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Automated Visual Inspection

Essay: Software Agents

Semantic Interoperability

Essay: Safety and Security

Risk Management



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Editorial

Dear friends of the IITB,

»The whole is much more than the sum of its parts« – this statement applies not only to well-functioning systems, but is particularly true of the IITB. With its ten business units and research groups, the IITB encompasses the computer-supported activities in the field of information technology at all of its levels of abstraction at great breadth and depth.

From sensor-based signal interpretation in the business units »Visual Inspection Systems«, »Measurement, Control, and Diagnostic Systems« and »Autonomous Systems and Machine Vision« to the handling of symbolic knowledge in the business units »Interoperability and Assistant Systems«, »Guidance Systems« and »Information Management« a seamless spectrum of competencies is available at the IITB. Complex tasks can be comprehensively transformed - from signal to action - into tailor-made solutions. Complete systems, not just individual components, are a particular strength of the IITB. Professional project management and high quality work round off the palette of competencies, resulting in high repeat customer rates for the IITB of > 5 orders / customer.

Based on these solid foundations, the IITB is now focusing and deepening its core competencies. At the same time, the goal is to organically expand the IITB's strengths in order to – in the words of our president – 'strengthen our strengths'. Synergies, as yet unrealized, will be developed through structurally intensified communication and greater substantive networking among the business units. To this end, working committees were formed for seven strategically important key topics, where our scientists from different business units will work together with the goal not only to maintain but to expand their excellent competencies in these fields.

These key topics are: Agents, Fusion of Heterogeneous Information, Image Acquisition and Interpretation, Cooperative Real-time Systems, Resource Management, Security, and Knowledge Representation.

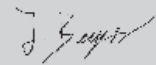
A main priority will be to further sharpen the profile of the institute's priorities in the area of Automated Visual Inspection and Image Interpretation through the creation of a new research group »Variable Image Acquisition and Processing«, in close cooperation with the new professorship »Interactive Real-time Systems« at the University of Karlsruhe (TH).

Karlsruhe, February 2005

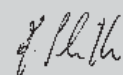
Jürgen Beyerer



Jürgen Beyerer



Jörg Schütte



Themes

Automated Visual Inspection and Image Inter – Increasing our Efforts



As of March 1 2004, Professor Dr.-Ing. Jürgen Beyerer is the Director of the IITB and holds the newly-created Professorship in Interactive Real-Time Systems at the Department for Information Technology at the University of Karlsruhe (TH), where he studied electrical engineering from 1984 to 1989. He received his doctorate in 1994 from the Institute of Measurement and Control Technology under Professor Franz Mesch. In 1995, his thesis on texture analysis received the Measurement Technology award of the AHMT (Working Committee of University Teachers of Measurement Technology). He subsequently formed a research group for Automated Visual Inspection and Image Processing at the same institute. He qualified for a university lectureship in measurement technology (Habilitation) in 1999 with his thesis: »Assessment of Prior Knowledge in Measurement Technology«.

He then went to work in industry with the firm of Hottinger Maschinenbau GmbH, a mid-size mechanical engineering company in Mannheim. His job consisted in building up the subsidiary of Hottinger Systems GmbH with a focus on automated visual inspection and robotics. Under his leadership,

Hottinger Systems attained the leading technology and market position for visual inspection systems for Casting. In February of 2004 he left the Hottinger Group to accept positions at the IITB and the University.

His goal is to increase the success of the IITB by using his scientific and industry experience and to set the course for the future development of the institute. Because of his background, visual inspection and image processing are at the heart of his interests.

The IITB has a long and broad-based scientific tradition, especially in the fields of automated visual inspection, image interpretation, knowledge-based image processing, and assistant systems for complex tasks in image interpretation.

The IITB even developed its own hardware components in real-time operations of time-critical inspection systems.

Divided into the four business units -Visual Inspection Systems, Autonomous Systems and Machine Vision, Interactive Analysis Diagnosis and Interoperability and Assistance Systems - a total of 70 full-time employees as well as 35 scientific assistants have been working very successfully on a broad spectrum of civil and military image



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pretation



Professor Beyerer's thematic focus during the past 5 years:
Automated visual inspection in the rough environment of foundries –
Systems of the Company of Hottinger Systems GmbH / Mannheim.

interpretation tasks. World-wide more than 250 IITB systems are successfully used in industry and in the public sector – with considerable benefit to the clients.

