN) have been developed in a joint project between Fraunhofer Institutes IAF, IOSB, IPM, ISIT and IFAM. These novel detectors are intended to overcome the weaknesses of Si and SiC. The project is funded through a Fraunhofer internal grant. Photodiodes and line sensors are epitaxially grown at the Institute for Applied Solid State Physics (IAF), while integration and hybridization of the detectors is performed at the Institute for Silicon Technology (ISIT). The Institutes for Physical Measurement Techniques (IPM), Manufacturing Technology and Advanced Materials (IFAM) and of Optronics, System Technologies and Image Exploitation (IOSB) develop applications and prototype systems based on these detectors.

Electro-optical properties of Al\(_{x}\)Ga\(_{1-x}\)N (0<x<1) are determined by the ratio of aluminum to gallium. The cutoff wavelength decreases from 365 nm (GaN) to 210 nm (AlN) with increasing Al content. This allows the detectors to be spectrally optimized for a given application. Inclusion of an additional layer with higher Al content – and therefore shorter cutoff wavelength – during epitaxial growth of the detectors, results in narrow-band sensitivity (minimum bandwidth of approx. 10 nm) without the use of external filters. This additional layer can be used as a second active layer yielding a detector with two distinct spectral channels.

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Electro-optical characteristics of the detectors manufactured so far are comparable with the best values published for AlGaN detectors and with the maximum values of SiC and Si detectors. Detectors for different sub-bands of the ultraviolet spectrum – UV-A (320 - 365 nm), UV-B (280 - 315 nm) and UV-C (240 - 280 nm) – have been produced.

Work at Fraunhofer IOSB focuses on imaging applications using these detectors. To investigate the potential of the AlGaN technology we are developing a scanning camera system with the AlGaN line arrays supplied by IAF and ISIT. Fig. 1 shows the demonstrator of this system, which is currently operated by an external data acquisition system. Fig. 2 shows an image of a scene taken in the visible spectral range (left), in the complete UV range (center) and in UV-C (right). Both UV images were taken with our camera. A deuterium lamp (200 - 400 nm) is located in the center of the images.

One potential application of the line sensors is its use in sorting machines. The ability to match the detector’s spectral sensitivity to the investigated material, and the potential of having a second channel that is sensitive at another band within the same sensor (dual color capability) may simplify system design and improve system performance. Further possible applications are remote sensing from airborne platforms, for example with the aim of detecting oil spills on the sea surface, or monitoring combustion or plasma processes.

Our focus is on a possible deployment of the UV-C detectors as part of a civilian missile approach warning system. Compared to the photocathode systems currently used in military systems, the new solution promises robustness of the semiconductor sensor, small size, comparatively low cost, low weight and the inherent insensitivity to the solar background beyond 280 nm, which reduces the need for external filters. In addition, the aforementioned inclusion of a second channel with a different spectral sensitivity could facilitate a rough determination of the distance to the missile and estimation of time-to-impact.

There are many imaging applications for which AlGaN sensors appear to be well suited. For low-light scenarios, further improvements of the sensors are, however, necessary. Future research will therefore include feasibility studies on AlGaN-based avalanche photodiodes. An improved version of our (scanning) line camera and the development of focal plane arrays are further tasks we will pursue.
MobSC – Mobile Situation Center for the Management of Complex Crisis Situations

In sudden crisis situations there is always the need of rapid decisions based on a huge amount of information from different tasks and sources. The MobSC of Fraunhofer IOSB is an experimental platform for the interactive handling of such information by a combined team. It is a cluster with ergonomic display and interaction devices combined with high-performance work places. Featuring energy and climate facilities as well as broadband communication, it is able to work completely autonomously.

Fraunhofer IOSB has been working on team workspaces for many years, using large horizontal and vertical displays with gesture interaction, fovea tablets™ for detailed views and selection, other mobile devices and conventional work stations. They set up a combined working landscape for heterogeneous teams and individual specialists for dedicated tasks. The Mobile Situation Center realizes this working environment within a medium-size truck (Figure 1) that is able to work completely autonomously due to its own power supply, triple climate system and several information interfaces to the environment. Figure 2 shows the architecture of the complete system. All calculations are performed in an on-board processing center in a separated room. The core system for the interaction is the digital situation table, which is located in the center of the room and based on a 42 inch multitouch display with camera-based gesture control. On the front wall, four 46 inch panels set up the wall display realized as one virtual display with quad HD resolution and two Microsoft Kinect® devices for the gesture control. Optionally tablet systems and workstations can be used.

In addition to the interaction control systems there are several subsystems for different tasks: the CSD (Coalition Shared Database) system is an IOSB product for specialized access control to security-relevant information. The ABUL system supports automatic and interactive image and video analysis, especially for security applications such as screening, tracking, and change detection. The INSENSUM system is a meteorological measuring and analyzing system for incorporating weather information, such as temperature, wind and humidity, as well as their history and prognosis.

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An external subsystem interfaced with a standard network connection is the IOSB AMFIS systems for the control of mobile sensor carriers such as UAVs and UGVs for cameras and special sensors (e.g. chemical or nuclear).

The Mobile Situation Center can be used for the management of crisis situations or for supporting situation awareness in critical environments such as mass events or congresses. The following example shows how the change detection works. Steady and UAV-based cameras deliver live streams to the MobSC for successive monitoring of the area. These streams are normally shown on the wall display. In addition, the ABUL system uses one of them to create a geo-referenced mosaic of the area (Figure 3). At fixed intervals (e.g. every 30 minutes), a new mosaic is created and can be used for automatic and interactive change detection. In Figure 3 the red square marks an object which the automatic component of ABUL has detected as new at this position since the last monitoring flight and which might be dangerous (e.g. explosive (IED) or toxic).

The current mosaic is displayed on the digital situation table as a geo-referenced overlay on the airborne image of the area. The combined team in the MobSC can select any suitable view of the sensor signals on the displays to support them in the decision of how to handle the current situation. For this purpose the immediate history at the current position can be reconstructed with video sequences from the database on the CSD.

In addition, the INSENSUM system delivers the current weather conditions together with the weather history and forecast. This can be provided as a condensed view of a wind rose (Figure 3). For access to the respective sensor data, OGC conform services, such as the SOS (Sensor Observation Service) or the WMS (Web Map Service) are provided for request and delivery of the wind rose as an overlay image. The displayed information can be very important for the decision of whether or not to evacuate an area or a certain building. Finally, the stored video sequences can be helpful in supporting the search for a suspicious person who may have deposited the object and be on their way to other serious actions.

The experimental Mobile Situation Center shows that it is possible to integrate sensing, analysis and interactive display tools with high-performance capabilities in a small, mobile platform that can be ready for operation within a couple of minutes and offers nearly the full set of functions, residential interaction capabilities and measuring and analyzing subsystems available and suitable for the respective tasks.

Fraunhofer IOSB has held several exhibitions in the last years, including the Security 2012 fair in Essen, the ISCRAM 2013 in Baden-Baden and the internal cluster workshop of the Innovation Cluster “Future Urban Security” in Freiburg (Figure 4).
Objectives

The objective of the EU-project “Intelligent Tutoring Interface for Technology Enhanced Learning” (INTUITEL, www.intuitel.eu) is to enhance state-of-the-art e-learning content and learning management systems (LMS). The INTUITEL framework can be integrated into existing e-learning systems and will then provide additional functionality. An INTUITEL-enabled system adapts itself in response to the learners, monitors their progress and behavior, combines this with didactic and domain-specific knowledge and, by automated reasoning, deduces optimal guidance and feedback. In particular, it finds an optimal sequence of course modules for the student w.r.t. a pre-specified reference path in the presence of incomplete information and concurrent learning paths.

Project overview

INTUITEL is an interdisciplinary project joined by a consortium of twelve international partners from pedagogics, education and IT technology. The Fraunhofer IOSB contributes with its expertise in technology, e-learning and knowledge transfer. As established experts in image exploitation the institute brings in learning content for a radar image interpretation course as testing ground as well its state-of-the-art learning management system Crayons®. The experience of the Fraunhofer IOSB in semantic web technologies is a main pillar of the automatic reasoning and deduction capabilities of the intelligent part of INTUITEL.
The architecture of INTUITEL is organized in five main areas: (i) a lightweight interface to LMS; (ii) a semantic learning object model (SLOM) specification for learning content interoperability; (iii) pedagogical and domain models to describe didactical concepts as well as domain knowledge; (iv) the backend with a model that monitors the learner’s progress and the reasoning engine; (v) a communication layer which handles internal and external messaging.

In INTUITEL, learning goals will be defined according to the desired competency, which will be mapped to the available content, thereby providing means for companies and educational organizations to better manage their collective knowledge. At the same time, high flexibility to choose a learning pathway is maintained by offering system-driven and learner-directed navigation tools, thereby increasing the empowerment of teachers and learners and fostering the acquisition of methodological knowledge. By interpreting the learner’s responses INTUITEL will automatically determine his position within a cognitive map for the particular learning content. The INTUITEL-enabled LMS then plays the role of a pedagogically skilled teacher, transparently guiding the learner towards the required competencies. Positive and goal-oriented feedback messages will provide important advice to learners in their learning experience. Furthermore, by providing the cognitive position also as a feedback, INTUITEL will enable the learners to establish an intuitive model of their current learning effort and therefore also enhance their metacognitive skills. Several market-leading LMS, including the Open Source platforms Moodle and ILIAS, will be equipped and tested with the technology to achieve these pedagogical goals. The involvement of several project partners in commercial e-learning activities and other project partners in university e-learning activities will ensure the testing and evaluation of the pedagogical and technical aspects of INTUITEL under realistic conditions.

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Literature
PATIENT-TRACKING FOR EPILEPSY MONITORING

When security technology helps fight diseases

Epilepsy monitoring is vital in the accurate diagnosis of uncontrolled seizures and in preparation for epilepsy surgery. The epilepsy monitoring unit (EMU) is where continuous video EEGs are performed. The video records the patient’s physical activity, including seizures and what happens in the moments before and after seizure. Simultaneously with the video recording, the EEG records brain activity. Both video and EEG information allow physicians to pinpoint the type of seizure that is occurring and precisely locate the source. On the one hand it is necessary to keep the patient as close as possible in the focus of the video to see also, for example, small muscle twitches; on the other hand the patient should also have the freedom to move around in the patient room.

For this purpose today’s video EEG systems use pan-tilt-zoom cameras that are manually controlled by medical staff, who are usually in charge of continuously controlling the camera to keep the patient in focus while at the same time observing EEG activity for diagnosis. However, manual camera control and video monitoring over a longer period of time is exhausting and lowers operator’s attention.

To overcome this problem, an innovative automated patient tracking system has been designed and developed together with NIHON KOHDEN, which consists of a two-camera setup connected to the Fraunhofer IOSB AutoTrack® patient tracking software.

The system concept

The AutoTrack® software is responsible for real-time processing of video streams from all cameras available for monitoring as well as for automatic camera control.

The typical camera setup consists of two cameras: a static overview camera and a pan-tilt-zoom camera. The static wide-angle camera provides an overview of the entire monitoring room, while the pan-tilt-zoom camera is used for active high-resolution patient observation. Both camera streams are processed independently by dedicated video processing modules, which are able to detect and localize the observed patient.

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Detection is performed based on color appearance features and by the use of visual tags (IOSB MXT badges), which are fixed to the monitored patient’s clothes. MXT badges (Fig. 1) are defined visual patterns which can be identified and localized in image data reliably and very quickly, even under adverse lighting conditions (e.g. low light, low contrast, or low resolution).

One unique feature of the AutoTrack® system is its ability to track the patient in the monitoring room in 3D space, instead of tracking in video (pixel coordinates) only. This approach allows a higher scalability of both the camera network and camera mounting positions. Since the images from each camera are processed by independent video processing modules, and position information is exchanged between modules based on a common 3D coordinate system, camera control can be performed by any available camera in the network.

Furthermore, MXT badges can be identified by an integrated code (ID number). These IDs are used to distinguish between patients in the same monitoring room and to avoid mix-ups during automated tracking.

**From prototyping to product**

In 2013 the AutoTrack® system prototype has been evaluated by medical technicians at Heidelberg University Hospital (Universitätsklinik Heidelberg). After proof of concept and user-oriented software optimization the AutoTrack® software has been presented to the public and end-users at the MEDICA Düsseldorf Trade Fair, and at the AES (Annual Meeting of the American Epilepsy Society) in Washington D.C. with big success and very positive market feedback.

In the near future integration of the AutoTrack® software into Nihon Kohden EEG products is planned.
CyphWay – THE ONE DEVICE FOR SECURE COMMUNICATION

The use of mobile terminals such as notebooks, tablet PCs, and smartphones are of increasing significance today. Usually these efficient terminals provide immediate access to the Internet and to an organization’s intranet. In particular through their multifunctionality tablet PCs and smartphones are becoming a lucrative target of industrial espionage. According to a survey on industrial espionage conducted by Corporate Trust in 2012 [1] the increasing use of tablet PCs and smartphones is, at 63.7 percent, ranked number 1 in development efforts, thereby presenting an increasing risk of know-how leakage for German enterprises.

The security of several of these terminals is, however, highly controversial. To ensure data security, various cryptographic methods are used. Since these terminals are used to output data to humans via a user interface, a continuous encryption of the transmitted data is not possible. Leakage of any single item of data cannot, therefore, be fully prevented. However, the loss of control over a large set of sensitive data is much more problematic than the loss of single data sets. This may occur, for example, if the used encryption keys are obtained by an adversary.

This is where CyphWay, developed at Fraunhofer IOSB, comes in. CyphWay protects keys through encryption. Decrypted keys are available only within specially developed, trusted hardware modules that are separate from the mobile device. These modules also perform the task of encrypting and decrypting the data and keys. CyphWay has a modular structure and permits the use of different communication media, such as USB or Bluetooth. It can therefore be used within different scenarios and for different terminals – from smartphones to desktops, for data clouds to end-to-end communication – without the need for intermediate servers. CyphWay can be easily adapted to new requirements, such as new methods or data security requirements, by simply customizing its modules.

An intelligent key management system (part of which has been published in [2]) prevents data being decrypted when a mobile terminal is attacked. Combining safety-critical components (i.e. the encryption and decryption functions), and the key management system in a trusted hardware crypto module guarantees the best possible protection of sensitive data.

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CyphWay consists of the three following components:
1. the trusted hardware crypto module
2. the communication module
3. the integration module

The integration module is implemented directly on the terminal. Depending on the terminal’s design and capacity the communication module, too, can be implemented on the terminal. The trusted hardware crypto module, in contrast, must be physically separate from the terminal. To verify authorization, users have to authenticate themselves at both devices – the terminal and CyphWay.

Message encryption consists of the following steps (see Figure 1):
1. The terminal sends the unencrypted data to CyphWay (using protective mechanisms of the appropriate near-field communication channel)
2. Using the key management system CyphWay determines the required key.
3. The data is encrypted on the trusted hardware crypto module.
4. CyphWay sends the encrypted data to the terminal.
5. The terminal sends the encrypted data to its destination using the appropriate wide-field communication channel.

**Decryption takes place in the same way**

**Secure end-to-end communication, for example via SMS, e-mail, or online chat**
The data sets are encrypted by sender’s CyphWay before transmission and decrypted by the recipient’s CyphWay after receipt of the data. All data traffic between the terminals is encrypted. The integrated key management system ensures that only authorized receivers can decrypt these messages. Eavesdropping on the communication is therefore doomed to fail.

**Secure data storage in the cloud**
Data encrypted with CyphWay can be stored in the cloud. The encryption protects these data from access by unauthorized parties. As in the previous use case the integrated key management system guarantees that only authorized parties can decrypt the data. Sensitive information can therefore be provided for authorized persons even if senders and recipients are not active at the same time.

