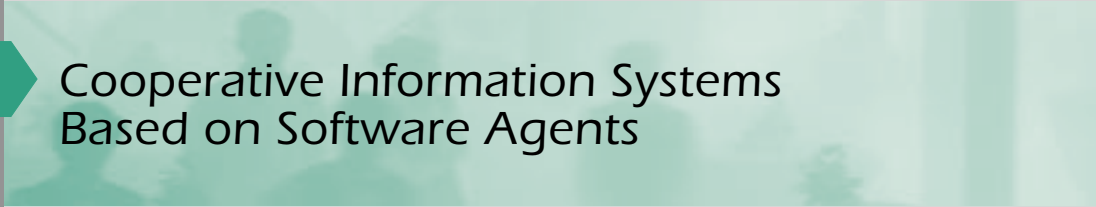




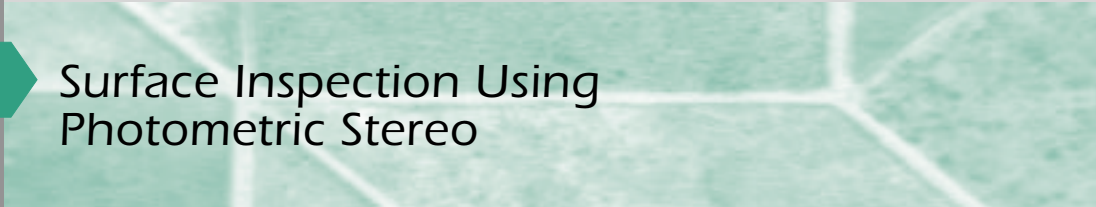
Cooperative Information Systems
Based on Software Agents



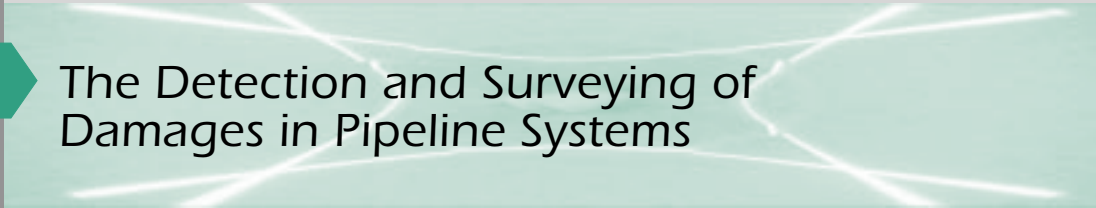
Interaction with Automatic Image
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Surface Inspection Using
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The Detection and Surveying of
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A Comprehensive Network of
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People Making News

► Ladies and gentlemen,

The secret of getting ahead is getting started. The secret of getting started is breaking your complex, overwhelming tasks into small manageable tasks, and then starting on the first one.

Mark Twain (1835-1910)

A characteristic property of modern IT systems is complexity which can be measured through the number of system internal objects and their interdependability. This complexity of systems prevents a single human brain from completely understanding and predicting their behaviour. The only promising approach of dealing with highly complex systems combines decomposition and collaboration.

The projects presented in this issue of visIT International represent the ever valid and indispensable sequence of information acquisition (sensor systems), information processing (image interpretation), human interaction for evaluating the information and, closing the loop, information feedback to production and services processes.

The “art” of problem decomposition and collaborative achievement of advanced results is very often still a matter of learning by doing. Neither elementary education nor university courses impart this art to young people familiarizing them with the insight of such fundamental ways of carrying out work on complex systems. This should be the task of even pre-elementary education since research found that the individual ability of analyzing and describing complex facts is developed already during the fourth and fifth years of human life.

Collaboration means doing things together in a well defined order! Joint problem decomposition, skilful collaboration of system users and suppliers and applying the results of the decomposition phase in a well controlled way: The secret of successfully managing complex IT projects!



Hartwig Steusloff

A handwritten signature in cursive script.