Our goal is to intensify and expand our efforts in three ways:

- To strengthen the scientific and project-based cooperation among all nine business units of the IITB and to put in place the structural measures required to improve networking. In addition to the synergies already existing between the business units highlighted in the previous section, the cooperation in image processing envisages the inclusion of the business units Information Management and Measurement, Control, and Diagnostic Systems.
- Formation of a new research group to function as nucleus for a future business unit concerned with applied »Variable Image Acquisition and Processing«. The goal is the optimal application of degrees of design freedom in the layout of image acquisition constellations of automated visual inspection systems. The geometric and optical parameters of the recording situation are numerous (e.g. object, lighting, ac-

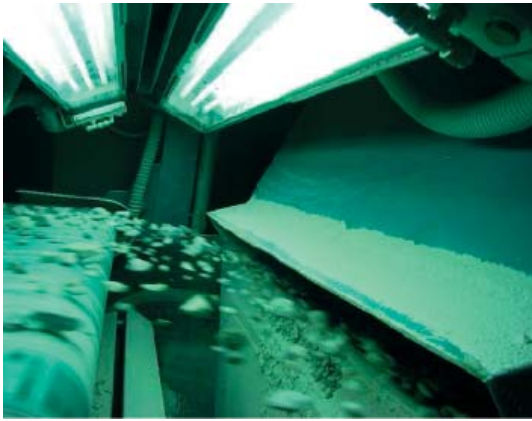
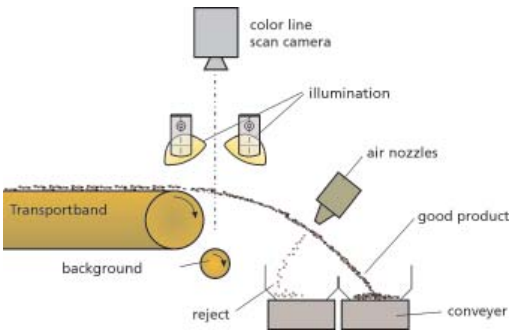
quisition system). The scientific inquiry is concerned with, e.g., the optimal planning of the acquisition constellation and all its parameters, the deliberate variation of parameters to achieve image series of higher information content, and the fusion of image series into extremely precise resulting images.

- Finally, the topic will be researched theoretically at the newly created chair in close cooperation with the group at the IITB.

The chair will be concerned with researching problems such as : information content of images, economical scanning of the parameter space and the resulting acquisition of optimal image series of minimal size, as well as the active feedback of image information into the recording process enabling active scene exploration. The ultimate goal is the development of a suitable systems theory to deal with both theoretical and practical problems.

With this orchestrated, broad-based approach to a diverse complex of topics, chances are good that novel approaches will be developed and turned into effective total solutions to meet our clients' needs.

A visual inspection system from the IITB as used, for example, by the Paltenhaler Company, Austria for the automated sorting of gravel.



good gravel

bad gravel

Software Agents – Beneficiaries of Ontologies as Knowledge Representation

In today's information society, enormous amounts of directly accessible information are at our disposal. In addition to the benefits, there are, however, a number of problems resulting from this flood of information:

The variety of data formats and information sources can, for example, mean that relevant information cannot be used directly or found in time, i.e. because the machine of the user lacks the programs to read the particular data format. This necessitates a support system for the user to enable the following: identification, access, and retrieval of the desired information as well as categorizing, summarizing, filtering and interpreting existing information.

This type of support is made possible by progressive software architectures, in which intelligent software agents cooperate with the user and each other to provide the necessary services.

Software Agent Characteristics

The programming paradigm for software agents was introduced in the early 90's. A software agent is a program which possesses the following characteristics (Jennings and Woolridge, Nwana):

- Agents are autonomous, i.e., they operate without direct intervention on the part of the user, and they have a certain control over their actions and their inner state.
- Agents have social capabilities, i.e., they interact with the user and with

other agents by means of an agent communication language. Communication takes place on a semantic rather than a syntactical basis, i.e. it takes place not by following commands but rather in response to requests, offers, inquiries, explanations, etc.