**Literature**
CORE COMPETENCE
OPTRONICS
CORE COMPETENCE

OPTO

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Optronics (OPT)

Competencies and portfolio

The Department of Optronics (OPT) develops methods for experimental and model-based performance evaluation and for optimization of passive and active optronic systems. Laboratory evaluation systems are being developed for infrared detector mosaics, thermal imaging equipment, image intensifier tubes and laser sensors, taking into account perturbation and hardening. Theoretical work related to novel evaluation methods and variables have resulted, among other innovations, in new analytical range models and imaging simulation models.

Our thermal range model IOSB_TRM4 allows a calculation of the performance of scanning and rigid thermal imaging devices, and cameras in the NIR and SWIR spectral range. IOSB_TRM4 is being continually adapted to current requirements and equipped with new features. Currently it is being extended for thermal bolometer cameras.

For image simulation of IR sensors in static applications, the simulation model SITOS(S) has been developed. This can be used to simulate real-life scenes from a thermal imaging device. The simulation uses high-quality IR image templates as a substitute for real-life scenes. Using a computer process the templates are degraded to the extent that the resulting image most closely resembles the image that the thermal imaging device being simulated would show of the scene.

New device concepts are being analyzed and assessed with IOSB_SITOS(S). For this purpose 3D scenes (simulation model IOSB_SITOS(D) for dynamic applications) are also generated, and visual simulations to evaluate the performance of imaging sensors conducted.

The use of laser sensors is often limited by the safety requirements associated with laser equipment. To estimate the hazard range of the laser sensor, the degree of reflection of the laser radiation from the investigated object must also be known. Both modeling and numerical calculation of the reflection behavior of laser radiation on surfaces that are subject to statistical fluctuations – such as water surfaces – present a particular challenge. For this purpose the dynamic water surface model IOSB_WOM has been developed.

Novel sensing methods and components are being developed and implemented in laboratory samples. They include gated viewing cameras and laser radars with heterodyne detection for determining 2D and 3D laser reflection signatures, and 2D vibration signatures for target classification over long distances.
To obtain the 2D vibration signature, the laser beam scans the target in X and Y direction. For each measuring point a frequency analysis is performed. If the target vibrates (e.g. a running drive unit) a micro Doppler shift is imprinted onto the laser beam. This allows vibrating targets to be located through partial obstructions (vegetation, fog, camouflage nets, etc.) to analyze their vibration behavior. From the findings conclusions about the motorization of the objects can be drawn and their geometric shape partially reconstructed.

In addition, concepts for the protection from laser radiation are being developed for optronic sensors, with a particular focus on protection against laser dazzling.

Projects

- Laser radar demonstrators and methods for target classification
- Use of laser vibrometry for remote diagnosis of mechanical structures
- Analytical calculation, modeling (IOSB_TRM4), and experimental verification of the range performance of imaging sensor systems (passive and active) in the spectral range from UV to thermal infrared for military and civilian tasks
- Experimental performance evaluation of passive and active optronic sensors
- 3D scene generation and image simulation for performance evaluation of imaging sensors (IOSB_SITOS(D))
- Eye protection against laser radiation (protection from dazzle and injury)
- Influence of and protection from laser radiation on optronic sensors
- Propagation phenomena of ultra-short laser pulses (femtoseconds) in atmosphere and in optical materials
- Investigations on the use of laser radiation in maritime environments using a water surface model IOSB_WOM
- Development of laser safety concepts

1, 2 Gated-viewing exposure of a ship, using the sliding-gate technique in Figure 2.
3 Dual-color image processing (MW, medium-wave; LW, long-wave).
4 Image simulation for evaluation of IR camera performance.
SIGNATORICS (SIG)

Competences and Portfolio

The competences of the department SIGNATORICS (SIGNATORIK – SIG) focus on the following areas:

- Warning sensor technology
- Signature management
- Environmental limitation

The activities comprise, amongst others, performance optimization of electro-optical technology in the atmospheric environment (from ultraviolet to the infrared spectrum), as well as development and improvement of signature management measures.

One of the core research themes within the field of warning sensor technology, beside the characterization of the environment and the backgrounds, is information gathering on the signatures of potential threats. Warning sensor systems are developed for diverse threat scenarios.

Within the department, research is also being carried out on the use of warning sensors in the civilian settings. On the one hand, research projects in the area of signature management conduce to change and/or reduction of the owned signature and thus to the reduction of discoverability. On the other hand, possible adverse camouflage and deception measures are also being evaluated. Both, ground- and air-based measurement methods are developed and deployed in aircrafts and helicopters within the scope of complex field trials over land and sea. Relevant material and system properties are identified with the help of innovative laboratory and field measurement systems and are used in numerical simulations for signature evaluation.

An essential subtopic within all research areas of the department is the analysis of atmospheric effects on electro-optical systems. As far as suppression of environmental effects is concerned, the department makes use of a comprehensive database on limiting factors, like atmospheric refraction and turbulence, acquired over the past years. These measurements are the basis for evaluation of atmospheric effects on sensors, with the objective of achieving optimum compensation for such effects.
Work within the department focuses on the following topics:

- Innovative warning sensor technology for the military and civilian sectors
- Designing sensors for satellite-based monitoring systems
- Measurement of atmospheric parameters and development of corresponding compensation methods
- Application of adaptive optics and software-based methods for image correction
- Development, testing, and evaluation of multi-spectral signature management approaches and deception measures
- Laboratory experiments and field trials in maritime and terrestrial environments with passive and active sensors
- Identification of optical properties of materials within the full spectral range
- Design of analytical models and numerical simulations for radiation transport and propagation processes in maritime and terrestrial scenarios
VISUAL INSPECTION SYSTEMS (SPR)

Competences and portfolio

The Visual Inspection Systems (SPR) department develops and delivers systems for automatic visual inspection tasks in industry. The main areas of application are currently the automatic sorting of bulk goods in recycling, mining and the food industry (e.g. waste glass, metals, gold, diamonds, tea, herbs, coffee, grains, and seed), the inspection of surfaces for defects (e.g. paint coat inspection), the inspection and characterization of transparent materials of all shapes (e.g. flat glass, headlight glass, and sunroofs), color measurement of granulates and inspection of blister packs.

All these applications are characterized by the fact that the inspection is performed at high throughput rates inline with the higher-level process, which thus calls for high-performance image exploitation systems. The imaging sensors are used for high-resolution line scan cameras of various types (color, grayscale, UV, and imaging NIR), 3D area array scanners or laser scanners. The image acquisition equipment is individually tailored to the specific task at hand, making particular use of folded beam paths and LED flash illumination.

The system platform for solving application tasks consists of standard PCs based on the PCIeexpress bus under the Windows 7 and Windows embedded OS. The system’s high processing power is achieved with specially developed plug-in cards for the PCIeexpress bus. Together with a real-time system of algorithms for the capture and exploitation of images, this platform is at the core of the delivered application systems.

The department’s products are used in industrial applications around the world. Partnered companies are responsible for marketing and service. In some cases, however, the department develops directly for end users and takes care of installation and service in the process.

The department operates an image exploitation center and a cross-application multi-sensor lab with experimental apparatus for process clarification as well as development systems for a variety of application areas. On the “multispectral workbench”, materials can be inspected within the frequency range from ultraviolet (UV) up to and including near infrared (NIR) in order to obtain optimal decision-making criteria for the inspection task. Such “hyperspectral imaging” experience is directly linked to the work group for multispectral data analysis coordinated by SPR.

Projects and products

- VisioChromHR: Image exploitation system for automatic inspection of tablet blisters
- Clarity: Image exploitation system for automatic sorting of waste glass shards
- ClarityHR: Image exploitation system for automatic sorting of heat-resistant glass
- ClarityLead: Image exploitation system for automatic sorting of lead-containing glass
- Minexx: Image exploitation system for automatic sorting of minerals
- GemStar: Image exploitation system for automatic detection of diamonds in granulated rock
- FoodControlHR: High-resolution image exploitation system for automatic purification of tea, herbs and dried vegetables
- CoffeeControl: Double-sided image exploitation system for automatic sorting of coffee
- WheatControl: Image exploitation system for automatically cleaning grains
- GranuControl: Image exploitation system for automatic sorting of plastic granulates
- SpotInspect: Image exploitation system for automatically detecting contamination in a material flow
• Purity: Image exploitation system for detecting defects as air bubbles or inclusions in arbitrarily-shaped transparent materials (e.g. flat glass, curved glass, lentils, or granulate)
• Purity tension: Image exploitation system for detecting defects and measuring tension in arbitrarily-shaped transparent materials
• MultiScan: Image exploitation system for automatic detection of defects and for evaluating texture, color and luster of industrial goods (e.g. tiles, base plates, coated steel belt, or copper laminates)
• ColorControl: Image exploitation system for automatically identifying the color of granular products (e.g. synthetic granules)

Infrastructure and equipment

Image exploitation systems for industrial visual inspection are application-specific or customer-specific. This is why almost all research projects start with the question of whether the respective task can be solved at all using an image exploitation system. After that, the limits of the recognition capacity are determined. Eventually, an estimation of the resource requirement for system realization is performed. Satisfactory answers to these questions can be obtained only through experiments, which tend to be costly and time-consuming.

The image exploitation center and the cross-application multi-sensor lab of the IOSB were set up for the purpose of experimental procedure clarification with, if applicable, the involvement of other IOSB departments and the KIT research group. The image exploitation center and the multi-sensor lab offer numerous facilities for image acquisition and exploitation. In addition to cameras and lighting equipment, they include:

• Sliding tables with a variety of different lighting fixtures for image acquisition
• Experimental systems for sorting bulk goods (each equipped with a camera and blow-off device) in various configurations as a belt sorter, sorter with chute and free-fall sorting
• Measurement stations for inspecting surfaces
• Measurement setup for 3D inspection
• Test system for transparent materials
• Multispectral workbench (240 – 2500 nm)
• Lab equipment for material characterization
• Sorting container for fast prototype production

The methods used for image exploitation permit evaluation of shape, texture, color, luster, material signature and 3D characteristics of the specimens.
Expertise and portfolio

The German and European energy supply is facing major challenges: Renewable energy is only one aspect of the current structural changes to the energy system. Energy efficiency and cross-cutting issues such as electric mobility, power analyzes, forecasts, virtual power plants and energy storage are gaining importance through the interconnected European power system. Fraunhofer IOSB-AST, department energy, has in all these areas extensive knowledge which is applied in various projects over fifteen years.

In the industrial sector, the software solution EMS-EDM PROPHET® is successfully represented in the German and Turkish energy market by major partners such as Compello GmbH and BTC AG. Here topics such as energy and energy data management are at the forefront. In 2013 EMS-EDM PROPHET® became certified by TÜV within a project with Dow Olefinverbund GmbH.

In energy research, more forward-looking issues like demand response and demand side management, energy storages, wind power forecast technologies or the integration of renewable energy into the power grid are explored.

The department energy consists of five working groups:

**EMS-EDM PROPHET® - Engineering**
- Project management
- Demand and feed-in forecast
- Procurement optimization in liberalized markets
- Optimization of energy processes
- Accounting grid and network utilization management

**EMS-EDM PROPHET® - Development**
- Software solution EMS-EDM PROPHET®
- Implementation of forecast and optimization methods
- Support of market regulations (MaBiS, KoV IV)
- Open, cross-system IT architecture
- Scalable, high performance client/server development

**Energy systems**
- Grid simulation and network planning
- Smart grids
- Optimal system management and adaptive grid protection
- Grid integration, energy storage and e-mobility
- Safe IT infrastructures for smart grids

**Energy business and system analysis**
- Liberalized energy markets and business models
- Market processes and communication
- Smart metering
- Energy economic analysis
- Development of forecast and optimization methods

**Energy technology components and equipment**
- System engineering and small producer
- Components for efficient energy usage
- Decentralized energy storages / grid protection components
- Automation device / safe IT components
Tasks and projects

- ADELE ING - Adiabatic compressed-air energy storage (CAES) for electricity supply (BMWi, Energy Storage Funding Initiative)
- Energy storage study for medium and low voltage power grids (Thuringia energy and GreenTech-Agentur (ThEGA))
- Gesteuertes Laden 3.0 managed by BMW AG (BMWi)
- Smart Region Pellworm managed by E.ON Hanse AG (BMU, Energy Storage Funding Initiative)
- ICT energy lab - research and development platform for analysis and development of IuK technologies for centralized and decentralized intelligent energy supply systems and training center for EMS-EDM PROPHET®
- EMS-EDM PROPHET® - energy management with forecast and optimization as well as energy data management for liberalized energy markets
- SuperGrid - The future power highway - analysis of a meshed high-voltage direct current transmission grid in Western Europe and North Africa (Fraunhofer Society)
- Hybrid urban energy storage - regional grid balancing with virtual energy storages (Fraunhofer Society)
- Demand analysis energy storage (BAES, BMWi)
- sMobiliiTy - development of a cloud-based system and service platform for electric mobility (BMWi)
- REM 2030 - Regional Eco Mobility 2030 (Baden-Württemberg, Fraunhofer Society)
- EBUS - Implementation of an e-mobility concept in the Thuringian tramway cities, including vehicle technology, infrastructure and energy supply, Working group 2: Concept study for a town-wide power supply system for the operation of electric buses in Thuringia (Ministry of Construction, State Development and Transportation)
- EnEff:Stadt / EnEff:Wärme - Concomitant research (BMWi)

1. Smart charging methods for E-Mobility.
2. SuperGrid - meshed HVDC grids in Western Europe and North Africa.
WATER AND MOBILE SYSTEMS (WMS)

Expertise and portfolio

The department water and mobile systems is engaged in the field of holistic and integrated consideration of water supply systems, the development of embedded systems, assistance systems, and autonomously driven land and underwater vehicles. The department is split into three working groups:

**Embedded systems**
- Integration of embedded systems
- Embedded control and regulation systems
- System design and modules for autonomous vehicles
- Hardware integration
- Guiding systems for vehicles
- Maintenance and diagnostic systems
- Sensor data fusion and simulation

**Water supply and wastewater treatment**
- Drinking water abstraction
- Drinking water treatment
- Drinking water distribution
- Reservoir and dam systems
- Wastewater collection
- Wastewater treatment
- Sludge treatment
- Recycling of wastewater

**Maritime systems and surface water**
- Simulation and guiding software for underwater vehicles
- Design, engineering and construction of underwater vehicles and compression-proof modules
- Virtual test environment for simulation of mobile systems and evaluation of vehicle guidance strategies
- Control functions for the automated inspection of underwater infrastructure, sea cables and pipelines
- Modeling, simulation and optimization of surface water systems
- Flash flood warning systems
- Water demand forecast

**Tasks and Projects**
- AVATARES: autonomous test platform for proving and evaluating driver assistance systems (ARIES Ingeniería Y Systemas S.A.)
- ServiceAssist software adaptation: maintenance software for electric wheelchair systems (Otto Bock mobility Solutions GmbH)
- Z60 controller hardware: development of a mechatronic concept to test and evaluate new additional operating systems for wheelchairs (Otto Bock Mobility Solutions GmbH)
- OTHHELLO: development of a mobile household assistant for people with limited mobility
- KLARA: development of a personal handling assistance to support tasks like grabbing, giving and depositing of low weights through semi-autonomous functions
- Test software for ultrasonic device: special real-time software for inspection systems to characterize ultrasonic transmitters
- SYTECH: Wiring loom fabrication: consulting project about automation solutions for flexible fabrication of wiring looms
- Additional Bluetooth module: concept and implementation of a module which can be integrated into the control unit of a wheelchair to control electronic devices (Otto Bock Mobility Solutions GmbH)
- Maritime systems and surface water
- HAPPI: small hydro power plant – evaluation of the potential of climate protection and improvement by intelligent technology
• 4D project DeDAvE: development of a deep-dive-able autonomous underwater vehicle for exploration
• INAPRO: innovative model- and demonstration-based water management for resource efficiency in integrated multi-trophic agriculture and aquaculture systems
• MoMo II: Integrated Water Resources Management for Central Asia: Model Region Mongolia (FONA – Research for Sustainable Development, BMBF)
• ABB Mina Abdullah (Industry)
• Market survey - Twenty20 - Partnership for Innovation (BMBF)
• EDIT - Pilot system for online monitoring of waterborne pathogens
• ZIM-ASWA - development of a autarkic system solution for water and wastewater treatment with on-line process control in lightweight construction (BMWi)
• ZIM-REWAnET - intelligent automation solution for a resource efficient water supply network management and high-level tank management in drinking water supply systems (BMWi)

1 Module based guidance systems for autonomous vehicles.
2 Mission of the TIETEK AUV.
The objective of the department Information Management and Production Control (ILT) is to develop components and complete solutions for the design, operation and maintenance of complex information, control and test systems. Our focus lies on the application domains of environment, health, risk management, resource efficiency, production and security.