Hans-Achim Kuhr

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Jörg Schütte

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CISSA

Cooperative Information Systems Based

The aim of modern IT technologies is to free humans from routine tasks, creating more time for substantive decision-making. The solicited CHIL project (Computers in the Human Interaction Loop) designs a vision of the 'invisible' computer as an intelligent assistant in the support of human-human communication. Analogous to a human assistant, the computer stays in the background, observes the 'user', acts proactively e.g. by activating equipment or by acquiring data and taking care of organizational tasks. The user no longer needs to communicate directly and explicitly with the machine (by giving commands).

▶ Agent-based Shared Infrastructure

Using a systems architecture based on the concept of software agents, cooperative information systems adapt themselves to the user and work proactively; i.e. agents in the role of intelligent assistants support man-machine communication/ interaction and represent the interests of the user inside the system without having to be asked directly to perform certain tasks. These agents fuse information and have the capability to learn through a knowledge base and a control-

based inference machine. Services to be performed are recognized dynamically, called up and aggregated. To this end, the infrastructure framework requires a syntactic as well as a semantic description.

The motivation for the application of such an architecture results from two projects currently carried out at the Fraunhofer-IITB:

- With the GSSW project (German Smart Sensor Web), a flexible, secure, and dynamic network was conceived which enables not only the availability of information serving the requirements of all command levels, processing, and presentation of information for military and political users, but also allows access to relevant services.

- In the ProvisAgent project, the goal of the Fraunhofer IITB is the networking of the individual components of a production control system with a software platform which is not built on to a manufacturer-specific platform, but which employs a generally-accessible software technical approach. This greatly simplifies both the integration of existing functional components of built-on systems and the networking with external products.

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on Software Agents

Generic Architecture

The generic software architecture of the CHIL project can be seen in the illustration:

The ontology includes the common terms, relationships and rules of business of the application domain.

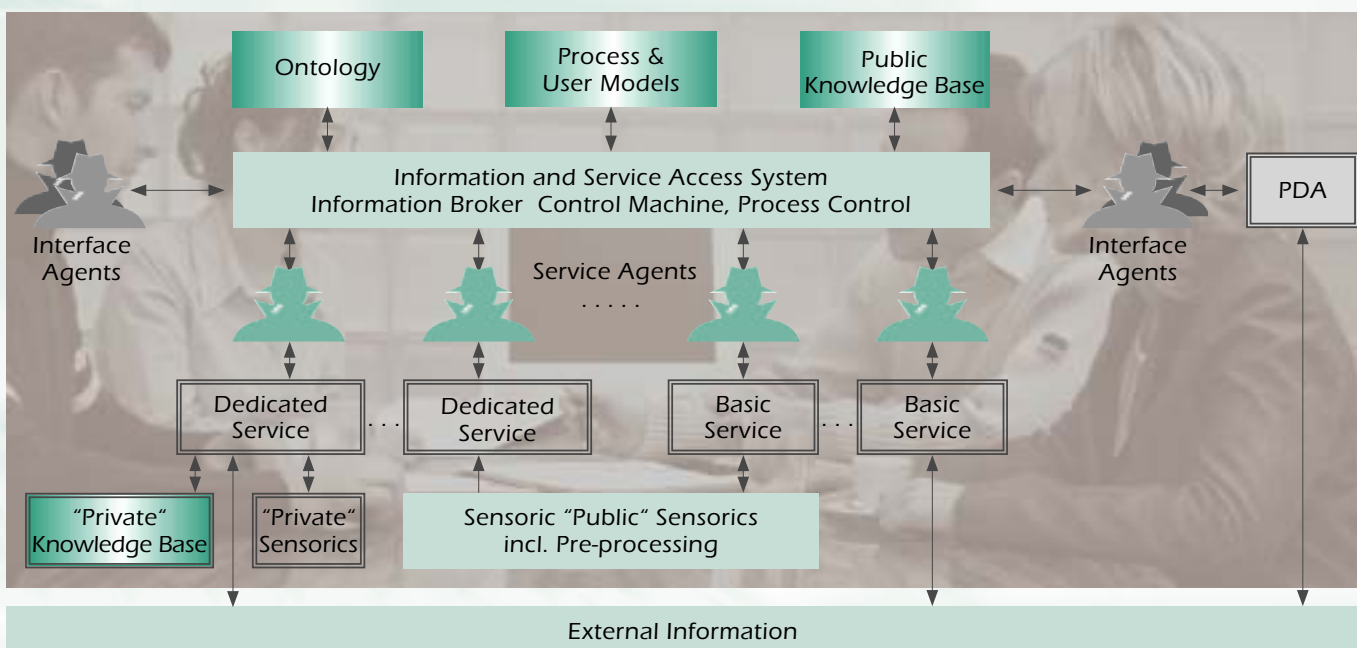
The process and user models describe the services and the system users. The public knowledge base contains the dynamic knowledge in the area of application. An information and services access system serves as central control. Self-adapting interface agents form the only interface between the system and the user. They act on behalf of the