- Agents are reactive, i.e. they are aware of their environments and react on time and in appropriate fashion to changes taking place in this environment. Environment is defined as follows: a user via graphic user interface, a collection of other agents, the internet, or all of the above combined.
- Agents are proactive, i.e. they do not simply react to their environment but are in fact capable of demonstrating goal-oriented action by taking the initiative.
- Agents are self-learning, i.e. they can improve their problem-solving behavior based on previous problems, environmental situations, and solutions achieved in the past.

Depending on their properties, agents are classified as follows: Collaborating, cooperative agents, autonomous agents, intelligent agents, and mobile agents.

Based on type and method of application, the following distinctions are made:

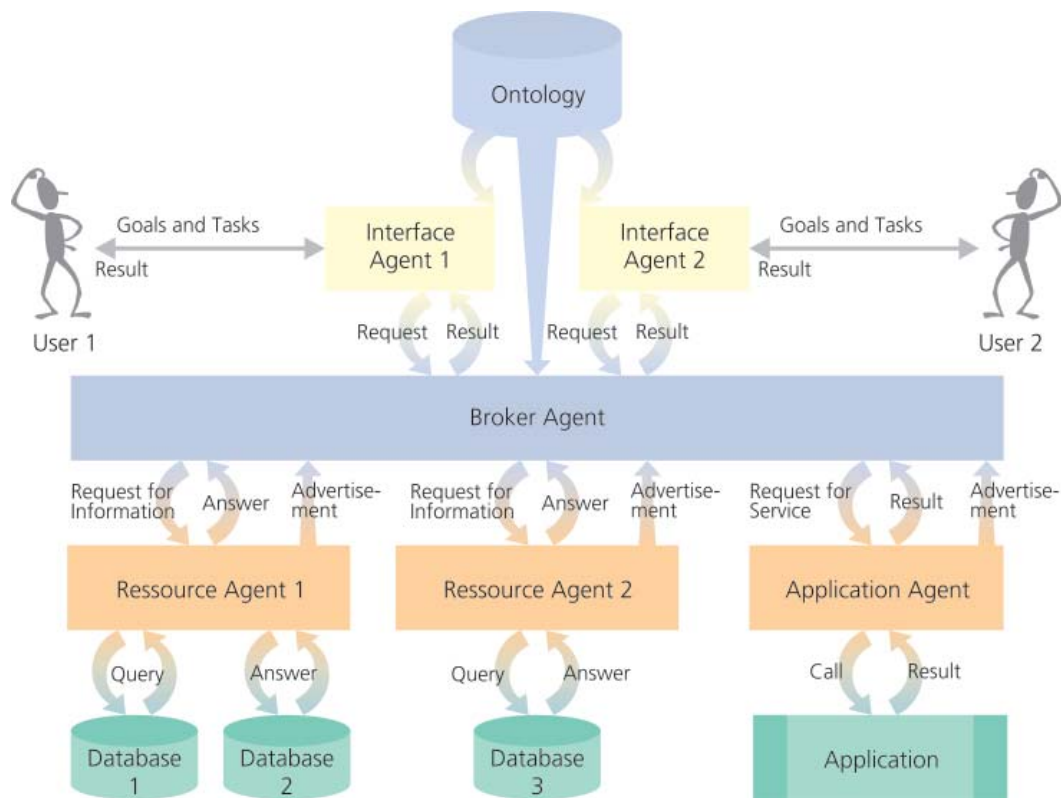
- Service agents which, for example, carry out access to data bases, document libraries, and knowledge bases and also start executable programs and control their execution.



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General architecture of a cooperative information system.

- Request agents which interact with the user, act on his commands, collect needed relevant information, present the user with the results of services, request additional information from the user if necessary, and, ask the user for confirmation in critical situations.
- Broker agents which provide services as so-called brokers or matchmakers. To carry out their tasks, broker agents require expert knowledge in the application domain on the one hand, and the capabilities of the other agents in the system.