On the basis of agile methods in requirements analysis, system design and recognized architectural and communication standards, we implement open, innovative, and customized software solutions, encompassing and driving new paradigms of the “Internet of Things and Services” as well as “Industrie 4.0”.

We analyze the suitability of modeling and communication methods for:

- Complex manufacturing processes and facilities (e.g. AutomationML and OPC-UA)
- Environmental sensors and models (SensorML)
- Environmental observations (geospatial standards of the Open Geospatial Consortium OGC)

We model customers’ domain-specific knowledge with ontologies (Web Ontology Language OWL). We couple simulators and models on the basis of the High-Level Architecture HLA. Our information management system “WebGenesis®” supports the ontology-driven generation of Web-based information systems and Web portals with complex cross-linking of knowledge elements, problem-specific information analysis and personalized user interaction.

Our research results regarding smart services for the efficient search and retrieval in heterogeneous data sets (“big data”), the extraction of knowledge with data mining methods (incl. semantic annotation) and the fusion of heterogeneous sensor data to meaningful technical information and decision support (“Fusion4Decision”) enrich our products.

In national and international projects we are responsible for the systematic and moderated requirements analysis as well as for the specification and realization of service-oriented and event-driven architectures (SOA/EDA).

We develop thematic applications and connect them to integrated environmental information systems. Our software framework WaterFrame® renders data sources accessible and integrates geospatial information system (GIS) components as well as innovative geostatistical methods. WaterFrame® provides support in generating thematic maps, diagrams and reports.

With the ProVis production suite we realize production control system components and integrated solutions according to functional requirements of MES (Manufacturing Execution Systems). The functions offered by ProVis range from monitoring and managing production facilities up to engineering control rooms and the processes of manufacturing control and fine-granular scheduling. This allows us to deploy production control systems in automotive production sites and the steel industry (soaking pit plants), including the engineering and automatic configuration of these systems and development tools for Web-based analysis and reporting systems.

We develop and run test systems for selected de-facto standards such as Foundation Fieldbus, AutomationML, and HLA. Our objective is to promote the adoption of standards in the market and to support interoperability in open systems. We therefore actively participate in the relevant standardization bodies in VDI/VDE, DKE, DIN, IEC and OGC.
Products

- **WebGenesis®** – Web-based information and knowledge management solutions for applications in the environment, traffic and automation sectors and for the documentation of research projects
- **WaterFrame®** – Java framework for the development of thematic applications and environmental information systems
- **Fusion4Decision** – service pattern and software platform for sensor data fusion and decision support based on OGC standards
- **ProVis.Agent®/Visu®** – agent-based production control and visualization system for managing and monitoring automated production facilities
- **ProVis.Paula** – production and plant data evaluation system with data mining components
- **ProVis.APS** – Web-based fine-granular scheduling system for continuous optimization of manufacturing schedules
- **AutomationML test system** – Web-based conformance testing of AutomationML descriptions, available online at http://amltest.iosb.fraunhofer.de
- **gERTICO** – Modeling and service infrastructure for coupled simulators based on HLA
- **SRL** – Simulation Resource Library for the documentation of simulation tools and models
- **Network Calculus** – methodology for the performance evaluation of communication networks

Infrastructure

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1. Environment portal and environmental information systems.
The Fraunhofer Application Centre for Industrial Automation (INA) in Lemgo, which was founded in fall 2009 in the center of East Westphalia-Lippe, one of the most important regions in the German engineering industry, pursues ambitiously its research vision: “an Internet for Machinery”, in which real-time information in all levels of an automation system is available and can be used by assistance systems for diagnosis and optimization. In this Internet for machinery devices and services should be integrated easily by using the plug-and-play principle. Hardware and software are clearly separated and functions and data are distributed – a cloud for automation emerges. Microelectronics, software technics and system engineering in conjunction with application knowledge from the automation provide the core competencies. Thus, immediately applicable results for IT-based automation products and systems can be offered. Target groups are producers of hardware and software for automation, machine and plant manufactures and operators of technical systems. There the main focus of the INA lies on the provision of required system engineering for automation, to be able to capture, connect and intelligently process information easily. This includes the microelectronic implementation of embedded system functions.

Since 2010 INA is a partner of the Centrum Industrial IT (CIIT). The CIIT, which is based on the Campus of the University of Applied Science East Westphalia-Lippe, is Germany’s first Science-to-Business Center in the field of automation technologies. Under the motto “Where IT meets Automation” science and industry has established an open partner network and develop technologies for future IT-based automation techniques under one roof.

The Fraunhofer Application Centre for Industrial Automation is a research institution in the BMBF-Edge Cluster “Intelligent Technical Systems East Westphalia-Lippe it’s OWL”, which is currently the largest project in the field of Industry 4.0.

Research and development

The Fraunhofer Application Center Industrial Automation implements publicly funded research projects, works in the area of bilateral contract research, develops software and hardware prototypes and designs test and hedging solutions.

Areas of application are industrial IT, automation techniques, the machinery and equipment manufacturing and related sectors.

Currently our work is based on the following priorities:

Cognitive processes for the automation:

In this working group, the development and use of computer models to support the life cycle of complex automation systems is the focus of our activities.

This includes per example:

- Data collection in distributed systems
- Modeling of technical systems (machine learning)
- Real-time forecast of technical systems with the goal of self-configuration, -diagnosis and -optimization, condition monitoring
Embedded Systems for the automation

This field summarizes our capabilities and activities in the development of innovative automation technologies, which are integrated by our partners in their products.

- IP core development (VHDL, Verilog) for system-on-chip solutions (ASIC, FPGA), including verification
- Intelligent networking, for example, based on real time Ethernet and Industrial Wireless
- Middleware solutions (e.g. OPC-UA)
- Design and implementation of embedded real-time systems

Lemgo Model Factory (LMF)

In the CIIT, Fraunhofer Application Centre together with its partner institute InIT – Institute for Industrial IT of the University of Applied Science OWL, operates the Lemgo Model Factory (LMF), as a research platform for IT-based automation. The complexity of design, commissioning and operation of technical systems increases due to increasingly higher demands. Therefore design, commissioning and operation of technical systems become time-consuming and error-prone. The automation technology in use today lack mechanisms for self-configuration, self-optimization and self-diagnosis, ability to face this progress and to suitable support the people. The impact of industrial IT in making technical systems in production processes more intelligent can already can be seen in the Lemgo Model Factory. The Model Factory is a production plant in the laboratory scale, in which real actuator, sensors, bus systems automation components and software of different vendors are implemented. The LMF focuses on the mapping of all information-processing procedures and information- and communication-technologies from the control level up to the sensor. It is a hybrid technical process, ie the plant contains both - continuous and discrete process elements. This offers an ideal proving ground for the testing and validation of innovative technologies and products, as well as for their interaction. Since the end of 2013 the Lemgo Model Factory is part of the German-wide first intern-site production network, which includes plant in Karlsruhe and Ilmenau.

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The acquisition and evaluation of sensory and other data plays a crucial role in many applications: in industry, sensory data, together with process models, establishes the basis for obtaining high-quality, universal functionality of products as well as facilitating an optimal productivity of production facilities.

A full understanding of the processing chain – from data acquisition through processing and evaluation to optimization or feedback into the process, and always considering the dynamics and other characteristics of the process – is essential also for other fields of application, such as environment processes, robotics, traffic and civil security. In this context the Systems of Measurement, Control and Diagnosis (MRD) department offers the following core competencies:

- **Modeling and simulation**
  - Analytical, knowledge-based and data-driven modeling (e.g. using Matlab / Simulink, COMSOL)
  - Block-oriented and finite element models (e.g. of finite element models for material and heat flows)
  - Model reduction and parameter estimation (e.g. under water, using deflectometry)
  - Applications in process engineering, ground water, biotechnology, automated visual inspection and robotics

- **Measurement and sensor techniques**
  - Optical and imaging measurement techniques
  - Automated microscopy
  - Deflectometry and other image-based surface inspection methods
  - Tailored solutions for special applications of common measurement techniques (e.g. laser triangulation in pipes)

- **Control and feedback control techniques**
  - Model predictive and structure-variable control for applications in process engineering, robotics, transportation and traffic engineering
  - Process control using data-driven models
  - Control using imaging sensors (visual servoing)

- **Data analysis for technical processes**
  - Development, adaptation and application of methods for classification, machine learning, and data mining
  - Generation of structure hypotheses, and analyses of causality
  - Performance and condition monitoring
  - Anomaly detection
  - Diagnosis (e.g. to identify cause-effect relationships)

- **Information fusion**
  - Multisensor fusion
  - Dynamic information fusion using heterogeneous sources (e.g. for environmental warning modules)
  - Fusion of image and geometry data (e.g. for pipe inspection, mobile robots, and surface inspection)

- **Robotics**
  - Environment-interactive trajectory planning and manipulation, also in cooperation with humans
  - Simultaneous localization and mapping (SLAM), also using multiple sensory sources
  - Localization, path planning and control, also for cooperating mobile robots
  - Detection of (dynamic) obstacles
  - Control of complex kinematics in mobile robotics
  - Robot control based on ROS middleware

- **Image and signal processing**
  - Real-time image and signal processing, suitable for industrial needs
  - Texture analysis
- Defect detection on surfaces (e.g. using adapted features and classification methods)
- Generation of 3D data (e.g. using deflectometry, sidescan sonars, stereo cameras and other reconstruction methods)
- Processing of 3D data (measurement data and reconstruction results)
- Image processing for applications in robotics
- Use of computer graphics for automated visual inspection

Applications and projects

- Monitoring, control and optimization in process engineering (e.g. chemical and biotechnological processes)
  - Model-based control in process engineering (e.g. for glass drawing and biotechnological processes)
  - Tools for online process monitoring
  - Monitoring of wind energy plants
- Quality and productivity assurance for process and manufacturing engineering
  - Optimization of production processes and products (e.g. for glass drawing processes and crop drying)
  - Tools for evaluating process and product data
  - Surface inspection (e.g. for painted, specular and textured surfaces)
- Sensor systems
  - Sensor development and adaptation for special applications (e.g. pipe inspection)
  - Image-based sensor systems for surface inspection
  - Systems for underwater applications
  - Automated microscopic inspection
- Robot systems
  - Service robots (e.g. for home applications)
  - Mobile assistance and inspection robots
  - Applications of robotics in logistics and production
  - Robots for security applications
  - Agricultural robotics (e.g. for precision farming)
  - Processing of sensor data for underwater robotics
- Assistance systems
  - Assistance for efficient mobility (individual mobility and logistics)

- Energy monitoring and optimization for home applications (e.g. coordination of heating and ventilation)
- Environment and resources
  - Quality control for water supply systems and waste water disposal
  - Early-warning systems for severe weather events (e.g. landslides)
  - Multisensor inspection systems for water pipes and sewer ducts
  - Mass flux management (for water and soil)
- Security
  - Security for drinking water supply (including sensor systems and management systems)
  - Surveillance of buildings and assets
  - Reconnaissance in emergencies (e.g. mapping and localization for assistance robots; detection of victims and hazard sources)
  - Robot-based exploration
  - Mine clearance in former conflict areas

1 Deflectometric inspection of a car body part.
SECURE COMMUNICATION ARCHITECTURES (SKA)

For companies, communication services that function properly are crucial to their survival. This includes globally networked locations, reliable, low-maintenance solutions, as well as protected critical infrastructures for production, energy supply, and logistics.

Our customers benefit from assured confidentiality and authenticity in communication processes, comprehensive, individual solutions, reduction of investments through the use of standards, and low personnel levels for network and security management. Clearly-defined communication and interfaces between IT service providers and customers, and between users and suppliers are a prerequisite for creating a continual improvement process.

Our work addresses the need for improved assurance of privacy and data economy, and for support in collecting and processing personal data. We research and integrate solutions for technical monitoring and assuring that data in surveillance systems is handled in accordance with the intended purpose.

Our current focus is on secure communication between mobile devices, suppression of unauthorized data loss, video surveillance in accordance with privacy-by-design principles, usage control in video surveillance, secure parallel operation of IPv6 and IPv4, private cloud solutions for secure mobile access, as well as consulting and auditing in accordance with ISO/IEC 20000 by certified employees.

On behalf of the Fraunhofer-Gesellschaft, we are responsible for WAN communication at the Fraunhofer IOSB for over 150 locations with more than 23,000 employees around the world, who rely on our centralized range of services for IT security, e-mail, DNS and remote access.

Cyber security
Security is a continual process that is essential for maintaining the effectiveness of necessary technical measures. The loss of sensitive corporate data to unauthorized parties and criminals is currently one of the most serious security issues. For this reason we devote as much attention to attacks and vulnerable points as we do to holistic security management that is, accounting for company processes and statutory boundary conditions.

Data protection in video surveillance
We address the need for privacy and data economy with solutions for monitoring the collection, processing and dissemination of personal data. On a technical level our work ensures that personal data is used only for the intended purpose within the surveillance system.

Watch over me!
Modern video-supported surveillance systems are capable of identifying and tracking persons or recognizing situations. We offer protection concepts for data management and processing. Our solution makes it possible to interactively alert the system through the use of gestures, so that affected parties are able to interact with surveillance systems. We also provide a video-based return channel from security personnel to affected parties, which can be used to handle emergencies in medical environments in particular.

Distributed usage control
Distributed usage control is a generalization of access control. Data can still be controlled once it has left your hands. In order to allow people to control the dissemination and usage of their data themselves, we conduct research for solutions together with Fraunhofer IESE and TU Munich. In the process,
we establish the implementation of legal requirements on data provenance and on the protection of intellectual property.

**An overview of our competences**

**Information security**
- Confidentiality, authenticity and integrity of data communication
- Protection of critical infrastructures
- Creation of robust and secure cryptosystems
- Process-based security management in accordance with ISO/IEC 27000
- Intrusion detection (IDS) and prevention (IPS)

**Identity protection and management**
- Privacy-by-design and data protection in video surveillance
- Distributed usage control
- Acceptance and usability of security and data protection solutions
- Public key infrastructure (PKI) and planning of trust centers

**IT service management in accordance with ISO/IEC 20000**
- Auditing and consulting

**Resources**
- Cyber security lab
- IPv6 security lab
- Privacy-by-design video surveillance

**Tasks and projects**
- Social media for companies – who is in control?
- Secure communication and data exchange between mobile end devices
- Industrie 4.0: intrusion detection in production
- KASTEL: IT security center of the BMBF
- PRECYSE: Prevention, protection and reaction to cyber attacks to critical infrastructures
- CYSPA: European Cyber Space Alliance
- Privacy and security in monitoring systems
- Cloud services providing mobile access for authorities and organizations responsible for security

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1 User interaction with the surveillance system enables transparency.
CORE COMPETENCE
IMAGE EXPLOITATION
CORE COMPETENCE

IMAGINATION EXPLOITATION
INTERACTIVE ANALYSIS AND DIAGNOSIS (IAD)

Profile and competencies

The department Interactive Analysis and Diagnosis (IAD) develops innovative interaction methods, smart environments and assistance systems with the aim of supporting people in various analysis tasks.