user. Service agents connect the services with the information broker. Agents communicate with the broker and with other agents on a conceptual basis, which is described in the common ontology.

Basic services are common services in the area of application and use available standard public sensorics. Dedicated services use private sensorics and private knowledge bases and are also used for more complex tasks. Incoming sensor data are stored and pre-processed in the sensorics. Mobile units (e.g. PDAs) allow the user access to both exter-

nal information as well as access to the information system through the interface agent.

With the implementation of the CHIL project, the Fraunhofer-IITB expects to gain new insights with regard to agent-based software architectures and the use of ontological descriptions in large, heterogeneous assistant systems which are expected to be a part of many areas of information technology in the future.



The Third Eye

Interaction with Automatic Image Interpret

Screening

Image interpretation processes can be fully automatic in domains where the task is carried out in a constant environment such as inspections in industrial production processes. In many cases, however, complete automation is not possible or desired. Therefore, good cooperation between human and machine is required, to which each partner brings his/her specific capabilities for the solution of the common task.

The German Bundeswehr (Federal Armed Forces) employs the Tornado as well as Drones (unmanned air vehicles - UAV) for reconnaissance and surveillance tasks. Both systems are equipped with infrared line scanners. This image acquisition system delivers large amounts of data. As an illustration, consider that for the projection of an image in complete resolution, more than one thousand monitors would be required. The image data must be interpreted in a very short time by the image interpreters. An essential task is the prompt detection and recognition of objects – frequently vehicles. Until now, this task had to be accomplished interactively; this is where the use of the high speed processing capabilities

of a PC seems an obvious choice in making a preliminary selection (screening) of those image areas that have a high probability of containing targets. In a natural environment, this is a highly complex task. Little can be done to influence the target area in a natural environment to enhance and optimize the image acquisition process.

Screening Process

As part of the research project WITMUS (knowledge-based, partially automatic image interpretation for multi-sensor reconnaissance) basic ATR (automatic target recognition) screening processes were developed which are capable of detecting relevant image areas with a high degree of probability; see illustration. Many critical application properties developed during commissions for EADS-Dornier were



Detected Regions of Interest (ROI) Involving

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ation Algorithms

added to these processes (among others, real-time capability). As the military image interpretation is carried out under unfavorable conditions, it is, however, not possible to completely avoid false alarms at a high detection rate. For this reason, too, the automatically generated results must still be validated by a human image interpreter.

In a cooperative venture with the SaLVe-Project (satellite and aerial photography interpretation for verification purposes) a concept was developed which aids the interpreter in applying this processing capability in the overall interpretation process.

A systems observation was undertaken with the purpose of answering a series of questions: At which point in the operation are the automatically generated process results

of most value? In what way should the process be altered? How are the results to be visualized? etc. Discussions with military image interpreters and simulated tests of the developed processes were crucial. The discussions and tests brought very favorable results. One image interpreter summed up the results as follows: "The ATR is our third eye".