The knowledge required by agents is based on modeling of concepts, relationships, and rules by means of ontologies which make human understanding of facts and processes accessible and processable to software agents. »Intelligent« software agents are thus realizable in the future.

Sample Projects:

The IITB has been working in the area of agent technologies for the past five years and has successfully completed several projects and systems using agents.

In the ISVA project (Intelligent Sensor Network for Reconnaissance) a cooperative information system is being developed on the basis of software agents and ontologies (see illustration).

In the ProVis.Agent guidance system, production and system monitoring are coupled with surrounding subsystems. ProVis.Agent enables an easier integration of existing systems, external systems, and special functions.

In OVID (Strengthening of self-organizing capabilities in traffic using LuK – supported systems) the IITB is developing a software-based infrastructure for

the simulation of future telemetric services in traffic planning and control.

In CHIL (Computers in the Human Interaction Loop) computer services are being developed by means of software agents that observe humans and evaluate their activities and intentions. By taking into consideration the entire recognized context, these CHIL-services will be capable of unobtrusive support of humans with only a minimum of human attention.

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Semantic Interoperability through Ontologies Interactive Image Interpretation in Remote Reconnaissance



Karlsruhe, aerial image taken by the IKONOS satellite.

Introduction

The term 'ontology' originates in philosophy and describes the aspect of meta-physics which deals with the nature of existence and existing. As used in IT, the term ontology signifies the representation and formalization of knowledge. According to Gruber, »an ontology is an explicit specification of a conceptualization« (Gruber 93). In this sense, ontology refers to a description of concepts (terms) and relationships within a certain domain, which the user can share with a software agent or a group of software agents. Ontologies represent a key technology for semantic networks.

Ontologies combine human understanding of symbols with the processing capabilities of machines (Gomez-Perez et al. 2004). To simplify the reusability and exchange of knowledge, it is advantageous to manage it in different ontologies. This is particularly true in information search in networks and in network supported cooperative processes.

Interoperability in Remote Reconnaissance – the ISVA-Ontology Concept

The goal of the ISVA ontology (intelligent sensor interconnection reconnaissance, Schönbein 2005) is the support of an application in the search for persons, information and services in the area of remote reconnaissance to simplify reconnaissance and surveillance; of particular interest is the simplification of interactive image interpretation in this area of application. The search for persons or organizations include place and time related options, e.g. an expert or service provider must be located in a specific radius of the actual site of operation, or an expert with special knowledge of the site must be found who is available at a specified time.

The search for information also has to take into consideration the properties of the underlying data, e.g., the date of generation, size and type of data is



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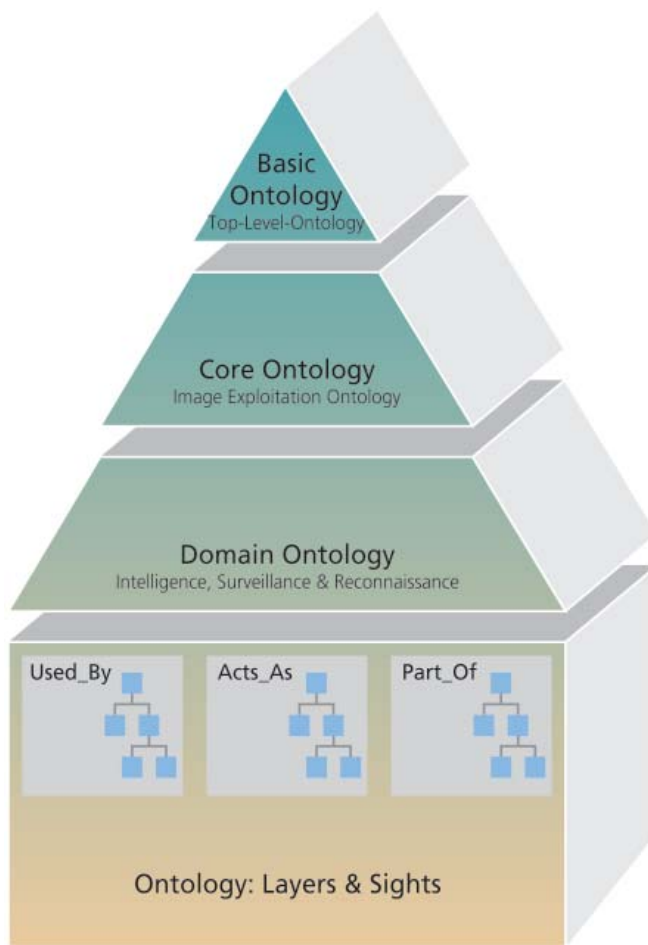
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of interest to the searcher. Another important aspect is the thematic classification of data according to the domain ontology. In addition to relating various areas of knowledge, alternative user, or service-specific views between domain objects must be supported. Image interpretation or the required underlying tasks are services offered by means of these ontologies in accordance with the needs of the user of the service. This requires a detailed syntactic and semantic specification of the service through the service provider. Based on this specification, alternative services can be found and compared. A user must also specify his requirements from the service. In addition to name and description of service, this also includes cost, required time, and quality of the service.