On one hand IAD is focused on the development of multimodal interaction within smart environments. The developed interaction techniques apply mostly to video-based interaction methods which cover capturing and tracking of persons, recognition of hand pose and pointing gestures, and analysis of activities within a certain environment using gaze-based interaction and speech.

On the other hand IAD develops assistance systems, which support people in the process of decision-making. Application areas are diagnosis of technical systems, image interpretation, and intelligent surveillance systems. Our concepts take into account the strengths of both computer systems and humans. Computer systems are capable of rapidly saving, searching and calculating large quantities of data. Humans, on the other hand, are still superior to computers when it comes to recognizing and interpreting complex structures in images.

The following solutions are currently provided:

**Multimodal interaction**
- Interaction with multi-display environments
- Video-based posing and gesture recognition for human-machine interfaces
- Gaze-based interaction for video image analysis
- Person tracking for interaction and building automation
- Interaction techniques for mobile augmented-reality applications
- Gesture-based interaction for industrial applications

**Assistance systems**
- Interactive and knowledge-based object recognition
- Situation analysis for crisis management and security services
- Setup of geodata infrastructure and software architectures for surveillance systems
- Optical measurement and vibration analysis applied to wind turbines

The following products and projects are provided:
- SmartControlRoom – An intelligent crisis center including innovative interaction
- Gaze-based interaction for video image analysis
- Digital Engineering Table DigET – Interactive decision support for industrial applications
- Digital Map Table including Fovea-Tablett® – A multi-display workspace for computer-supported collaborative work on geodata
• RecceMan® – Interactive assistant for object identification
• Site Analyst – Assistant for analyzing complex object arrangements
• Maritime situation assessment for the detection of critical situations
• ARTISENSE – Interaction techniques for mobile augmented-reality applications
• Vibration analysis of wind turbines with long-distance laser vibrometer
• Image-based pitch angle analysis for wind turbines
• MCMXT – Embedded system for 3D measurement tasks based on optical markers

1 SmartControlRoom.
2 Gesture controlled Digital Map Table.
3 Smart Video analysis.
INTEROPERABILITY AND ASSISTANCE SYSTEMS (IAS)

Competencies and portfolio

The department Interoperability and Assistance Systems (IAS) offers solutions to the market in which the interaction of people with complex information systems plays the key role. In a “system of systems” approach interoperability is vital.

With research and development projects in the field of software architecture for computer-based assistance systems with a focus on dialog design and semantic interoperability, we contribute to the technical and content networking of systems. By designing dialogs that are adapted to the users and tasks we promote collaborative work using innovative multi-modal and multi-media interaction technologies. With ontology-based information systems, web services and intelligent software agents the knowledge needed is distributed on time to the right people through suitable connections to personalized end-user devices in a layer-compliant granularity. Modern, technology-based learning environments and the use of “serious games” provide users with the required decision-making abilities. Providers of knowledge-intensive services will be supported in focusing on their core competencies and creativity.

The work includes the design, implementation and evaluation of system solutions for interactive sensor data analysis, knowledge creation and integration of knowledge into expert systems to support networked data analysis, the modeling of users, workflows and application domains, as well as competence management in distributed systems. Laboratory and field experiments on demonstrators and operational systems are performed to optimize system performance and to evaluate human-machine communication. In addition to developing basic system architectures that promote interoperability the department’s product range includes components for interactive image analysis, ontology-based specialist databases, network-enabled information management systems, and training and education systems. Compliance with and monitoring of national and international software quality standards is an integral part of the development activities.

Our partners and clients include the German Federal Ministry of Defense (FMOD), Federal Office for equipment, information technology and use of the Armed Forces (BAAINBw), the defense industry and the European Union. In various international cooperations experience in the field of image-based reconnaissance and surveillance is exchanged. In our research we cooperate with universities, colleges and partner institutions. Applications are mainly in the fields of defense and civil security.
Projects and products

- Image database – archiving system for the management of aerial and satellite images
- Image data management system for aerial and satellite image analysis in the field of reconnaissance and surveillance
- SAR Tutor – web-based training tool for SAR image analysis
- Crayons® – Web-based authoring and learning environment
- ViSAR – simulator for visualizing geometric radar effects
- CSD/NSD Coalition/National Shared Database. Client-server system for distributing reconnaissance-relevant information (requests, orders, messages, sensor data and products) in accordance with STANAG 4559
- ISAAC (ISr Artifact Access Client) Software Suite (.lib, .bat, desk, .map, .web) for accessing CSD/NSD servers according to STANAG 4559 (NSLI – NATO Standard ISR Library Interface)
- ISVA – intelligent reconnaissance sensor combination for networking data, information, services and experts
- I2Exrep – database-supported form-based report generation for analysis of aerial and satellite images according to STANAG 3377/3596 and other reporting formats
- DbEd – Data Tree Editor for creation and maintenance of the reporting vocabulary used in image based reconnaissance
- MAJIIC 2 – Multi-INT All-source Joint ISR Interoperability Coalition
- AMFIS ground control station – Generic ground control station. AMFIS (reconnaissance and surveillance with miniature aircraft in sensor networks) for controlling and coordinating stationary and mobile sensors/sensor carriers, and for evaluating sensor data and situation reports

Equipment

- ISVA demonstrator – a hub for national and international secured networks in the field of reconnaissance and surveillance
- SaLVe – radar image database center: a multi-sensor image data archive for remote sensing
- AMFIS – reconnaissance and surveillance with miniature aircrafts in the sensor network (configurable ground control stations, various UAVs, UGVs and sensors)
- A mobile ad-hoc sensor network (GPS, imaging and acoustic, vibration, temperature, motion and light sensors)
- MAJIIC – demonstration laboratory (restricted area): Multi-sensor Aerospace-Ground Joint ISR Interoperability Coalition
- DNBL – development laboratory (restricted area): Distributed Network Battlelab Laboratory for certification and testing of components for networked intelligence gathering and reconnaissance
Expertise and Portfolio

The department Object Recognition (Objekterkennung - OBJ) develops and evaluates algorithms for automatic object detection and object tracking in sensor networks. The department's activities range from the evaluation of video streams in the infrared and visual spectral band and the analysis of laser sensor data to the semantic description of a three-dimensional, dynamic environment via multi-sensory data acquisition and automatic alerting in case of specifically defined occurrences. In addition, real-time implementations of the algorithms are evaluated on the basis of heterogeneous hardware structures.

The research work in the field of Object Recognition in Sensor Networks is focused on the detection and representation of objects in imagery data streams of interconnected mobile sensors. In this context the technologies investigated include aspect-independent descriptions of objects, the registration of sensor-generated images with three-dimensional context data, and bandwidth-economical transfer of object information.

Video Content Analysis combines methods for the detection and tracking of objects in video streams with algorithms for the conceptual description and analysis of the extracted quantitative information. The studies aim at devising systems for the semantic analysis of videos. This means that videos are not only analyzed quantitatively, but that the extracted information is associated with conceptual background knowledge in order to draw conclusions from the visually perceived environment.

Machine vision algorithms extend from simple filtering functions up to complex analysis methods. Currently available hardware also varies with respect to computing performance, programming paradigms, architectures, and power consumption. The field of Heterogeneous Hardware Structures deals with the specification and combination of hardware structures suitable for complex real-time vision systems.

Especially with regard to military tracking systems, performance evaluation is an essential topic. Based on years of experience the field Tracking and Tracker Assessment deals with the development and design of evaluation schemes that interrelate and evaluate both the performance ability of tracking algorithms and the risk analysis, while possible counter-measures are taken into account.

The acquisition and analysis of 3D data is of increasing importance in those application areas that require a high degree of automation and reliability of object recognition. The department's work in the field of Object Recognition in 3D Data is concerned with the development, optimization, and evaluation of methods for 3D data analysis for use with established sensor techniques as well as prototypical hardware. In addition to object recognition, data acquired by these sensors is used for detecting changes and for providing context information for image exploitation.

Selected Projects

- THS® - Target Handoff System
- Semantic Video Analysis
- MODISSA – Mobile Distributed Situation Awareness
- Change Detection in Lidar sensor data
- VibroTrack – distant vibration measurement on running wind turbines
1 Change detection based on two aerial lidar scans: green color indicates manmade structures present in both datasets, whereas red and yellow color indicate vanished or added structures, respectively.

2 The project Semantic Video Analysis aims at detecting, classifying, and conceptually describing events and interrelations of events in visually perceivable scenarios.
Core Competencies and Portfolio

Background of the department’s research activities is the demand of intelligence and reconnaissance for the prompt availability of interpretation results with georeference. This includes both wide-ranging evaluation (screening) and local 3D scene reconstruction, required as a basis for decision making in the context of military operations and disaster management. A multitude of powerful airborne and spaceborne systems, e.g., Heron, SAR-Lupe and TerraSAR-X, deliver data that can no longer be evaluated by humans due to its sheer volume and the resulting work load. Automatic conditioning and processing of the data draws the analyzer’s attention to relevant sections, thereby also enabling the efficient processing of large data volumes. For a fast and precise evaluation, the analyzer needs assistance systems that are able to detect, analyze and classify objects and scene changes.

The Scene Analysis department develops and studies methods for the automatic evaluation of multi-sensor image data in reconnaissance networks. For this purpose efficient procedures are being developed for segmentation, classification, scene reconstruction, change detection, and fusion of a wide range of sensor data. The research focuses on

- Image interpretation
- 3D object analysis
- Cooperative data evaluation in sensor systems
- Exploitation of Synthetic Aperture Radar (SAR) images

For processing large data volumes, the high-performance systems exploit the micro architecture of current workstations. In the scope of image interpretation the analysis of hyperspectral data is of particular importance. Here, methods for the extraction of relevant information take center stage. Applications range from the pure reduction of data for a better utilization of transmission bandwidths to the generation of indications in both single and multiple images (change detection and change categorization). The common exploitation of data from a multi-sensor platform (VIS, LWIR, Hyperspectral and LIDAR) is one of the key features of actual demonstrators or future operational systems. Data fusion and information extraction capabilities are the core competencies for a successful exploitation and are therefore one of the department’s main research activities.

Often a scene can be evaluated properly only if its spatial extent can be determined. Therefore, the Scene Analysis department develops procedures for the automatic derivation of 3D descriptions of urban terrain based on the evaluation of multi-sensory image data acquired by spaceborne, airborne, or land-based reconnaissance systems.

To utilize the efficiency of networked sensor systems, the method of interconnected sensor data evaluation must be designed based on the “system of systems” concept. For this purpose, procedures are being developed which relate the data of imaging sensors to a common reference frame. The potential applications from the fusion of sensor data up to a real-time-generated overview of situations are being analyzed and adequate procedures realized.

Only few sensors can acquire evaluable image data, irrespectively of the daytime or current weather conditions. The performance of imaging radar systems, with a synthetic aperture (SAR) is hardly limited in this regard. Because of their phase-preserving evaluation, interferometric SAR systems are able to capture the 3D shape of a scene. Furthermore, by using time series, minimal surface movements can be detected. SAR images are difficult to interpret by a human due to the specific mapping characteristics. Therefore, interpretation support is particularly valuable. SAR image analysis and simulation are

SCENE ANALYSIS (SZA)
therefore among the core competencies of the department, with a special focus on feature analysis, change detection and change categorization in SAR data.

**Research work focuses on the following core topics:**

**Image interpretation**
- Efficient screening procedures for the analysis of large data volumes
- Structural change detection
- Analysis of hyperspectral image data
- Fusion and exploitation of data from multi-sensor systems

**3D object analysis**
- Reconstruction of 3D objects from image sequences or laser scanner data
- Automatic derivation of 3D building models from 3D point clouds
- Image-aided navigation

**Cooperative data evaluation for networked sensor systems**
- Information fusion of sensor data and geo-information
- Automatic georeferencing of image contents
- Preparation of sensor data showing urban terrain for simulation systems

**SAR image exploitation**
- Feature extraction and analysis, change detection and categorization
- Simulation of SAR image signatures for interpretation assistance (CohRaSS: Coherent Raytracing-based SAR Simulator)
- Determination of ground heaving or depression by means of time series
- Model-based building reconstruction from interferometric SAR images

1. Evaluation of hyperspectral sensor data.
2. View on an automatically extracted model of the scene „Vaihingen“ with buildings, vegetation and terrain. 
   ISPRS Benchmark: 
   www.isprs2012.org/abstract/1113.asp
Competences and portfolio

Especially in image sequences pattern and situation recognition play a vital part in the fields of disaster management, criminalistics, homeland security, defense against terrorism, driving assistance, and industrial quality control. The complexity and demands for robustness, reliability, and efficiency of the results are steadily increasing.

The Video Exploitation Systems (VID) department is active in the fields of automatic processing and exploitation of image signals in complex, mainly non-cooperative surroundings. The image data comes mainly from image acquisition sensors in multi-modal platforms (space, air, land, or water). VID develops and integrates software for image processing, fusion, and exploitation for autonomous and human-operated systems. The main sensors to be exploited are visual-optical, infrared, SAR (Synthetic Aperture Radar), and others. A major aspect of our work is the realization of components to be integrated into larger systems. In specific cases we can also develop the whole system. Further areas of expertise of the department include interoperability in heterogeneous networks and application domain knowledge. The use and performance profile of the developed software are measured by benchmarking and with test systems. Current activities include the development of components for land vehicles, unpiloted air systems, autonomous land robots for surveillance, and security applications. Military applications – the exploitation of airborne and space-borne imagery – are also being developed.

Another focus lies on developing new methods in the field of situational awareness and biometrical approaches.

Tasks and projects

- ABUL – Automatic Image Exploitation for Uninhabited Aircraft: Exploitation of video streams in ground control stations. Main systems:
  - LUNA drone: UAV-based system for tactical purposes (deployed by the German Bundeswehr in Afghanistan)
  - ADS-95 RANGER: UAV-based system for border surveillance
  - MISAR: Exploitation of SAR image sequences
  - HERON: NATO STANAG 4609 streaming test system
  - DNBL: Integrated system (connected with PPQ, Airbus Defence image exploitation system) for NATO exercises
  - SD9.4: Visualization and processing of STANAG 4609 video streams in the SD9.4 net as VM ware application

- VABUL – Video Database ABUL: video database for the Swiss Confederation
  Interactive see-through augmented-reality device: augmented-reality device with integrated eye tracking

- NEST – Network Enabled Surveillance and Tracking: Open system architecture for multi-sensor property surveillance

- Federal Ministry of Education and Research (BMBF): Video-assisted systems for detecting conspicuous movement patterns, attacks and assaults, and abandoned luggage

- Federal Ministry of Education and Research (BMBF): Video-assisted system for riot detection

- Federal Ministry of Education and Research (BMBF): Person detection in forensic mass data

- Federal Ministry of Defense (BMVg): Automatic camouflage assessment
- Federal Ministry of Defense (BMVg): Robust tracking of moving objects from moving platforms in real-time
Federal Ministry of Defense (BMVg): Image and image feature fusion (e.g. for automatic image stitching with high precision)
- European Union (EU): System for offshore monitoring (detection of illegal border crossings and, smuggling of people, weapons, and drugs)
- European Union (EU): System for the detection of vehicle collisions
- European Union (EU): Body identification assistance system

1 Automatic Exploitation of Aerial and Satellite Image Data.
2 Pose and gaze estimation for mobile information systems.
COMPETENCES AND RESEARCH TOPICS

The Variable Image Acquisition and Processing (VBV) Research Group develops methods and systems for automated visual inspection that are based on variable image acquisition techniques, or, more generally, exploit various kinds of heterogeneous information. Multiple theoretical and application-related issues studied here in close cooperation with the other departments of the IOSB and the Vision and Fusion Laboratory (Lehrstuhl für Interaktive Echtzeitsysteme – IES) of the Karlsruhe Institute of Technology (KIT) include:

- Holistic systems theory-based modeling of image acquisition and optimization of the evaluation process
- Reproducible acquisition of optimal image series, for example by variation of illumination, focusing, camera position and optical filters
- Fusion of data from the image series and from the other available information sources
- Online control of the variable acquisition parameters (Active Vision)
- Inspection and reconstruction of partially or fully specular surfaces

The variability of image acquisition is crucial if a single image does not fully capture the features of interest of a studied object or scene. The control system may then take multiple images, adjusting the parameters – such as the camera’s position or field of view (for example to improve visibility of the occluded objects) – or switching to different spectral bands. In combination with data fusion, this may provide a description quality that is hardly if at all achievable with other inspection methods. Facilitated by the availability of inexpensive camera and manipulation systems and by the progress in modeling and planning algorithms, this kind of approach paves the way for novel applications where traditional methods would fail or not be flexible enough.