Time Saver

In a purely interactive image interpretation the prescribed time limits can rarely be kept due to the large quantity of data. Evaluations of the tests at the IITB showed that using automation as part of the interpretation process made it possible to keep within the prescribed time requirements and produced qualitatively high interpretation results with less stress for the human image interpreter.

Summary

By combining the strength of the automated image interpretation with the strengths of the human image interpreter, it is possible to achieve a highly efficient overall system for reconnaissance and surveillance tasks.

Tests successfully demonstrated that a careful optimization of the processes with regard to their application and the corresponding optimization of the interactive application were instrumental in reaching the overall desired goal. This is, of course, only possible when the capability for the breadth of the system exists, from formulating the general scope of the task to the interactive process components and finally the automated process.

This capability can be found at the IITB and, with it, the solution to problems that cannot be solved through purely automated or purely interactive approaches.



Vehicles

Stereoscopic Vision

Surface Inspection Using Photometric Stereo

Approximately half of all applications of industrial image interpretation take place in the area of quality inspection. The automatic inspection of surfaces is considered one of the most complex tasks in this area. Of course, in regard to image interpretation, there is no problem in detecting dark stains on a homogeneous, flat, light-colored surface. The task becomes more complex when a textured, colored surface must be inspected for faults in color, gloss, and 3-D properties. It is a characteristic of such inspection tasks that the various types of defects are detectable only under different inspection conditions.

Variations in the gloss are best detected using bright field illumination, faulty colors require dark field illumination and 3-D defects (e.g. grooves and dents) become most visible when the light enters laterally to the main expansion of the defect. Human inspectors, therefore, move the test object (e.g. a tile) under the light source and inspect the surface in succession under various inspection conditions. To imitate the behavior of the human inspector, a measurement setup would be ideal which gives precise information as to color, gloss, and 3-D properties for each surface element, thus

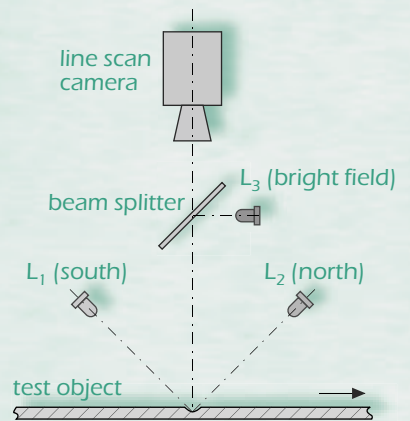


Illustration 1: Principle of the Measurement Set-Up.

providing the basis for a reliable differentiation of defects and permissible structures. The IITB developed a measurement apparatus which comes very close to this ideal. The apparatus is based on the principles of photometric stereo.

Measurement Apparatus

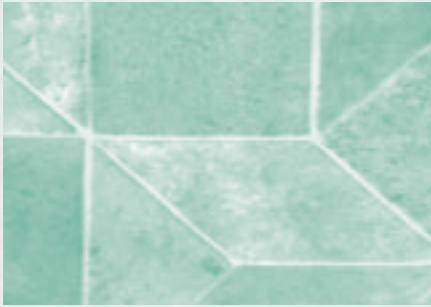
The measurement apparatus consists of a high-resolution line scan camera and six groups of light diodes. The line scan camera views the surface vertically. The LEDs illuminate the surface from six different directions. Synchronously with the line cycle of the camera, the six groups are flashed all around. With the movement of the test object, therefore, six images of the surface are produced simultaneously.

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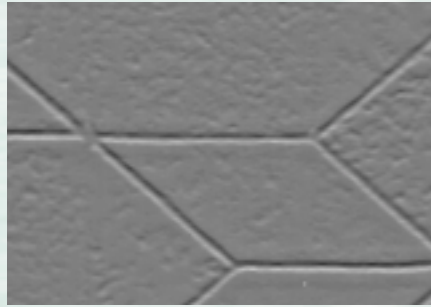
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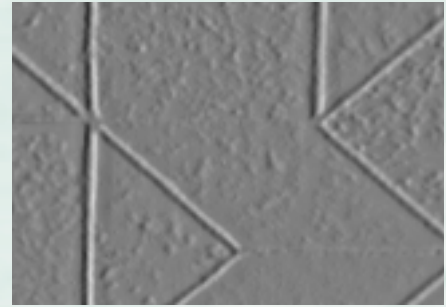
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colored image



relief N/S



relief W/O

Illustration 2: Floor Covering with Imprinted Pattern.