To improve the clarity and above all to facilitate improved reusability, the ontology to be developed is divided into several supporting partial ontologies (illustration). Starting with a top level ontology with the fundamental basic concepts (e.g. person, organization, address, means of communication, place, direction, time, status), followed by an image interpretation ontology (core ontology) with description of concepts of the interactive image interpretation (e.g. service, service group, service parameter, target area, provider, owner, user, user profile, costs, quality, time requirement, information, interaction concept, geometric objects, texture), a domain ontology can be created for the field of remote reconnaissance. This ontology includes the description of observ-

Basic design of the ISVA ontology.



able objects (e.g. land vehicles, aircraft, ships, cultivated areas, terrain, persons of interest). In addition to the static descriptions of object properties, possible activities of those objects are included. To this end »roles«, and »variants«, as well as status of objects are modeled as concepts explicitly using taxonomic relationships.

Application

The ISVA ontology described here is applied as a component of a software agent-based cooperative information system for intelligence, surveillance and reconnaissance. The ongoing development is part of a research project sponsored by the BMVg (Federal Ministry of Defense) and BWB (Federal Office of Defense Technology).

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Fachbereich Informatik, 2005

»No-one gets out of here without paying!« with these words, security guards pushed customers back into a burning shopping center and locked the few exits which had not been welded shut. Almost four hundred people died in Asunción, Paraguay on August 1, 2004. Smoldering carbon particles in a kitchen vent had caused the devastating fire in the largest shopping mall of the city.

This horrific event highlights the two facets of 'safety' on the one hand and 'security' on the other with 'security' as the prevention of intentional harm and 'safety' as a measure against negligent or accidental damage. By welding shut emergency exits, the owner of the shopping mall gave precedence to security over safety, fearing loss due to theft more than injuries and death of his customers through fire and smoke inhalation.

German knows only one word, 'Sicherheit', for the certainty of humans to remain free from harm. It refers to the flank of vulnerability, in other words to the point of susceptibility to danger. At this point, it is immaterial whether the damage occurred intentionally or accidentally. This is where the measures for the protection of humans are effective. These measures are intended to strengthen, steel, and immunize a person against damaging effects: from fire-proof clothing and bullet-proof vests, from gas masks to firewalls, the iron curtain of the computer system. Protection at the point of vulnerability

is always reactive and allows the danger to evolve. The advantage of protective measures is that they can be tailored exactly to the susceptible flank. The disadvantage lies in the fact that these measures must always be carried along in anticipation of potential danger, even if they may never be needed.

The closer one gets to the source of danger, the more essential it is to separate intention and accident, safety and security. Establishing safety / security at the source of danger means defense; it is proactive and constitutes the recognition and neutralization of impending danger. It illustrates the cyclical process of the guaranteeing of safety/security: from the recognition of the danger and the decision as to what protective and defensive measures to use, to the employment of these measures, and finally to the recognition of the success of these measures.