PROJECTS

- Situation analysis in maritime surveillance systems
- Navigation of autonomous deep-sea vehicles
- Object classification in reconnaissance and surveillance via imaging sensors
- Dynamic infrared pattern generation for deflectometric inspection
- Open adaptive modeling of the environment for artificial cognitive systems
- Probabilistic planning methods for deflectometric surface inspection
- Optical signal pre-processing in spectroscopy and 3D shape measurement
- Model reduction for non-linear and spatially distributed processes
- Underwater Vision: acquisition and exploitation of underwater imagery
- Interactive techniques for augmented reality environments
- Detection of surface defects based on deflectometric measurement data using wavelet analysis
- Person identification and face recognition in video data
- Control of cyber-physical production systems
- Methods of face registration, 3D reconstruction, and super-resolution in video data
- Methods of classification in hyper-spectral inspection
- Planning and execution of maneuvers for autonomous vehicles in traffic
- Analysis and generation of regular and statistical textures
- Methods for specular 3D reconstruction
Infrastructure and equipment

**Robot laboratory:**
The laboratory’s industrial robot provides precise, automated, and reproducible adjustment of the image acquisition geometry. For example: illumination re-positioning allows very complex objects to be captured with a high degree of accuracy. In addition to traditional camera-based inspection, the laboratory is used for the inspection of specular objects with a deflectometric sensor head.

**Infrared deflectometric laboratory:**
Certain diffuse surfaces (such as metal sheets used in auto bodies) are specular when observed in the thermal infrared spectrum allowing their accurate inspection for the presence of dents, waves, and irregularities using deflectometry. However, unlike thermal infrared cameras, long-wavelength imaging devices are not readily available. The laboratory hosts several prototypes of devices to generate fast thermal deflectometric pattern series. In particular, one prototype utilizes a powerful laser to “draw” a pattern on a moving plastic band.

**MiniCAVE laboratory:**
Typically, the smaller the pattern projection screen, the longer a deflectometric inspection of a complex object takes. The radical way to increase the inspection area processed with a fixed camera-screen constellation is to completely enclose the object in a shell that serves as a screen. The MiniCAVE laboratory is equipped with digital projectors that enable a nearly complete coverage of the environment with encoding patterns (displayed on the walls and the ceiling). The research here is focused on calibration and measurement techniques in such environments and the associated advantages and challenges for the inspection tasks.

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MinR Norbert Michael Weber  
Bundesministerium der Verteidigung, Bonn

Christoph Winterhalter  
ABB AG Forschungszentrum Deutschland, Ladenburg

Gäste im Kuratorium:

Andreas Ernst  
Rheinmetall AG, Düsseldorf

Dr. Thomas Steckenreiter  
Bayer Technology Services GmbH, Leverkusen

Ständige Gäste im Kuratorium:

Dr. sc. techn. h.c. Dietrich Ernst  
Erlangen
INTERNATIONAL GUESTS AND VISITING SCIENTISTS

Qiucheng Li, PhD-Student, China Agriculture University Beijing, China, 1.9.2012-31.8.2016

Dr. Eduard Santamaria, Post-Doc Stipendium, ERCIM Fellowship, Universitat Politecnica de Catalunya, Spanien, 1.1.-31.5.2013

Prof. Daoliang Li, Head of China-EU Center for Information & Communication Technologies in Agriculture (CICTA), 16.1.-6.3.2013

Dr. Zhenbo Li, Scientist at Faculty for Information & Communication Technologies in Agriculture, 16.1.-28.1.2013

Dr. Xinhu Chen, Scientist at Faculty for Information & Communication Technologies in Agriculture, 16.1.-28.1.2013

Prof. Yaoguang Wei, Scientist at Faculty for Information & Communication Technologies in Agriculture, 2.4.-6.6.2013

Dr. Chunli Zhang, Scientist at Faculty for Information & Communication Technologies in Agriculture, 2.4.-6.6.2013

Dr. Yingyi Chen, Scientist at Faculty for Information & Communication Technologies in Agriculture, 15.7.-31.8.2013

Dr. Qui Ying, Scientist at Faculty for Information & Communication Technologies in Agriculture, 15.7.-31.8.2013

China Agriculture University Beijing, China,

Baena Galle, Doktorand, University of Barcelona and Royal Academy of the Sciences and Arts of Barcelona, Spanien, 1.2.2013-31.8.2013

Dr. Yaping Gao, Scientist at Yellow Fishery Research Institute, 26.2.-4.3.2013

Prof. Jihong Zhang, Yellow Fishery Research Institute, 26.2.-4.3.2013

Yellow Fishery Research Institute, Qingdao,

Italo Toselli, Italian citizen from the Italian Marine, ERCIM scholar (prior to that Naval Postgraduate School, Monterey, CA, USA), 1.9.2013-31.8.2014


Herr S. Elbegbayan, Director of the water and wastewater company of Darkhan, Mongolia, 21.11.-1.12.2013

Mr. Benoit Mellier (FR), Mr. Ric Schleijpen (NL), Mr. Keith Naylor (GB), Mr. Neil Towning (GB), Mr. Jan Bekkeng (NO), Mr. Anders Clausen (DK), NATO-Gruppe SCI-239, 17.-19.12.2013
MITARBEIT IN ARBEITSKREISEN
WORKING GROUPS

Counter - Improvised Explosive Device
Ilja Kaufmann (Spokesperson),
Jan Bartels, Yvonne Fischer, Jürgen Geisler, Wolfgang Groß,
Klaus Jäger, Alexander Schwarz, Peter Solbrig

Health & Care
Kym Watson (Spokesperson),
Thomas Bernard, Yvonne Fischer, Michael Heizmann,
Joris Ijsselmuinen, Andreas Jakoby, Ilja Kaufmann, Erik Krempel,
Kristian Kroschel, Andreas Meissner, Eduardo Monari, Markus
Müller, Tanja Schultz, Rainer Stiefelhagen, Igor Tchouchenkov,
Michael Voit, Frank Weichert, Andreas Wenzel

Maschinelles Lernen (Machine Learning)
Oliver Niggemann (Spokesperson),
Christian Frey, Vladimir Hinze, Christian Kühnert,
Fabian Müller, Matthias Richter, David Schaffranek,
Andreas Wenzel, Sebastian Wuttke

Mobile Endgeräte (Mobile Devices)
Simon Lemaire (Spokesperson),
Frank Pagel (Spokesperson),
Björn Böttcher, Alexander Enderle, Peter Frühberger,
Tianyi Guan, Marcus Hebel, Mario Kaufmann, Erik Krempel,
Birger Krägelin, Siegbert Kunz, Christian Negara,
Michael Okon, Daniel Szentes, Florian van de Camp,
Hylke van der Schaaf

Multispektral (Multi Spectral)
Thomas Längle (Spokesperson),
Sebastian Bauer, Jürgen Beyerer, Carsten Dachsbacher,
Jörg-Detlef Eckhardt, Wolfgang Gross, Robin Gruna,
Michael Heizmann, Matthias Michelsburg, Christian Negara,
Fernando Puente, Henning Schulte, Uwe Sörgel,
Günter Struck, Kai-Uwe Vieth, Max Winkelmann

Oberflächeninspektion (Surface Inspection)
Michael Heizmann (Spokesperson),
Robin Gruna, Sebastian Höfer, Ilja Kaufmann, Thomas Längle,
Wolfgang Melchert, Eduardo Monari, Thomas Müller,
Christian Negara, Max-Gerd Retzlaff, Martina Richter,
Matthias Richter, Masoud Roschani, Henning Schulte,
Alexander Schwarz, Miro Taphanel, Markus Vogelbacher,
Stefan Werling, Mathias Ziebarth

Eduard Santamaria, Igor Tchouchenkov, Rainer Schönbein, Florian Segor received Best Paper Award for the publication “Path Planning for Rapid Aerial Mapping with Unmanned Aircraft Systems”. The Eighth International Conference on Systems (ICONS 2013), Spain, Seville, 27.1.-1.2.2013

Jutta Hild, Elke Müller, Edmund Klaus, Elisabeth Peinsipp-Byma, Jürgen Beyerer were awarded Best Paper Award for the publication “Evaluating Multi-Modal Eye Gaze Interaction for Moving Object Selection”. The Sixth International Conference on Advances in Computer-Human Interactions (ACHI), France, Nice, 24.2.-1.3.2013

Jochen Meidow received the Hansa-Luftbild-Award 2013 for his article: “Efficient Multiple Loop Adjustment for Computer Vision Tasks” published in the journal “Photogrammetrie – Fernerkundung – Geoinformation” in the course of the 33rd Scientific-Technical Annual Conference of the German Society for Photogrammetry, Remote Sensing and Geoinformation of the Hansa Luftpil Bild plc, represented by Dr. Paul Harfield (member of the board), Germany, Freiburg, 28.2.2013

INNOVATIONSPREIS-IT (Innovation Prize-IT) under the patronage of the Ministry for Economics, Labour and Transport of Niedersachsen, BEST OF 2013, Solutions: Business software, EMS-EDM PROPHET®, 20.3.2013

Alexander Schick received the Industriepreis 2013 (Industry Pize 2013) in the category research & development for “Gesteninteraktion der Qualitätssicherung” awarded by Huber Verlag für Neue Medien during the Hannover Messe 2013, 3.4.2013

Marcus Hebel was awarded Förderpreis Geoinformatik 2013 for his dissertation: “Änderungsdetektion in urbanen Gebieten durch objektbasierete Analyse und schritthaltenden Vergleich von Multi-Aspekt ALS-Daten”, The award was given by Verein Runder Tisch GIS e.V., Technische Universität München, 10.4.2013

Andrea Zielinski received Best Research Paper Award for her publication: “Detecting Natural Disaster Events on Twitter across Languages”, 6th International Conference on Intelligent Interactive Multimedia Systems and Services, Portugal, Sesimbra, 26.-28.6.2013

David Münch, Ann-Kristin Grossefinger, Wolfgang Hübner, Michael Arens received Best Paper Award for their article “Unconstrained Online Configuration of a Master-Slave Camera System, 9th. International Conference on Computer Vision Systems ICVS 2013, Russia, Saint Petersburg, 16.-18.7.2013

Buren Scharaw received an honor by the Ministry Road, Transport, Construction and Urban Development Mongolia during the BMBF-delegation trip an, 2.9.2013

Prof. Maurus Tacke from the NATO Research and Technology Organisation (NATO-RTO) was honored with the Von Kármán Medal for his impressive career, his dedication and his personal contribution to improving the research and technology cooperation between the NATO-States in the field of optronic.

The Von Kármán Medal is the highest honor, which this committee awards. The Von Kármán Medal was conferred on Prof. Tacke in Vilnius during the Fall 2013 STB Symposium 18.-20.9.2013.

Thomas Usländer, Arne J. Berre, Carlos Granell, Denis Havlik, José Lorenzo, Zoheir Sabeur, Stefano Modafferi received Best Scientific Paper Award for the publication: “The Future Internet Enablement of the Environment Informations Space”. ISESS 2013, Austria, Neusiedl am See, 9.-11.10.2013

Tobias Munz passed his exam as IT administrator with distinction (“sehr gut”). He was awarded “BEST AZUBI” by the Fraunhofer-Society.
BESONDERE VERANSTALTUNGEN
SPECIAL EVENTS


VDI Zukunftskongress Industrie 4.0
Leistungsspektrum des GF Automatisierung
Düsseldorf, 30.1.2013

Counter-IED Workshop, Fraunhofer IOSB, Organisation: I. Kaufmann, Ettlingen, 29.-30.1.2013, ca. 40 Teilnehmer

47. Regelungstechnisches Kolloquium in Boppard, Ausrichtung durch das Fraunhofer IOSB, organisatorische Leitung: Dr. M. Heizmann, Boppard, 20.-22.2.2013, 33 Beiträge, ca. 200 Teilnehmer aus Hochschulen und Industrie

Seminar »Sonne, Mond und Planeten«, Hector-Akademie, Leitung: Dr. J. Krieg, IOSB, Ettlingen, 23. 2.2013, 7 Teilnehmer

Seminar »Wie wird das Wetter gemacht«, Hector-Akademie, Leitung: Dr. K. Stein, IOSB, Ettlingen, 2.3.2013, 7 Teilnehmer

16. SpectroNet Collaboration Forum, IOSB Karlsruhe, 5.3.2013, 95 Teilnehmer

1. Internationale Konferenz OCM 2013
»Optische Charakterisierung von Materialien«,
IOSB, Karlsruhe, 6.-7.3.2013, 74 Teilnehmer

Seminar »Sehen was andere nicht sehen«, Hector-Akademie, Leitung Dr. K. Stein, IOSB, Ettlingen 20.4.2013, 7 Teilnehmer


Girls’Day – Mädchen - Zukunftstag
Fraunhofer IOSB, Karlsruhe, Ilmenau, 25.4.2013, 40 Teilnehmer


»IEEE International Conference on Robotics and Automation« (ICRA2013), Mitarbeit bei der Koordination der Robot Challenges: Dr. M. Heizmann, J. Petereit, T. Emter, Karlsruhe, 6.-10.5.2013

Workshop »Where is the business in IoT?«, Leitung des Workshops: R. Herzog, Future Internet Assembly, Irland, Dublin, 8.-10.05.2013, 80 Teilnehmer

10th International Conference on Information Systems for Crisis Response and Management, ISCRAM 2013, Chair: Prof. Dr.-Ing. J. Beyerer, Co-Chair: Dr. T. Usländer, Baden-Baden, 12.-15.5.2013, ca. 300 Teilnehmer

EMS-EDM PROPHET Anwendertage für Kunden von EMS-EDM PROPHET®, Ausrichter AST Ilmenau, Auerstedt, 4.-5.6.2013, 50 Teilnehmer
VDI-Fachkonferenz: »Zustandsüberwachung und Optimierung«, fachliche Konferenzleitung: Prof. Dr.-Ing. habil. J. Beyerer, inhaltliche Koordination der Konferenz: Dr. M. Heizmann, Karlsruhe, 12.-13.6.2013, ca. 45 Teilnehmer


Veranstaltung gesamt: 114 Teilnehmer

Workshop: »Marktregulierungen«, Ausrichter: AST, AST Ilmenau, 23.7.2013, 10 Teilnehmer