The six groups of LEDs are arranged in pairs: one pair illuminates the surface in the dark field from north and from south (in and against the direction of the movement), a second pair provides the illumination in the dark field from east and from west (transverse to the movement) and the third pair illuminates under bright field conditions (from above) and in the dark field (from north and south). The three groups each consist of LEDs of the colors red, green, and blue. Illustration 1 shows the arrangement in simplified form. Only the bright field illumination and the north/south pair are shown. The east/west pair is missing.

The desired information as to color, gloss, and 3-D properties is provided through combining or comparing pairs of the six images: a color image results from combining all five dark field images, information as to gloss is obtained by comparing the bright

field image with the corresponding dark field image, and information as to the inclination of the surface elements (3-D-properties) is gained by comparing pairs of images with illumination from north and south or from west and east respectively.

Illustration 2 shows the results obtained by the measurement setup from inspection of a colored floor covering with imprinted grooves (the colored image is reproduced here only in gray tones, however).

Applications

The business unit "Visual Inspection Systems" is currently working on two industry projects for the automatic inspection of surfaces. The first project deals with the quality control of a steel strip coated with a colored, marbled synthetic coating. The second project is concerned with the inspection of copper

laminates. In addition to the detection of flat defects (e.g. dirt), both projects are primarily concerned with a reliable detection of elevations and indentations on the surface in the presence of permissible small areas of imperfection.

These consist mainly of small gloss stains, dried water stains, color contrasts, and a weave-structure of the surface. Because of these problems, conventional systems cannot attain the desired detection reliability, the false alarm rate becomes too high.

The photometric stereo, however, achieves a reliable detection and differentiation of elevations and indentations starting at a size of approx. 300 µm (at an inspection width of 300 mm). Moreover, miscolorations and flat defects are detected.

Axial 3-D Light Stripe

The Detection and Surveying of Damages in



Prototype Development of the Sensor.

Currently, the inspection of pipelines in community water management systems is carried out using remote-controlled, cable-dependent robots equipped with CCTV cameras and video recording technology.

This standard technology is available on the market, but is used only rarely in clean water distribution networks, since it neither detects damages automatically nor

does it survey them accurately. It is even possible that video sequences documenting visible damage are interpreted either incorrectly or insufficiently by the operator.

A comprehensive and qualified assessment of damage in communal and industrial pipe systems is only possible when the existing technology of the inspection robots is enhanced by an objective, damage-specific sensor system.

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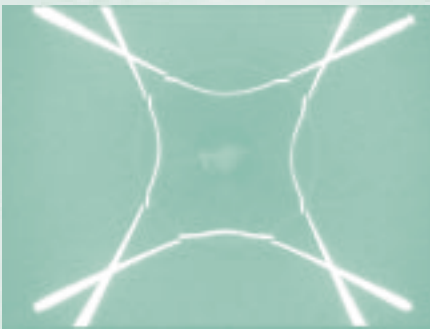
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Sensor

Pipeline Systems

► Prototype Development

In cooperation with the British company **Yorkshire Water**, based on our own prior developments in the waste water sector, an axially symmetric 3-D light stripe sensor was developed for the detection and surveying of anomalies in clean water pipes.