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Process



This process can be applied in three phases: preventative, acute, or rehabilitating. In the preventative phase, danger is suspected and preventative measures are taken. In this phase there is uncertainty as to the actual potential for danger. A reliable evaluation is essential here in order not to get stuck in an ever-present suspicion of danger. In the acute phase, however, the danger is present and clear. The main goal is the fast and decisive protective and defensive reaction. The rehabilitative phase begins when the danger has already developed; damage control is the purpose of this phase. It necessitates a solid organization of measures to be taken which will work effectively even in the presence of catastrophic damage.

To actively meet dangers, it is necessary to understand their causes. This is relatively successful when the cause of the problem is accidental albeit natural

phenomena such as weather or forms of human failure or failure of technical apparatuses. The better researched the accidental sources of dangers are, the more effectively they can be met at their source, and remedies can be initiated. It is a 'game' against nature and against the fallible nature of man. This game can be won in the long run. The safety / security processes converge. Before long, a far-reaching automation of the security process can be achieved.

If the adversary, however, is a human intent on causing damage, the process no longer converges. This constitutes a 'security' issue; here we are faced with an adversary intent on evading apprehension, one who camouflages himself, who deceives.

Technical solutions for the recognition of and defense against danger help only temporarily, i.e. until the adversary

recognizes the rules underlying the counter measures and changes his modus operandi. Recognition of and defense against 'security' threats are determined by the clash of human interests. This requires an active, continuous, and tenacious human effort in the security process.

Technical aids are essential tools which help significantly, above all, in improving the perception of the impending danger. These tools to meet security threats are always in the service of humans engaged in these interpersonal types of conflict and whose essential interaction with the technical tool consists mainly in constantly adapting the process for the conflict with the adversary.

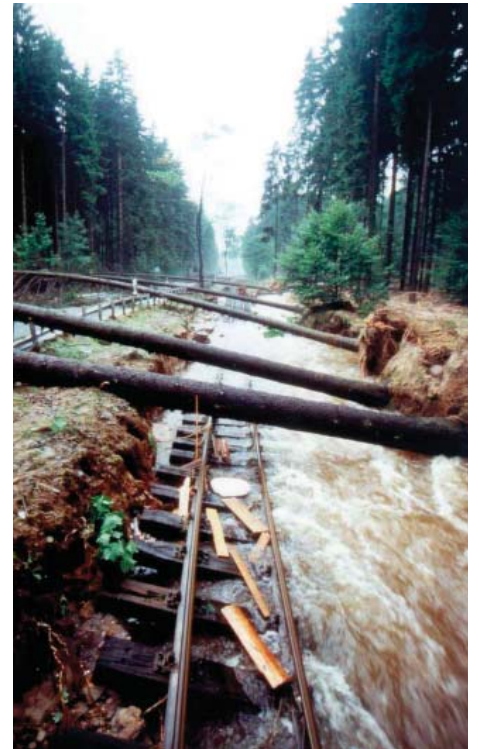
Risk Management in Natural Disasters

Interoperability of Information Services Increases the Efficiency in Preventive Disaster Management

The Elbe River floods of 2002, numerous wildfires in the record heat of 2003, the sinking of the tanker Prestige off the coast of Spain in 2002 – the increasing intensity and frequency of such events, also in Europe, in the past few years have led to a heightened awareness in politics and in the public of safety issues relating to natural disasters.

While experts around the globe argue about the socio-economic and geo-scientific causes and preventative measures, agreement exists on the following: effective access to information of all types, be it geographic or thematic maps, measured data, damage reports or weather predictions, plays a vital role in risk identification, analysis, and required measures during disasters. Risk management constitutes the preventative, integrated actions taken to deal with these tasks. Information Technology (IT) plays a key role in this.

Risk management tasks in Europe are mainly handled by public institutions on a variety of administrative levels, each with their own IT systems for the provision of data and services. The ability to share all relevant data, especially in disasters which cross international borders, is, however, often very limited. But even in cases where the exchange of data is possible in principle, different data formats or service interfaces as well as differing expert views on the nature of the problem make fast inter-



pretation of the existing data sets very difficult. A lot of 'manual labor' is required to process the data in such a way that reliable and definitive information and statements to aid in the decision making can be derived.