Tutorial: »Exploiting Social Media for Natural Language Processing: Bridging the Gap between language-Centric and Real-World Applications«, 51st Annual Meeting of the association for Computational linguistics. Leitung des Tutorials: Prof. Dr. S. Ponzetto, Dr. A. Zielinski; 3.-9.8.2013, Bulgarien, Sofia, ca. 60 Teilnehmer


73. Sitzung des Fachausschusses 1.10 »Grundlagen Messysteme« der VDI/VDE-GMA, Organisation und Leitung: Dr. M. Heizmann, Maulburg, 16.9.2013, 9 Teilnehmer

DAAD-Sommerschule »Sustainable Water Management« 2013, Mitausrichter: AST Ilmenau, AST Ilmenau und TU Ilmenau, 16.-27.9.2013, 18 internationale Teilnehmer

IEEE Symposium on Precision Clock Synchronization for Measurement, Control and Communication (ISPCS 2013), Lemgo, 22.-27.9.2013, 150 internationale Teilnehmer

Unified Greding (Messkampagne) 2013

Wehrtechnische Dienststelle (WTD) 81, Greding, 23.-27.9.2013


Sitzung des EMS-EDM Produktbeirates, Ausrichter: AST Ilmenau, 24.10.13, 12 Teilnehmer

MAJIC 2 MAJEX (Simulated Exercise) 2013


Workshop »IT-Administration von EMS-EDM Prophet®«, Ausrichter: AST Ilmenau, AST Ilmenau, 5.11.2013, 11 Teilnehmer

Seminar VS 10.05 »Videoüberwachung für Sicherheitsaufgaben« der Carl-Cranz-Gesellschaft e.V., Organisation und Leitung: Dr.-Ing. G. Grasemann, Karlsruhe, 12.-14.11.2013, 6 Teilnehmer

Sehen, Verstehen, Vernetzen – Technologien des Fraunhofer IOSB für den Bedarf der Streitkräfte, Leitung / Organisation: Prof. Dr.-Ing. habil. J. Beyerer, Dr. J. Geisler, Karlsruhe, 13.11.2013, 87 Teilnehmer

Vortragsreihe: »Informationstechnologie«, Vorsitz: Prof. Dr. J. Jasperneite

Vortragsreihe: »Produktion & Supply Chain«, Vorsitz: Dr. O. Sauer

Kongress Industrie 4.0 – Flexibilisierung durch digitale, intelligente und agile Produktionsnetzwerke, Stuttgart, 18.-19.11.2013, ca. 100 Teilnehmer

Industrie 4.0: Von der Strategie zur Praxis, Süddeutscher Verlag Leistungsspektrum des GF Automatisierung Esslingen, 4.-5.12.2013
TriDec: Tsunami Early Warning System
The TRIDEC-exhibit shows new developments in intelligent data processing for Crises Management based on two examples: a system for early discovery of impending incidents in drilling operations, not unusual at oil/natural gas boreholes, which have the potential to cause enormous damages to the environment, and the Tsunami Early Warning System for the Mediterranean and the Northeast Atlantic (under development). Visitors will be able to let the "Globe" vibrate and see the seismological outcome.

AquaBioTox: Online Monitoring of drinking water quality
Water supply networks are constantly exposed to deliberate or accidental contamination. For the protection of public health there is significant interest in sensors and software systems to answer the following questions: Where is the source of the contamination? What impact will the contamination have on the water distribution network? Which measures are needed to contain the harm? This exhibit presents the online broadband sensor »Aquabiotox« and a simulation tool for the transport of ingredients in drinking water networks.

SENEKA - Sensor Network with Mobile Robots for Disaster Management
The SENEKA project idea aims to provide task forces and rescue teams with sensors and robots capable of forming dynamic networks, thereby significantly reducing the time required for the most important phases of disaster management when it comes to saving lives: reconnaissance of the disaster area and the search for victims and sources of danger. The SENEKA concept is particularly quick and efficient when it comes to exploring an unknown devastated area as the various sensors and robots distributed throughout the area are capable of networking with one another based on the situation (swarming), thereby enabling them to cooperatively complete complex reconnaissance and search missions.
Industrial Smart Grids
Acquisition, monitoring and optimization of energy consumption are getting a central question in plant construction and mechanical engineering. An Industrial smart grid supports the operator of machines and plants to analyze and improve the system performance and efficiency continuously and to seek an optimum working point. An Industrial Smart grid supports a more uniform energy consumption by an active real-time load management as well as to improve the power quality by reducing harmonics. As a result energy costs will be reduced and the life-time of electronic equipment used in production lines will be extended.

The demonstrator shows a technical process with a real-time energy management at the PLC-level and the data communication with the energy provider.

Interactive Video Surveillance
Interactive Video Surveillance systems enable communication with the monitored people. This can happen either via gesture recognition or by mobile devices. These new “active” users aid the operator which now can react faster and more precisely. Important information is send to the security guards mobile devices, which improves reaction time and team coordination.

Additional features become available for the supervised persons. They can receive navigation help and view which personal data is processed by the system. Next to these new features, we will also present the integration of some privacy protection principles, i.e., “Privacy by Design” and “Privacy by Default”. These principles become increasingly important, as they are required in the proposal for the reform of the EU data protection reform.

Gesture recognition in manufacturing
For quality assurance, BMW checks all their bumpers and other painted parts multiple times. Currently, workers have to leave their workplace and enter the results into the quality assurance system after visual inspection. The Fraunhofer IOSB developed a gesture recognition system that can make this process more intuitive and efficient. Pointing gestures are now recognized at the place of inspection to directly tell the quality assurance system the location and type of the production error. The workers do not need to leave the place of inspection anymore and the whole process becomes faster and more intuitive.
CyphWay: The One Device for Secure Communication

Her wide range of use makes tablets and smartphones to be a lucrative destination for espionage. The CyphWay - developed at the Fraunhofer IOSB - closes this vulnerability. The core of the CyphWays is a trusted hardware module. It encapsulates and protects the safety-critical components, such as the en- and decryption unit as well as key management. It ensures optimal protection of sensitive data. A communication module enables the connection of the trusted hardware module to the used terminal.

Deflectometry

Fraunhofer IOSB offers solutions, for measurements and assisted evaluations of painted surfaces. Basing on deflectometry, shape and waviness of surfaces will be analyzed. The FEM based measurement allows the direct, automated comparison with the CAD design as well as the detection of local surface defects. The manual, gesture based evaluation of the measured results and their documentation within the measurement protocol, complete the process. Indexed by gesture control, features are forwarded with position information to the testing system. The completed document contains the 3-D reconstruction and information which have been generated by additional interaction with the object.

VibroTrack

Vibrations are one main issue on the developing and maintenance of wind turbines. Laser vibrometry, based on doppler shift of light, is able to determine vibrations from a distance also on parts of the turbine, where no sensors have been integrated. Fraunhofer IOSB has developed a tracking system and an optimized laser vibrometer, which are able to even scan the moving rotor blades. An image processing system tracks and stabilizes the laser spot on the rotating blade. This allows for scanning the vibration characteristics of the whole blades under real operating conditions.

Microlab

Fraunhofer IOSB combines in its newly arranged microscopy laboratory MikroLab several microscopic devices with different sensor properties each. This combination is achieved by instrumenting well-established automation systems to provide an automatized microscopic inspection. Thinking of quality assurance, microscopic inspection is getting more and more important. In order to preserve given installations a non-invasive way of integration must be followed. The measurement setup given demonstrates an experimental setup by using standard industrial components.
**SpectralFinder: System for real-time distinction of materials**
The system developed by Fraunhofer IOSB uses hyperspectral data for the distinction of materials in real-time. While regular cameras capture colors in only three broad channels (red, green and blue), the system’s hyperspectral videocamera has a spectral resolution of over 130 much finer channels. These allow distinction of chemically different but visually similar materials. Applications include mining operations, airborne evaluation of large areas and also, due to its video capabilities and efficient processing algorithms, moving objects at production lines.

**EO2HEAVEN: Man, Environment and Health**
A global challenge is to better understand the complex relationships between environmental factors, population exposure and their impact on human health. The exhibit builds on results of the FP7 projects ENVIROFI and EO2HEAVEN to demonstrate early warning systems (EWS’) in environmental health relating to air pollution and the water-borne disease cholera. The EWS’ for both decision makers and scientists use a GIS and Spatial Information Infrastructure based upon open standards for web-services. A mobile app to record health data in the field provides data to the EWS.

**SENEKA: Sensor Network with Mobile Robots for Disaster Management**
The SENEKA project idea aims to provide task forces and rescue teams with sensors and robots capable of dynamically forming demand-responsive networks, thereby significantly reducing the time and improving accuracy required for reconnaissance of the disaster area and the search for victims and sources of danger (e.g. gases). The ad-hoc nature of natural disasters (e.g. earthquakes), terrorist attacks and large-scale industrial accidents (e.g. in nuclear power plants) makes rapid, extensive, situation-specific reconnaissance and detection of victims and sources of danger essential for saving lives.

**NurseEye**
Video-based fall- and emergency detection contributes greatly to safety in hospitals and care facilities. Due to highly winding and vast campuses it is often complicated to provide fast and reliable help for those in need without technical support. The care sector comes with additional requirements on data protection and respect for privacy. With the video-pillar care we present novel concepts for emergency detection, alerting of care attendants as well as methods for data protection and acceptance of such technology by staff and patients.
E-world energy & water
2013
Essen, 5.-7.2.2013
Exponat:
- EMS-EDM PROPHET

Leipziger Buchmesse
Leipzig, 14.-17.3.2013
Experteninterview zum Thema Energiewende (Martin Käßler)

HMI 2013
Hannover, 8.-12.4.2013
Exponate:
- SENEKA - Sensornetzwerk mit mobilen Robotern für das Katastrophenmanagement
- AquaBioTox-Demonstrator II
- Gestenbasierte Qualitätskontrolle
- TRIDEC - Tsunami Frühwarnsystem
- NEST-Flughafen-Demonstrator
- Energiedemonstrator
- Industrie 4.0: Virtual Fort Knox (ProVis APS – Feinplanung aus der Cloud)
- BMBF-Stand: Secure-Plug-and-Work
- Stand Fraunhofer-Allianz Energie: Bildschirmexponat »Die Welt der Energie in Zahlen «
- Gemeinschaftsstand mit CIIT Partnern: Spitzencluster »Intelligente Technische Systeme OstWestfalenLippe, it’s OWL «

VfS Kongress
Leipzig, 9.-10.4.2013
Exponate:
- (1,e)-Gateway

Wasser Berlin 2013
Berlin, 23.-26.4.2013
Exponat:
- BMBF-Stand: Touchscreen Exponat MoMo

AFCEA
Bonn Bad Godesberg, 24.-25.4.2013
Exponate:
- ABUL
- AMFIS
- A3GSim
- (1,e)-Gateway
- Blickbasierte Interaktion

IT&Media
Darmstadt, 24.-25.4.2013
Exponate:
- (1,e)-Gateway
- CyphWay

Control 2013
Stuttgart, 14.-17.5.2013
Exponate:
- CCT-Sensor
- Deflektometrie-Sensor

Cloudzone
Karlsruhe, 15.-16.5.2013
Exponate:
- CyphWay
- Cloud für sensible Daten

Jahresfachtagung der Vereinigung des deutschen Brandschutzes e.V. (vfdb)
Weimar, 27.-29.5.2013
Exponate:
- SENEKA - Sensornetzwerk mit mobilen Robotern für das Katastrophenmanagement
- QUANJO TDS

1. Thüringer Elektromobilitätstag
Erfurt, 7.6.2013
Exponat:
- sMobilTy

Fachtagung Produktionsmesstechnik
Buchs, Schweiz, 3. – 4.9.2013
Exponat:
- CCT Sensor
VDMA Kongress
„Intelligenter Produzieren“
Hannover, 16.-17.9.2013
Posterpräsentation: Automatisierung und Industrie 4.0

MSV Brünn
Brünn, Tschechische Republik, 7.-11.10.2013
Exponat:
- Bildschirmexponat »Die Welt der Energie in Zahlen«

It-sa
Nürnberg, 8.-10.10.2013
Exponate:
- (1,2)-Gateway
- CyphWay
- InfoVis
- Cloud für sensible Daten

INTERGEO
Essen, 8.-10.10.2013
Exponate:
- Wingpod
- Beispiel zur Änderungsdetektion im Bergbau
- Software zur Echtzeitklassifikation hyperspektraler Bildsequenzen

VDE-ETG-Kongress 2013
Energietag
Berlin, 5.-6.11.2013
Posterausstellung der Abt. Energie

Medica 2013
Düsseldorf, 20.-23.11.2013
Exponat:
- AutoTrack (Patienten-Tracking-System)

AES 2013
Washington DC, USA, 6.-13.12.2013
Exponat:
- AutoTrack (Patienten-Tracking-System)

ThEGA-Forum 2013
Arnstadt, 14.10.2013
Stand mit Präsentation der Abt. Energie
Adomeit, U.:
- Mitglied der NATO-Gruppe ET-080 »Exploitation of Human Signatures for Threat Determination«
- Vorsitzender der NATO-Gruppe SET-ET-083 »Assessment and modelling the performance of digital night vision image fusion«

Agsten, M.:
- Mitglied VDE Arbeitskreis Smart Grids

Ament, C.:
- Mitglied im Rat der Fakultät für Informatik und Automatisierung der TU Ilmenau
- Gutachter des DAAD: Auswahl für Doktorandenprogramme

Arnoldt, A.:
- Mitglied und Vertreter der Abt. NRG des IOSB-AST im Fraunhofer-Netzwerk Windenergie
- Mitglied im VDE/DKE Backendsysteme

Batz, T.:
- Mitglied der Gesellschaft für Informatik, Fachgruppe Datenbanksysteme
- Mitglied der Gesellschaft für Informatik, Fachgruppe Requirements Engineering
- Mitglied bei Gesellschaft für Projektmanagement (GPM)

Baumann, M.:
- Mitglied im Industriearbeitskreis »Produktionslogistik für die variantenreiche Serienfertigung«

Beyer, J.:
- Stellvertretender Vorsitzender des Fraunhofer-Verbundes für Verteidigungs- und Sicherheitsforschung VVS
- Mitglied des Kuratoriums des Forschungszentrums Informatik (FZI), Karlsruhe
- Vorstandsmitglied des Kuratoriums der Hochschule Karlsruhe Technik und Wirtschaft
- Leitung des Technischen Forums der Firma inspectomation GmbH, Mannheim
- Mitglied acatech - Deutsche Akademie der Technikwissenschaften e.V., München und Berlin
- Sprecher Themennetzwerk Sicherheit, acatech
- Mitglied des Editorial Board der Zeitschrift »Information Fusion« Elsevier
- gewähltes Mitglied im Beirat der VDI/VDE GMA
- Mitglied im wissenschaftlichen Beirat der Zeitschrift at – Automatisierungstechnik der GMA (VDI/VDE-Gesellschaft Mess- und Automatisierungstechnik) und der NAMUR (Interessengemeinschaft Prozessleittechnik der chemischen und pharmazeutischen Industrie)
- Member of IEEE Computer Society
- Member of IEEE Intelligent Transportation Systems
- Member of Society for Industrial and Applied Mathematics (SIAM)
- Member of The International Society for Optical Engineering (SPIE)
- Mitglied der Deutschen Arbeitsgemeinschaft für Mustererkennung e.V. (DAGM)
- Mitglied im VDE
- Mitglied im Beirat der Deutschen Initiative für Netzwerkinformation (DINI)
- Mitglied im Beirat der Zeitschrift »Strategie und Technik «
- Mitglied im Beirat der Zeitschrift »Europäische Sicherheit und Technik «
- General Chair der OCM (International Conference on Optical Characterization of Materials), Karlsruhe, 6.-7.3.2013
- Robot Challenge Chair of the IEEE Conference on Robotics and Automation (ICRA), Karlsruhe, 6.-11.5.2013
- Conference Chair of the ISCRAM 2013, 10th International Conference on Information Systems for Crisis Response and Management, Baden-Baden, 12.-15.5.2013
- Session Chair Conference EOM 106B Automated Visual Inspection, SPIE Optical Metrology, München, 13.-16.5.2013
- Konferenzleiter der vom VDI Wissensforum organisierten Konferenz Zustandsüberwachung und Optimierung, Karlsruhe, 12.-13.6.2013