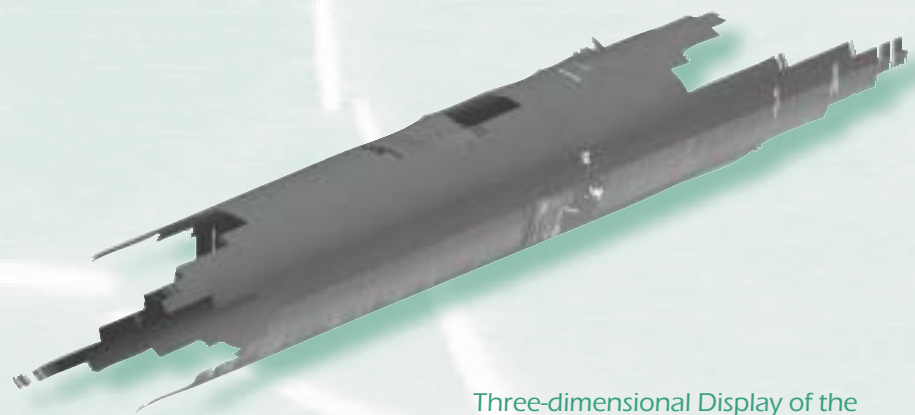


Laser Projection onto the Interior Pipe Surface.

The developed sensor is based on the well known structured light projection technique. Contrary to the standard procedure, however, the light structure is projected axially symmetric onto the surface to be surveyed, i.e. the interior of the pipe, using several laser projectors. By illuminating the interior of the pipe with structured light a 'scale of light' is inserted into the recorded video image, which then enables the calculation of the three-dimensional coordinates using suitable image-processing algorithms.

► Inspection Run

During the inspection run, the entire interior of the pipe surface is recorded and its topography is calculated. This process reveals anomalies and damage of the pipe. Not only does the image-processing software developed for this procedure enable the automatic detection and accurate surveying of damages, the three dimensional display of the topography also gives the operator a clear image of the pipe condition.



Three-dimensional Display of the Surveyed Pipe Topography.

Digital Factory

A Comprehensive Network of Digital Models

► Factory Planning

When talking about manufacturing, the buzzword 'digital factory' appears everywhere these days. DaimlerChrysler announced that they would in future not start any new work sites or production plants without first carrying out digital testing. An expert committee of the VDI (Society of German Engineers), in which the IITB is represented, recently defined the term as follows: "'Digital Factory' is a generic term for a comprehensive network of digital models and networks, which includes, among others, simulation and 3-D visualization. The purpose of the 'digital factory' is the overall planning, implementation, control, and continuous improvement of all factory processes and resources in connection with the product".

In terms of factory planning, every facet of the process of factory planning is included: concept, strategic organization, detailed planning, control and monitoring, transfer planning, implementation and start up, acquisition of operating data, and permanent continuous project management. The result is a reference model for the factory planning including the essential access processes.

► Planning Procedure

Following the design of the factory concept, a decision model which comprises the entire planning is to be worked out which gives precise information regarding budget, time-frame for the implementation and the economic feasibility of the investment. Currently, the assurance that all aspects of the planning process have been taken into consideration depends mainly on the experience of the planner. No tool of the digital factory can guarantee this (to date). This most creative phase in the planning stage requires simple planning tools which effectively support the planner and free him/her from routine tasks.

► Work Distribution

After the investment has been approved by management, the next step consists in detailing and implementing the factory concept. These phases are well suited for the use of planning tools of the 'digital factory'. Analogous to the deployment of the digital mock-up (DMU) in the product development, the planning process will be accelerated by using tools to take over routine tasks such as modeling and organization of production plants or building tech-

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and Methods

niques using libraries or 'features'. Planning tasks during these phases can be outsourced to service providers who work out the required planning results quickly and at low cost. Around-the-clock, world-wide planning is thus only a step away. In the future, customers will assign planning and implementation services more and more to service providers functioning as general contractors.

New Tools

After the investment decision has been made, the 'builder' is faced with two major risks:

- the approved budget and schedule must be adhered to and
- the completed factory must indeed deliver the availability and output calculated during the conceptual phase

The purpose of the 'digital factory', to begin with, is to minimize the investment risks with regard to the equipment (machines and installations) during the conceptual phase. This results in new demands on the planning tools, which must cope with imprecise and uncertain input data. In actuality, the 'digital factory' can be compared to a factory-DMU (digital mock-up) with the difference that relevant simulators additionally

allow predictions as to the dynamic behavior of the factory. Ideally, the input data used in the simulation are actual plant data recorded and processed by the production monitoring and control system. The IITB is working on agent-based systems to enable the cooperation of these tools.

