Fraunhofer IITB

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2003

- Real-time Communication Using Switched Ethernet in Industrial Automation
- Monitoring of Large Diesel Engines of High-speed Ferries
- Interactive Image Interpretation in the Right Light
- A Process-following System for Print Inspection
- Intelligent Control Concepts Leading to Human-Robot Cooperation

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Content

Ladies and gentlemen,

Humankind has survived and developed into the most powerful species on our globe due to its ability of extensively employing natural resources for reaching its goals. This use of natural resources requires the extension of the creative and communicative capabilities of humans for dealing with complex systems and environments. The work of IITB is dedicated to assist humans in numerous tasks and situations where human capabilities need to be and can be increased through technical systems. The examples in this international issue of visIT are taken from our work in mobile and robot systems as well as from evaluating and communicating large quantities of information.

Latest alarming accidents in international shipment by sea indicate the demand for on-line monitoring and inspection of ship systems. Our tele-monitoring system for large Diesel engines of high-speed ferries contributes to the safety of naval transportation. In the home environment, intelligent and interactive robots will be and are already available for assisting humans at workplaces of all kinds and in dealing with unexpected situations. Printed product information will be checked for correctness under realtime production process conditions. And the co-operative analysis of large images with regard to expected and unexpected objects is among IITB's assistance systems for dealing with complex situations. This all needs to be supported by powerful and economic realtime data communication networks.

Humans are controlling increasingly complex systems and environments. The final responsibility for humankind's activities is up to single humans who must be equipped with adequate aids for successfully tackling such complexity.

Hartwig Steusloff

Hans-Achim Kuhr

Jörg Schütte

Themes

Industrial Ethernet

Real-time Communication Using Switched

The past 3 years have seen a euphoric discussion of the penetration of Ethernet TCP/IP in automation.

This discussion has focused on the following aspects:

• Ethernet is clearly not a new technology. Still, until very recently, use of this technology was limited to the transmission of time-independent data. The introduction of switching technology according to the IEEE802.1 standards (1998) now promises the capability of transmitting time-critical data because of the avoidance of interfering collisions and the added capability of prioritized traffic classes.

• Progress in micro-electronics and a continued decentralization of automation functions have given field instruments much greater functionality, making them that much more ‚communicative' as well. Aside from classical data transmission, this has created an increasing need for performance-oriented communication, which the field bus systems in use today can meet only marginally. Operator-instrument interaction using web-techniques, archiving of data over FTP, and instrument diagnosis using SNMP are examples.

• Integration of automation technology into a company-wide information management system currently requires a great deal of effort and cost because of the numerous communication systems that must be coupled in existing architectures.

• There is a strong desire to use standard products and technologies available in a mass market. These promise advantages in cost, know-how, and rate of innovation.

Before Ethernet can be used at the process level, the question of real-time capability must be answered. Because of their proximity to the technical process, these domains are characterized by distinct time and topology constraints.

Real Time

Time-critical processes such as request-response transactions between applications must be evaluated quantitatively.
The main criterion here is the determination of reliable upper limits for the turnaround time and the time jitter. Mean values and quantile data („99,9 % of the data packet will be processed on time"), which are often cited for an application, are not sufficient to quantify real-time

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Ethernet in Industrial Automation

behavior in industrial automation. Even a slightly delayed message can have serious consequences for the application.
Likewise, it is not sufficient to rely on a low to medium load on the network resources since this does not consider the peak load caused by a sporadic burst of requests. To ensure that limits for the transaction times are practicable, they must be of the same order of magnitude as the execution requirements themselves, meaning that, depending on the type of application, they must be within a few ms or less.

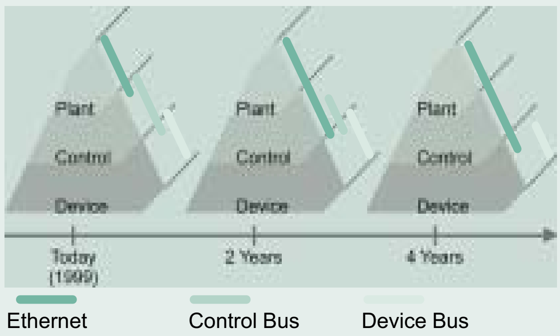
Simulation

The planning and evaluation of systems under real-time conditions requires the use of modeling and evaluation tools, since measurements in real systems are at best only possible for individual components. Communication networks are modeled with queues and service nodes. Simulation using professional tools such as the OPNET modeler is a useful technique to calculate performance data for specific scenarios. However, simulation runs cannot cover all possible application scenarios and can, therefore, not provide universally-applicable time limits.