Bernard, T.:
- Mitglied im NAMUR-Arbeitskreis 2.2 »Prozessführung«
- Stellvertretende Ombudsperson im IOSB zur Sicherung guter wissenschaftlicher Praxis

Bier, C.:
- Mitglied im DIN-Gremium Arbeitskreis »Normung«

Birkle, M.:

Bohn, S.:
- Mitglied VDE Arbeitskreis »Smart Grids«

Boldt, M.:
- Session Chair for the SPIE Conference Session 2: »Infrastructures and Urban Areas II«, and Session 3 »GIS Education«, Conference: Earth Resources and Environmental Remote Sensing / GIS Applications IV

Bretschneider, P.:
- stellv. Sprecher Fraunhofer-Allianz Energie
- Koordinator im Netzwerk »Intelligente Energienetze«
- Mitglied im Netzwerk Windenergie
- Mitglied im Fraunhofer-Netzwerk »Energiespeichersysteme und Netze«
- Mitglied im GMA FA 5.14 »Computational Intelligence« (GI Fachgruppe Fuzzy-Systeme und Soft-Computing)
- Mitglied im BDI-Arbeitskreis »IT für Energimärkte der Zukunft«
- Mitglied im Institut für Energiewirtschaftsrecht Jena
- Mitglied im IEA ECES Annex 26 »Electric Energy Storage - Future Energy Storage Demand«
- Mitglied im Netzwerk Solarinput
- wissenschaftlicher Leiter der Arbeitsgruppe Energiespeicher im Thüringer Netzwerk »Material innovativ Thüringen«
- stellv. Vorstandsvorsitzender des Thüringer Erneuerbare Energien Netzwerk (ThEEn)

Bulatov, D.:
- Reviewer »Photogrammetrie – Fernerkundung – Geoinformation (PFG)«
- Reviewer »ISPRS-Journal of Photogrammetry«

Bürsing, H.:
- Mitglied NATO-Gruppe SCI-239 »Countermeasure Concepts Against Future IR/EO Threats«
Carmer von, C.F.:
- Mitglied in der NATO SET-144 Gruppe »Mitigation of ship Electro-Optical Susceptibility against Conventional and Asymmetric Threats«
- Mitglied der NATO-SET-ET-082 »Naval Platform Protection in the EO/IR Domain«
- Mitglied in der NATO SCI-224 Gruppe »ET on EO & IR-Countermeasures against Anti-ship Missiles«
- Mitarbeit CSSM WG 2 an IR Ship Signature Management Systems, DEu, NLD, CAN, NOR, BEL

Chaves, F.:
- Vertreter des IOSB im Koordinierungsausschuss F+E IuK im Rahmen der Kooperation KEWA des Umweltministeriums Baden-Württemberg

Dimitrov, T.:
- Mitarbeit im BITKOM AK Industrie 4.0

Dimmeler, A.:
- Mitglied der NATO-Gruppe SCI-239 »Countermeasure Concepts against future IR/EO Threats«
- Mitglied der NATO-Gruppe SET-190 »Phenomenology and Exploitation of Thermal Hyperspectral Sensing«
- Mitglied bei EDA DUCAS »Detection in Urban scenario using Combined Airborne imaging Sensors«

Dunau, P.:
- Mitglied in der NATO SCI-212 Gruppe »Performance Criteria for Camouflage Systems derived from Operational Scenarios«

Eberle, B.:
- Chairman der NATO-Gruppe SET-ET-198 »Visible Laser Dazzle – Effects and Protection«
- Mitglied im »Team of Experts« zur Revision der STANAG 4495 »Eye Protection for the individual Soldier – Laser Protection«

Ebert, R.:
- National Member NATO SET Panel
- Governmental Expert of EDA CapTech IAP03 »Optical Sensor Systems & Signal, Image Processing«

Eck, R.:
- Mitglied im Fachbereich 2 »Dienste und Anwendungen« der Informationstechnischen Gesellschaft (ITG) im VDE

Even, M.:
- Mitglied NATO-RTO-SET-145 »Extraction of Geospatial Intelligence Information from Space Borne SAR Sensors«
- Reviewer IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing

Fischer, Y.:
- Technical Program Committee, CogSiMA, San Diego, USA, 25.-28.2.2013

Frey, C.:
- Mitglied im VDI/VDE-GMA-Fachausschuss 5.14 »Computational Intelligence«

Gladysz, S.:
- Mitglied in der NATO SET-165 Gruppe »Adaptive Optics for Laser Beam Delivery and Passive and Active Imaging and Turbulence Mitigation«
- Session Chair, Committee Member, »Adaptive Optics: Methods, Analysis and Applications« 23 - 27 Juni 2013, Arlington, USA
- Reviewer »Optics Express«

Grasemann, G.:
- Arbeitskreis Video des Verbands für Sicherheitstechnik e.V. (VfS), Hamburg
- Arbeitskreis Gebäudemanagement des Verbands für Sicherheitstechnik e.V. (VfS), Hamburg
Groß, W.:
- Mitarbeit bei DEU - CHE Kooperation »Hyperspectral Imaging«
- Mitarbeit bei DEU - ISR Kooperation »Hyperspectral Reconnaissance«

Hammer, H.:
- Mitarbeit bei DEU - ISR Kooperation »Visual Processing, Multisensor Fusion & Exploitation for ISR Application«
- Reviewer »GRSL – Geoscience and Remote Sensing Letters«

Hebel, M.:
- Mitglied der Deutschen Gesellschaft für Photogrammetrie, Fernerkundung und Geoinformation e.V. (DGPF)

Heizmann, M.:
- Stellvertretender Vorsitzender des Fachbeirats des Fachbereichs 3 »Fertigungsmesstechnik« der VDI/VDE-Gesellschaft Mess- und Automatisierungstechnik (GMA) seit 01/2012
- Vertretung des Fraunhofer IOSB im Arbeitskreis der Fraunhofer-Allianz Vision seit 06/2004
- Leitung des Arbeitskreises »Oberflächeninspektion« am Fraunhofer IOSB seit 10/2010
- Mitglied des Fachbeirats 1 »Grundlagen und Methoden der Mess- und Automatisierungstechnik« der VDI/VDE-Gesellschaft für Mess- und Automatisierungstechnik (GMA) seit 01/2013
- Mitglied im wissenschaftlichen Beirat des Kooperativen Promotionskollegs „Entwurf und Architektur Eingebetteter Systeme (EAES)“ der Hochschule Pforzheim und der Universität Tübingen seit 12/2012
- Mitglied im VDI

- Organisatorische Leitung des Regelungstechnischen Kolloquiums in Boppard
- Mitglied im Programmausschuss »International Conference on Optical Characterization of Materials« (OCM-2013), Karlsruhe, 6.-7.3.2013

Herzog, R.:
- MSG-ET-035: Leitung der NATO Arbeitsgruppe »Development of High Level Architecture (HLA) Federation Compliance Test Tool«
- MSG-106: Mitarbeit in der NATO Arbeitsgruppe »Enhanced CAX architecture, design and methodology«
- Mitarbeit in der Standards Working Group des Open Geospatial Consortium »Sensor Web for IoT SWG«

Hild, J.:
- Session Chair auf der DigitalWorld (ACHI), Nizza, Frankreich, 24.2.-1.3.2014

Jacobi, M.:
- Beirat VDI-GMA als Vertreter der Studenten und Jungingenieure des VDI

Jakoby, A.:
- Mitglied AG »Digital vernetztes Unternehmen« Initiative »Weiterentwicklung der IKT in Baden-Württemberg«
- Mitglied Forschungsorientierte sektorale Themenplattform 3 der Polizei
Mitarbeit in Gremien
Participation in Committees

Jasperneite, J.:
- Co-Chair des Subcommittee on Information Technology in Industrial and Factory Automation (IES FA 5) in der IEEE Industrial Electronics Society
- Mitglied der Fachredaktion der ATP (Automatisierungstechnische Praxis)
- Mitglied VDI/VDE Gesellschaft Mess- und Automatisierungstechnik (gMA)
- Mitglied gMA-Fachausschuss 5.12 Echtzeitsysteme
- Mitglied GMA-Fachausschuss 6.15 Zuverlässiger Betrieb Ethernet-basierter Bussysteme in der industriellen Automatisierung (Leitung)
- Mitglied GMA-Fachausschuss 7.21 »Industrie 4.0« - Begriffe, Referenzmodelle, Architekturkonzepte
- Vorstandsvorsitzender OWL-Maschinenbau
- stellvertretender Sprecher der Fraunhofer-Allianz Embedded Systems
- IEEE Senior Member
- Mitglied der IEEE Computer Society
- Mitglied der IEEE Communications Society

Kaufmann, I.:
- Mitglied der »Threat Detection Expert Community« der EDA

Krägelin, B.:
- Mitglied der Gesellschaft für Informatik
- Mitglied der Fachgruppe »Arbeitsplatzsysteme« der Gesellschaft für Informatik
- Mitglied im VDI
- Mitglied im Beirat der Deutschen Initiative für Netzwerkinformationen (DINI)
- Mitglied Sprecherkreis IT-Sicherheitsbeauftragten der Fraunhofer-Gesellschaft

Krempe, E.:
- Mitarbeit in ETCETERA - Workshop: Validation of Future Civil Security Technologies
- Mitarbeit in ETCETERA – Workshop: Framework Conditions of Civil Security Technologies

Kresken, T.:
- Mitglied Allianz für Cyber-Sicherheit
- Mitglied Cyberforum e.V.

Kroli, O.:
- Stellvertreter des IOSB in der Fraunhofer-Allianz SysWasser
- Vertreter des IOSB in der German Water Partnership

Kuntze, H.-B.:
- (Gründungs-) Mitglied des VDI-GMA-Fachausschusses 4.13 »Steuerung und Regelung von Robotern«
- (Gründungs-) Mitglied im VDI/VDE-GMA-Fachausschuss 5.14 »Computational Intelligence«
- Mitglied der Deutschen Gesellschaft für Robotik (DGR)

Kunz, S.:
- Koordinator des EMV-Kompetenzverbundes Fraunhofer EMC
- Mitglied in der Deutschen Gesellschaft für EMV Technologie e. V. (DEMVT)
- Mitglied in der Deutschen Gesellschaft für Produktmanagement (GPM)

Künnert, C.:
- Mitglied im VDI/VDE-GMA-Fachausschuss 5.14 »Computational Intelligence«

Längle, T.:
- Paritätische Kommission zum Leistungsentgelt am IOSB
- Mitglied Personalentwicklungskonzept 2 am IOSB
- Program Chair International Conference on Optical Characterization of Materials (OCM 2013) in Karlsruhe

Li, P.:
- Mitglied der Studiengangkommission Ingenieurinformatik
- Mitglied der Stipendienkommission der chinesischen Regierung für chinesische Studenten
- Beauftragter vom Rektor für den wissenschaftlichen Austausch China-Südasien
Meidow, J.:
- Mitglied der Deutschen Arbeitsgemeinschaft für Mustererkennung e.V. (DAGM)
- Mitglied in der Deutschen Gesellschaft für Photogrammetrie und Fernerkundung (DGPF)
- Mitglied im VDI
- Reviewer »Photogrammetrie – Fernerkundung – Geoinformation (PFG)«
- Reviewer »Measurement Science and Technology«
- Reviewer ISPRS Workshop »CMRT13«
- Reviewer Konferenz »Fusion 2013«

Meissner, A.:
- Vertreter des Fraunhofer IOSB im BITKOM Arbeitskreis Öffentliche Sicherheit
- Mitglied im Beirat des VfS - Verband für Sicherheitstechnik
- Mitglied der ISCRAM Association (Information Systems for Crisis Response and Management)

Michaelsen, E.:
- Co-Chair IAPR-TC7 (International Association for Pattern Recognition – Technical Committee 7, Remote Sensing and Mapping)
- Associate Editor, Pattern Recognition Letters, Elsevier Verlag

Middelmann, W.:
- Mitarbeit bei DEU – CHE Kooperation »Hyperspectral Imaging«
- Mitarbeit bei Detection in Urban scenarios using Combined Airborne imaging Sensors (DUCAS), EDA-Projekt (European Defence Agency) PROJECT ARRANGEMENT No B0294 IAP3 GC

Okon, M.:
- Mitglied im Arbeitskreis Mess- und Automatisierungstechnik (GMA) im VDI Bezirksverein Karlsruhe

Pfrommer, J.:
- Mitarbeit im Fachausschuss 7.21 »Industrie 4.0« der VDI/VDE-Gesellschaft Mess- und Automatisierungstechnik (GMA)

Pfützenreuter, T.:
- Vertreter des IOSB-AST in der Gesellschaft für Maritime Technik e.V.
- Vertreter des IOSB-AST im Subsea Monitoring Network

Rauschenbach, T.:
- Mitglied des VDI / VDE GMA-Fachausschuss 5.14 »Computational Intelligence«
- Mitglied der Gesellschaft für Maritime Technik (GMT)
- Mitglied im VDE
- Mitglied IEEE, Oceanic Engineering Society
- Mitglied Fraunhofer Allianz SysWasser
- Mitglied der Foren bei German Water Partnership (Länderforen China und Vietnam)

Repasi, E.:
- Mitglied der NATO-Gruppe SET-084 »Simulation of Active Imaging Systems«

Ritt, G.:

Roller, W.:
- Mitglied BITKOM Arbeitskreis »Learning Solutions«
- Mitglied im Institutsbildungsausschuss (IBA) des IOSB
- Mitglied im Arbeitskreis» Personalentwicklungskonzept« (PEK) des IOSB
Sauer, O.:
- Leitung des Fachbereichs »Informationstechnik« in der VDI-Gesellschaft gPP
- Leitung des VDI-GPL-Richtlinienausschusses »Digitaler Fabrikbetrieb«
- Mitglied im VDI-GPL-Fachausschuss »Digitale Fabrik«
- Mitglied im VDI-GPP-Fachausschuss »MES«
- Mitglied des VDI-GPP-Richtlinienausschusses »Logische Schnittstelle MES-Maschine«
- Mitglied in der VDA-ITA »Informationstechnologie für die Automobilindustrie«
- Mitglied im CIRP »STC »O« Optimization of Manufacturing Systems«
- Mitglied in der »OPC Foundation«
- Mitglied des Automotive Engineering Netzwerks Südwest
- Mitglied der smartFactoryKL
- Vorstand Wirtschaftsförderung Südwest
- Mitglied im Fachausschuss Modellierung und Simulation
- Mitglied im Fachbeirat Digitale Fabrik@Produktion
- Erstansprechpartner des IOSB in der Innovationsallianz der Technologieregion Karlsruhe

Scharaw, B.:
- Head of Section Central Asia, GWP
- Mitglied des wiss. Rates der Deutsch-Mongolischen Gesellschaft
- Mitglied im Kharaa River Basin Administration

Schilling, H.:
- Mitarbeit bei DEU - CHE Kooperation »Hyperspectral Imaging«
- Mitarbeit bei Detection in Urban scenarios using Combined Airborne imaging Sensors (DUCAS), EDA-Projekt (European Defence Agency) PROJECT ARRANGEMENT No 80294 IAP3 GC