The integrated EU project ORCHESTRA (Open Architecture and Spatial Data Infrastructure for Risk Management) initiated in September of 2004 has taken on this information technological challenge. The goal of the 3-year project is the specification and implementation of an open, service-oriented software architecture to improve the syntactic and semantic interoperability in the area of risk management.



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The following tasks in particular are addressed:

- development of an effective and highly functional but generic software infrastructure to enable expert service applications even for multi-risk management tasks such as floods, forest fires, earthquakes, or man-made risks.
- integrated treatment of spatial, time, or object-related information
- explicit handling of border-spanning aspects of technology, administration, and natural language
- explicit modeling and utilisation of expert knowledge using an ontology-based approach
- validation of the ORCHESTRA software infrastructure in practical, border-spanning application scenarios.

The Fraunhofer IITB has taken the leading role of software architect in the ORCHESTRA project and will contribute to the specification and implementation of the generic software infrastructure. In this project, the IITB can build on its

many years of experience in the development of the Web Content Management System 'WebGenesis' and the 'WaterFrame' product line in the field of water information systems.

A major challenge for ORCHESTRA is the EU commission's request to come to technical agreements on the following projects which play a central role in environmental and disaster management:

- INSPIRE – the EU-wide initiative for the development of a European spatial data infrastructure
- GMES – the EU-wide initiative for the use of air and satellite images for global environmental and security surveillance
- OASIS – the integrated EU project for the provision of an open crisis management system.

Because of this open, standard-oriented approach, the result of ORCHESTRA is of vital importance to the IITB in the entire field of 'security / safety'.

References:

INSPIRE – Infrastructure for Spatial Information in the Community, <http://www.ec-gis.org/inspire/>

GMES – Global Monitoring for Environment and Security, <http://earth.esa.int/gmes/>

OASIS - Open Advanced System for Improved Crisis Management, <http://www.oasis-fp6.org/>

ORCHESTRA - Open Architecture and Spatial Data Infrastructure for Risk Management, <http://www.eu-orchestra.org/>



Working Committee

»Knowledge Representation«

At the annual strategy meeting in 2004 it was decided to form interdisciplinary working committees to deal with important key issues at the IITB.

The goal of these committees is the interdepartmental preliminary investigation and processing of research topics of the various business units to then pass on the knowledge gained to the various internal projects. We plan to introduce the various working committees in coming editions of this magazine, beginning in this edition with the introduction of the working committee on 'Knowledge Representation' which is led by Rainer Schönbein of our 'Interoperability and Assistant Systems' business unit. (See page 8). The committee is made up of representatives from five different business units of our institute and plans to illuminate the topic according to their differing needs, perspectives, and applications.

The long-term goal of the committee is the acquisition of scientific progress in the field of knowledge representation. Initially, the guiding principle for the selection of suitable technologies in support of relevant projects will be an analysis of various representation systems structured according to type of knowledge and quality of knowledge.



Thematic areas will include questions of standardization, reusability, and tool support. In addition, gaps in the basics and application of technologies will be identified, and proposals for improvement will be worked out. Projects, and possibly ideas for products, are to be formulated from this process. The committee has set an initial target of one year for the exploration of these questions.

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Working Committee

»Safety / Security«



After introducing the »Knowledge Representation« committee, the committee on »Safety / Security« is introduced here.

Safety / security is a needs and market-oriented topic. The initial goal of the committee is to organize this complex field according to terminologic criteria and to put them into the context of current technological and market-oriented activities at the IITB.

To this end, the common core of the various activities at the IITB related to safety / security applications will be identified and analyzed as to their synergy potential: included are a wide range of applications from military reconnaissance, video monitoring in police work, accident and disaster management, to virus and spam protection, and from information technology to robot safety.

In addition to sharing reciprocal information on ongoing activities in the various business units, the committee will develop a common technology and marketing strategy for systematic safety / security solutions: solutions which support the guaranteeing of safety/security as a process (see essay page 10) and which aim beyond advanced technological components for a theory-guided synthesis of components towards a generic system of guaranteed safety / security.

The committee consists of members from six different business units and is led by Mr. Jürgen Geisler, the coordinator for »Safety / Security and Defence« at the IITB.

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