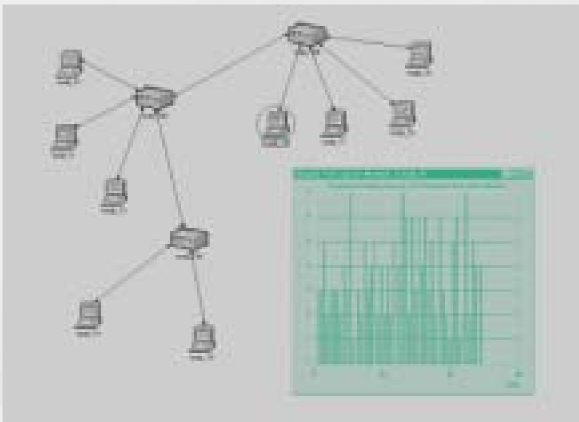
Network Calculus

This method is based on basic research done for event-oriented systems and was developed in the 1990's primarily for the performance evaluation of applications in the Internet. In contrast to classical queuing theory , which is based on stochastic processes, Network Calculus offers significant advantages: it requires only a few, realistic assumptions, making it ideally suited for the calculation of time limits in networks. Key elements are the so-called arrival curve and service curve, which describe limits for the packet generation and service respectively.

Current research is concerned with the development of design tools for real-time applications using switched Ethernet.



Prognosis for the penetration of Ethernet in automation according to ARC99.



Performance evaluation using OPNET™, Technologies, Inc.

Themes

Remote Monitoring

Monitoring of Large Diesel Engines of High-

World-wide, ferries complement and relieve overland traffic in many coastal cities. High-speed ferries sailing between mainland and islands or between islands are becoming ever more important. The reliability, punctuality, and safety of these ferries in the transportation of people and goods are paramount for their continued successful use.

DEUTZ AG produces and supplies high-power diesel engines of between 750 kW to 2200 kW for high-speed ferries. These engines run for between 2000 and 4500 hours annually. Adherence to required maintenance intervals, as well as constant monitoring of the most essential operation parameters, are vital for their safe operation.

Engine Monitoring

Deutz AG in cooperation with Woodward Leonhard-Reglerbau (Stuttgart) and the Fraunhofer-Institute for Information and Data Processing (IITB) developed an "Engine Control System" (MKS), a monitoring and safety concept for high-power engines. Beyond the basic monitoring and safety functions required by safety boards, this system features distributed monitoring components in the form of embedded systems, which communicate with each other as well as with a higher-level data coordinator; development took two years.

Storage of Operation Data

The IITB developed the long-term recording system for engine operation data, an essential component of the engine control system.

This component records engine parameters minute by minute e.g. number of revolutions, oil pressure, cooling water temperature, etc., acquired in a pre-process unit by a CAN-BUS, and stores the information on a memory card. This system also detects failures such as exceed-

Internet-capable, network-capable data logger using a GSM-Modem.

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for Large Diesel Engines

speed Ferries

ing limits, gives them a time stamp, and stores them.