Schleipen, M.:
- Mitarbeit in Arbeitsgruppe »DKE K941.0.2 AutomationML« der Deutschen Kommission Elektrotechnik Elektronik Informationstechnik
- Mitarbeit im DIN AK 060-30-05-04 des Normenausschuss Maschinenbau (NAM, gepflegt durch den VDMA)
- Mitarbeit in im Fachausschuss 7.21 »Industrie 4.0« der VDI/VDE-Gesellschaft Mess- und Automatisierungstechnik (GMA)
- Mitarbeit im Fachausschuss 142 »Manufacturing Execution Systems« der VDI-Gesellschaft Produkt- und Prozessgestaltung (GPP)
- Mitarbeit in der Arbeitsgruppe »Digitaler Fabrikbetrieb« der VDI-Gesellschaft Fördertechnik Materialfluss Logistik (FML)
- Mitarbeit in der IEC Working group 9 of SC 65E
- Stellvertretende Vorsitzende der Arbeitsgruppe »Schnittstellen MES Maschinenebene« des Fachausschusses 142 »Manufacturing Execution Systems« der VDI-Gesellschaft Produkt- und Prozessgestaltung (GPP)

Schönbein, R.:
- Mitglied der Deutschen Gesellschaft für Wehrtechnik e.V., Bonn
- Mitglied der Human Factors and Ergonomics Society, Santa Monica, USA
- Mitglied im Fachausschuss T 5.4 Anthropotechnik, Deutsche Gesellschaft für Luft- und Raumfahrt (DGLR)
- Mitglied im Editorial Board of the International Journal On Advances in Systems and Measurements (IARIA Journals)
- Mitglied im Programmausschuss ICONS

Schuchert, T.:
- Mitglied der Deutschen Arbeitsgemeinschaft für Mustererkennung e.V. (DAGM)
Schulz, K.:
- Conference Co-Chair for the SPIE Conference »Earth Resources and Environmental Remote Sensing/GIS Applications«, RS08
- Session Chair for the SPIE Conference Session »Infrastructures and Urban Areas«, RS08
- Session Chair for the SPIE Conference Session »Environmental Monitoring II«, RS08
- Deutsch-Israelische Kooperation TA 17, Working Group 4, Hyperspectral Imaging
- Member of IEEE Geoscience and Remote Sensing Society
- Mitglied NATO-RTO-SCI-248 »Vulnerability of NATO operations to current and future commercial space-based Synthetic Aperture Radar (SAR) sensors«
- Mitglied NATO-RTO-SET-145 »Extraction of Geospatial Intelligence Information from Space Borne SAR Sensors«
- Reviewer »Photogrammetrie – Fernerkundung – Geoinformation (PFG)«
- Reviewer »Information Fusion« Elsevier

Schwarz, A.:

Schweitzer, C.:
- Mitwirkung in der deutsch-israelischen Arbeitsgruppe SBMD »Satellite Based Missile Detection «

Sander, J.:
- Technical Program Committee der 16th International Conference on Information Fusion (Fusion 2013)

Segor, F.:
- Mitglied im Programmausschuss ICONS

Seiffer, D.:
- Mitwirkung in internationaler Arbeitsgruppe (SE, F, NL, UK) TA 108.019 »Laser beam propagation and imaging through severe environments«
- Mitglied in der NATO SET-143 Gruppe »Radar and Infrared Synergy for Military Situation Awareness «

Sprung, D.:
- Mitwirkung in der deutsch-israelischen Arbeitsgruppe SBMD »Satellite Based Missile Detection «
- Mitwirkung in der Kooperation mit dem Kiepenheuer-Institut für Solarphysik (KIS), Freiburg, »Bestimmung der optischen Turbulenz am Observatorium VTT auf dem Teide / Teneriffa, Spanien «
- Mitwirkung in der deutsch-israelischen Arbeitsgruppe mit dem Soreq / Israel »Wind and turbulence measurements «
- Mitwirkung in der deutsch-südafrikanischen Kooperation mit dem CSIR Südafrika »Determination of the vertical distribution of optical turbulence over savannah «

Stein, K.:
- Chairman der NATO-SET-143 Gruppe »Radar and Infrared Synergy for Military Situation Awareness «
- Mitglied und Chairman der NATO SET-ET-082 »Naval Platform Protection in the EO/IR Domain «, vom 14.-18.10.2013, Niederlande, Den Haag
- Mitglied in der NATO SET-144 Gruppe »Mitigation of ship Electro-Optical Susceptibility against Conventional and Asymmetric Threats «
- Mitwirkung in der deutsch-israelischen Arbeitsgruppe SBMD »Satellite Based Missile Detection «
- International Advisory Board IAB von FOCUS, Schweden
Mitarbeit in Gremien

PARTICIPATION IN COMMITTEES

Steusloff, H.:
- Kurator des Heinz Nixdorf Instituts, Universität Paderborn
- Vorsitzender des DIN-Präsidialausschusses SO-FIE (Forschung, Innovation, Entwicklung)
- Vorsitzender des DIN-Präsidialausschusses FOCUS ICT
- stellv. Vorsitzender der DKE (Deutsche Kommission Elektrotechnik Elektronik Informationstechnik)
- Vorsitzender des DKE-Beraterkreises Technologie (BKT)
- Vorsitzender des DKE-Lenkingausschusses »Elektromobilität« von DKE und DIN NAAutomobil
- Vorsitzender der DKE-Fokusgruppe »Netzintegration Lastmanagement und dezentrale Energieerzeugung« (NeLEDE)
- stellv. Vorsitzender der Regionalkonferenz der TechnologieRegion Karlsruhe
- Mitglied im Forschungsnetzwerk »Normung« des DIn
- Mitglied im Technologieausschuss der IHK Karlsruhe
- Mitglied im Cercle de l’ILL, Straßburg
- Mitglied der China Instrument and Control Society (CIS)
- Mitglied der Gesellschaft für Informatik (gI)
- Mitglied im Verein Deutscher Ingenieure (VDI)
- Mitglied im Beirat des Fachausschusses »Informatik« der Fachgesellschaft GPP im VDI
- Mitglied im Beirat des Forschungsrats des Wissenschaftsrats Deutschland, Sektion Karlsruhe-Bruchsal

Thiele, A.:
- Reviewer »Photogrammetrie – Fernerkundung – Geoinformation (PFG)«
- Reviewer IEEE Transactions on Geoscience and Remote Sensing (TGRS)
- Reviewer IEEE Geoscience and Remote Sensing Letters (GRSL)

Thomalla, C.:
- Mitarbeit im DIN AK 060-30-05-04 Normenausschuss Maschinenbau (NAM, gepflegt durch den VDMA),
- Mitarbeit im MES D.A.C.H Verband e.V., Technik Gruppe UMCM
- Mitglied im VDI/VDE-GMA Fachausschuss »5.23 XML in der Automation«
- Mitglied in der Arbeitsgruppe »Logische Schnittstellen MES - Maschinenebene« des VDI-KIIT, Fachausschuss 2.5.1 »MES«
- Mitglied im VDI
- Mitglied in der Gesellschaft für Operations Research (GOR)
- IOSB-Beauftragter für das betriebliche Vorschlagswesen

Tchouchenkov, I.:
- Mitglied im Richtlinienausschuss VDI/VDE-GMA

Usländer, T.:
- Mitglied im VDI/VDE-GMA Fachausschuss 7.21 »Industrie 4.0«
- Begriffe, Referenzmodelle, Architekturkonzepte
- Mitglied im VDI Fachausschuss »Ressourceneffizienz«
- stimmberechtigter Vertreter der Fraunhofer-Gesellschaft im Technical Committee des Open Geospatial Consortium (OGC)
- Vertreter der Fraunhofer-Gesellschaft im European Virtual Institute for Integrated Risk Management (EU-VRI)
- Technical Representative des IOSB im Industriekonsortium Object Management Group (OMG)
- Vertreter des IOSB im Koordinierungsausschuss F+E IuK im Rahmen der Kooperation MAF-IU5 des Umweltministeriums Baden-Württemberg
- Mitglied in der Arbeitsgruppe 5.11 »Computers and Environment« der International Federation for Information Processing (ifip)

Tacke, M.:
- Mitglied RTB Research Technology Board
- Mitglied Beirat ISL
- Mitglied F&T Beirat des BMVg
- Member SET- 136 STANDEX-Steering Committee
Vieth, K.-U.:  
- Paritätische Kommission zum Leistungsentgelt am IOSB  
- Stellvertreter im Wissenschaftlich-Technischen Rat der Fraunhofer Gesellschaft am IOSB  

Warweg, O.:  
- Mitglied im NPE Unterarbeitsgruppe IKT  
- Mitglied im VDE/ITG Energieinformationsnetze  

Watson, K.:  
- Co-Chair der GEO Health and Environment Community of Practice  
- Mitglied GEO Integrated Global Water Cycle Observations Community of Practice  

Wendelstein, N.:  
- Mitwirkung in internationaler Arbeitsgruppe (SE, F, NL, UK) TA 108.019 »Laser beam propagation and imaging through severe environments«  
- Mitglied in der NATO-SET-174 Gruppe »EO Sensor Performance Modeling«  

Wenzel, A.:  
- Mitglied Fraunhofer Allianz Embedded  
- Mitglied VDI/VDE-GMA FA 7.20 Cyber Physical Systems  

Werling, S.:  
- Beauftragter für Schutzrechte im IOSB (Patente, Marken etc.)  

Westermann, D.:  
- Mitglied im CIGRE SG B4, HVADC and FACTS, Strategic Advisory Group  
- Mitglied im CIGRE WG B4.58: »Devices for load flow control and methodologies for direct voltage control in a meshed HVDC grid«  
- Mitglied im Lenkungskreis Hochspannungs- und Höchstspannungsnetze des FNN  
- Ordentliches Mitglied der Sächsischen Akademie der Wissenschaften, Technikwissenschaftlichen Klasse  
- Mitglied im Beirat der Plattform Zukunftsfähige Energienetze des Bundeswirtschaftsministeriums  
- Mitglied im Vorstand der IEEE Germany Section (Industry Relation Officer) und der IEEE Power & Energy Society Germany (Treasurer)  

Winkelmann, M.:  
- Deutscher Vertreter in der Arbeitsgruppe »Multispectral Camouflage Concealment and Deception« der deutsch-israelischen Kooperation  

Zielinski, A.:  
- Mitglied F-AG7 CLARIN »Angewandte Sprachwissenschaft, Computerlinguistik«  
- Mitglied der COST Action »Multilingual and multifaceted interactive information access« (MUMIA)
PATENTE UND GEBRAUCHSMUSTER 2013
PATENTS AND UTILITY MODELS 2013


Vieth, K.-U.:  
Verfahren zum Einrichten einer dem optischen Identifizieren von Objekten dienender Anlage, Laborbildaufnahmesystem zum Durchführen eines solchen Verfahrens und Anordnung umfassend das Laborbildaufnahmesystem sowie die Anlage  
Method for preparing a system which is used to optically identifying objects, laboratory image capturing system for carrying out such a method, and arrangement comprising the laboratory image capturing system and the system  
DE 10 2012 001 868 A1  
Publikationsdatum 25.7.2013  
PCT/EP2013/050693  
anmeldedatum: 16.1.2013  
WO 2013/110529  
Publikationsdatum: 1.8.2013

Willersinn, D.; Ruf, M.; Scheuermann, B.; Vais, A.; Ziehn, J.; Rosenhahn, B.:  
Verfahren zum Steuern eines Fahrzeugs, Vorrichtung zum Erzeugen von Steuersignalen für ein Fahrzeug und Fahrzeug  
Method for preparing a system which is used to optically identifying objects, laboratory image capturing system for carrying out such a method, and arrangement comprising the laboratory image capturing system and the system  
DE 10 2013 225 057.6  
anmeldedatum 5.12.2013  
DE 30 2013 006 547  
intragungstag 30.10.2013  
Wortmarke »CyphWay®«  
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DE 30 2013 017 309  
intragungstag 11.3.2013  
Wortmarke »THS®«  
EM 011492758  
Veröffentlichungstag 14.10.2013  
Wortmarke »TISIM®«
LEHRTÄTIGKEITEN
TEACHING ACTIVITIES

Ament, C.:  
- Regelungs- und Systemtechnik 1, SS 2013  
- Regelungs- und Systemtechnik 2, WS 2013/14  
- Modellbildung, WS 2013/14  
- Systemidentifikation, SS 2013  
- Fuzzy und Neuro Control, WS 2013/14  
Fakultät für Informatik und Automatisierung, Technische Universität Ilmenau

Beyerer, J.:  
- Mustererkennung, SS 2013  
- Automatische Sichtprüfung und Bildverarbeitung, WS 2013/2014 (im WS 2013/2014 als beste Wahlvorlesung durch die Fakultät für Informatik des KIT ausgezeichnet)  
- Seminar: Technologie-gestütztes Lernen, SS 2013  
- Seminar: Bildauswertung und -fusion, SS 2013 und WS 2013/2014  
- Proseminar: Anthropomatik: Von der Theorie zur Anwendung, SS 2013 und WS 2013/2014 (gemeinsam mit Prof. Uwe Hanebeck)  
Fakultät für Informatik, Karlsruher Institut für Technologie (KIT)

Bier, C.; Birnstill, P.; Krempel, E.:  
- Blockseminar »Interdisziplinäres Seminar - Datenschutz zwischen Technik und Recht«, WS 2012/2013  
Fakultät für Informatik, Karlsruher Institut für Technologie (KIT)

Breitseidner, P.:  
- Vorlesungsbeitrag zum Thema Energieprognose im Rahmen der Lehrveranstaltung Elektrische Energieversorgung III von Prof. Westermann, SS 2013  
Fakultät für Elektrotechnik, Karlsruher Institut für Technologie (KIT)

Geisler, J.:  
Fakultät für Informatik, Karlsruher Institut für Technologie (KIT)

Heizmann, M.:  
- Einführung in die Informationsfusion, WS 2013/2014  
Fakultät für Informatik, Karlsruher Institut für Technologie (KIT)

Heizmann, M.:  
- Verteilte Messsysteme, 15.-19.4.2013  
Blockveranstaltung am Chinesisch-Deutschen Hochschulkolleg (CDHK) der Tongji-Universität, Shanghai, China

Jasperneite, J.:  
- Rechnernetze, SS 2013  
- Communication for distributed systems (CDS), SS 2013  
- Maschinenraum Vernetzung, WS 2013/2014  
- Weitverkehrsnetze, WS 2013/2014  
Fachbereich Elektrotechnik und Technische Informatik, Hochschule Ostwestfalen-Lippe, Lemgo

Längle, T.:  
- Echtzeitsysteme, SS 2013  
- Projektpraktikum Robotik und Automation I+II, SS 2013  
- Informatik für Naturwissenschaftler und Ingenieure I, WS 2013/2014  
Fakultät für Informatik, Karlsruher Institut für Technologie (KIT)  
- Kognitive Systeme, WS 2013/2014  
Fachbereich Informations-technik, Duale Hochschule Baden-Württemberg (DHBW), Karlsruhe

Hübner, W.:  
- Zweidimensionale Signale und Systeme, WS 2013/2014  
Fakultät für Elektrotechnik, Karlsruher Institut für Technologie (KIT)
Li, P.:  
- Regelungs- und Systemtechnik 1, SS 2013  
- Prozessoptimierung 1, SS 2013  
- Prozessoptimierung 2 / Dynamische Optimierung / Optimal Control, SS 2013  
- Hauptseminar Simulation und Optimale Prozesse, SS 2013  
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