The management of a project requires tools with which the planning quality can be judged. To illustrate, the project manager needs a tool such as the '4-D-Navigator' with which he can test whether the planned machine or installation will operate in its future context, or with the help of which he can release digital planning to service providers for more detailed planning and implementation.

In future, suppliers of manufacturing facilities will have to supply their geometry and planning data in a form in which they can be incorporated into plans of the client or the general contractor. Analogous to the digital mock-up, the general contractor reserves the 'building space' of the installation for his supplier. The general contractor or the contractor's project manager is then responsible for testing all production facilities within the factory



simulation system. Using efficient interfaces, not only static geometry but also dynamic simulation data must be able to be exchanged without loss of information.

There is a close connection between the concept of the factory and its control and monitoring during actual operation. The control philosophy, e.g. PUSH or PULL, is essential to the design of the factory and, therefore, to its profitability and flexibility. This means that demands for the future IT support of the enterprise must be determined in the initial conceptual phase. The tools of the 'digital factory' must in future integrate this linkage between factory planning, control, and monitoring, e.g. in the form of agent-based Manufacturing Execution Systems (MES).



▶ Sorting System for a Diamond Mine

The extraction of diamonds is an expensive undertaking: to obtain a 1 Karat (0.2g) diamond, 1 to 10 tons of the mineral Kimberlite, depending on the type of deposit, must be mined and investigated.

Finding the few valuable pieces in the huge quantities of dead rock is, therefore, of the utmost importance. To this end, sorting machines are employed.

In its quest for an improved sorting technology, **De Beers** went on a world-wide search. Based on the excellent results in preliminary trials, De Beers decided on an optical sorting system developed by OptoSort for a one-year trial period in South Africa. The trial project began in October of 2003.

The image interpretation system of the installation comes out of the business unit "Visual Inspection Systems" of the IITB; the illumination technology was developed in a cooperative effort by OptoSort and the IITB.

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▶ Computers in the Human Interaction Loop - CHIL

The aim of this European Union-funded project is the development of a new way of interaction with the computer. New technologies are intended to transform the PC into 'electronic assistants' which are able to detect the needs, intentions and situational context of the users and support them in their activities and interaction with others. The CHIL services to be developed will constitute a fundamental shift in our use of information and will constitute a major step towards the vision of the learning, self-reflecting and thinking computer assistant.

The international project team is directed by Professor Waibel (TH KA) as scientific coordinator and Professor Steusloff (IITB) as project coordinator. Continual updates on the progress of this major project will be available on the CHIL website:

<http://chil.server.de>

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People Making News

► Honorary Plaque of the VDI (Society of German Engineers)



Professor Dr. Steusloff was presented with the honorary plaque of the VDI by the chairman of the GMA (German Society of Measurement and Automation Technology), Professor Dr. Bretthauer

Professor Steusloff received the honorary plaque of the VDI/VDE-GMA (Society of German Engineers/ Society of German Electro Technicians-Sub Chapter Measurement and Automation Technology) in appreciation of his many years of volunteer services as a member of the Advisory Board. Through his efforts, he advanced the introduction of information-technological methods in automated systems and made information logistics an integral part of modern process control in the work of the GMA. In particular he contributed to the outstanding success of the European Control

Conference ECC '99 in Karlsruhe, through the preparation and realization of this international conference including the preparation and organization of the industrial participation.

► Awards

In December 2003, our visiting scientist from Italy, Dott.-ing. Giulio Milighetti, received a prize from the Italian Industry Federation UCIMU-SISTEMI PER PRODURRE for his outstanding thesis and for being the top student in his field at the University of Rome. His thesis deals with the topic of "Fault Detection and Localization in Robot Drives". Results of his work have been successfully applied and developed further in two research and development projects of the business unit 'Measurement, Control, and Diagnosis' of the IITB.



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