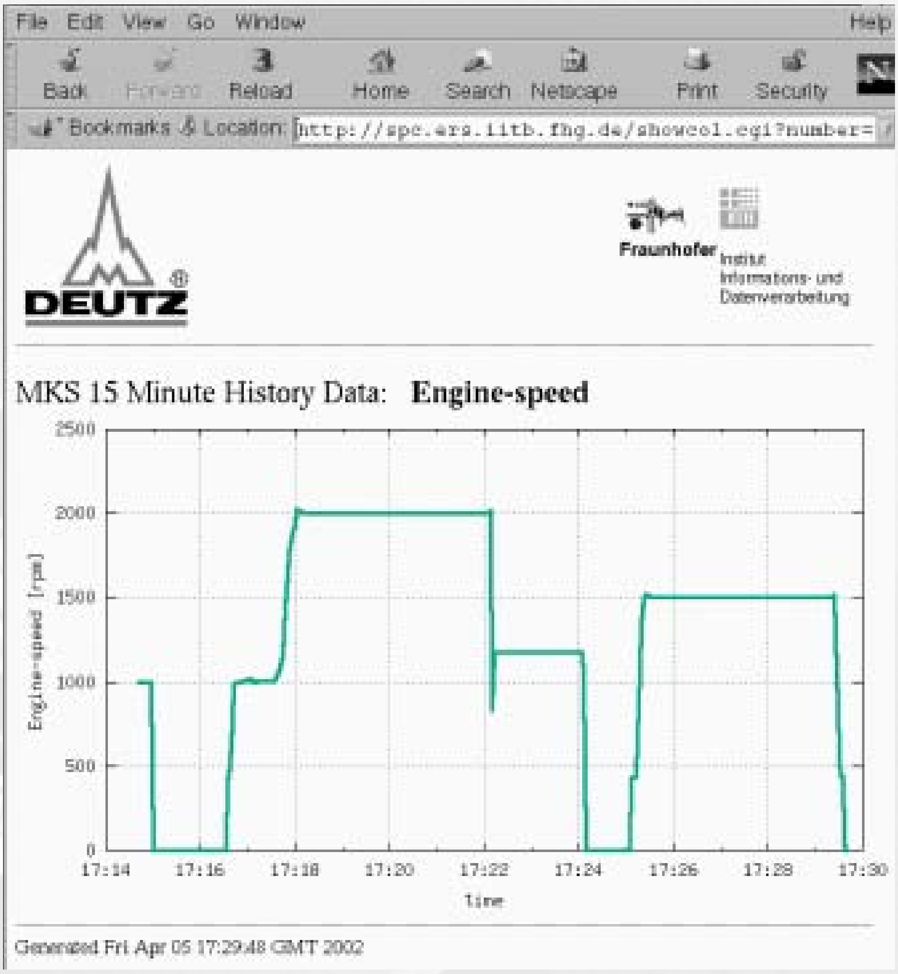
This extensive collection of operational data allows the human expert to make a detailed evaluation of the engine state throughout the monitoring period. These data can then serve as the basis for optimizing the engine performance with regard to the operational profile of the ship. Beyond that, in the case of engine failure, the course of the damage can be determined by investigating the engine history, an essential factor from both a legal and technical standpoint.

Remote Monitoring

The engine control system is currently being expanded to include the specific call-up of data by any given browser. In coastal areas, mobile communication using the GSM 900 standard is optimal. For operations at sea, one can fall back on direct satellite communication.

By using direct communication links, the time to access relevant data can be shortened drastically, making it possible to determine critical engine processes in time, and, if warranted, to initiate suitable measures instantly. In a further automation step, the diagnostic module, on detecting a critical engine problem, automatically sends an e-mail with the relevant diagnosis. The communication link offers the ferry operator distinct advantages: it determines the availability of the ship and allows efficient planning and carrying out of maintenance and service jobs.

The instant accessibility of comprehensive operational data worldwide by means of the newly developed engine control system makes a major contribution towards further improvement of fast, reliable, and safe ferry operation.



Using an Internet browser, the user can request a graphic illustration of the short-term history from the data logger.

Projectpartner
Norbert Eisinger
DEUTZ AG, Mannheim

COBALT

Interactive Image Interpretation in the Righ

Before the PC conquered the area of aerial image interpretation, the light table served as the work bench of the image interpreters. There they laid out their large-scale films and analyzed the image information. Today, in contrast, the PC work station with digital image evaluation offers a host of functionalities not possible with the classic light table.

Large Images, Large Display

From an ergonomic standpoint, however, today's PC workstation constitutes a step backwards. Aerial image interpretation focuses on the examination of large areas, but the limited screen size of current monitors clearly limits the area that can be viewed at a glance. The interpreters must move the image or change the zoom factor if they want to be able to orient themselves beyond the area of the detail focused on within the monitor borders. On the other hand, the light table permits a large scale layout of images and, through inclusion of a peripheral field of vision, permits an easy overview of the area to be investigated.. The idea that "four eyes see more than two" is an underlying principle of the team work used in aerial image interpretation. This, too, is clearly restricted with the traditional monitor set-up because it doesn't leave enough space for two people to work comfortably side-by-side. Last, the view box perspective of the traditional monitor hinders the stereoscopic image interpretation. At the customary visual distance from the monitor, the screen edges are part of the visual area and limit the virtual areal view of the stereoscopic image.

Touch and Talk

With the experimental COBALT (Computer-Based Light Table) set-up, the Fraunhofer IITB is developing the concept for a future work station for aerial image interpretation which combines the advantages of the processing of digital images with the ergonomic efficiency of the classic light table. The graphic signal of the PC is projected onto a large-scale, rectangular 67" table. This table is placed at an angle rather than lying flat. Digital images, of course, cannot slide down and, for the interpreter, a standing position is ergonomically preferable to a bent position – a COBALT advantage over the light table of old. Touch and talk commands replace keyboard and mouse. The interpre-

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t Light

tation of aerial and satellite images demands visual concentration on the image. Control of the system should, therefore, not involve the visual perception of the person to any extent. The beauty of COBALT lies in its ability to move an image through simple touch and to control enlarging and reducing processes through spoken commands. This keeps the control area very small, making room for the image to be interpreted.

Polarized Stereo Projection

Technically COBALT works on the basis of superimposed projection of two array projectors onto the back side of a polarization-preserving viewing screen. The projectors are fitted with polarizing filters.

This constellation permits the stereoscopic image display. The viewers in front of the viewing screen wear polarized glasses which separate the superimposed images.
Array technology produces extremely homogeneous pixel transitions. The clearly visible grid pattern of the traditional „beamer“ would be a considerable distraction at a short distance.

COBALT experienced its trial-by-fire in the fall of 2002 during a multi-national training exercise of the Euro Corps, where it was included on an experimental basis in the air-reconnaissance operation planning. The suitability for a large-scale team-based stereoscopic sampling of the area was noted especially favorably. Beyond the military applications, the use of this system also lends itself to distance and environmental surveillance, the management of large-scale events, or the planning of various systems (as a successor to the drawing board).

Progress in display technology will allow the use of highest-resolution, large-scale flat screens, making projectors obsolete for the most part. The IITB’s research on the COBALT will provide concepts which will help to enhance the potential of large-scale projection areas for the interactive use and interpretation of image data.

Themes

PrintInspector

A Process-following System for Print Inspection

Seductive, multi-colored packaging of products is supposed to attract attention as well as provide information for customers, producers, and suppliers.

Quality Requirements

The packaging of goods is increasingly moving towards printing package material online during the packaging process (white lines). This reduces expenditures during storage and in a change-over to other products. However, the printing of packaging during the packaging process can cause quality problems. Because of the high production speed, a human observer can detect a faulty print only on the finished packaging.
To assure a consistently high print quality, a machine must check the print continuously during the printing process. The quality demands for these imprints are enormous. They must be easy to read and should reproduce the company logo down to the smallest detail. Special care is needed in areas where the producer is liable for product information and use, e.g., expiration date of perishable goods.

For this task, the following outstanding system capabilities are a must:

- Inspection of high-resolution images: Even the smallest faults in an 8 point font must be detected on a DIN-A4 (210x297mm) page.
- Short processing time: During a one-second production cycle, between 1000 and 2000 characters must be checked.

Synchronous Quality Control

PrintInspector is an image evaluation system, which continuously checks the print quality during the production process. The system was especially developed for process-following print inspection and solves all of the following three tasks:

Print Quality Evaluation
During the inspection of the print quality, even minute, spatial deviations between the test sample and the master are detected. Missing contrast or bleeding colors on the prints are recognized as defects, as are missing or superfluous structures in the print pattern of a character.

Verification of Variable Data
Variable data on packaging are used to identify a product with product characterization, e.g. a serial number, a charge number, or an

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expiration date. During production this information is checked or interpreted with regard to its value and significance.
To successfully verify an identification code, all printed numbers of a code must be identical with the numbers and letters of the expected identification code. If this is not the case, the print image classifies the identification code as faulty, and all rejected characters are marked.

Detection of Spots and Other Impurities
PrintInspector examines the entire packaging, not just the printed parts. The non-print parts are checked for spots and other imperfections.

Applications

The printing of packaging in the packaging machine allows maximum flexibility and reduces changeover costs. This is only possible when the quality of the print can be inspected synchronously with the printing process.
The PrintInspector offers this capability, meeting the necessary prerequisites for efficient production.
PrintInspector examines prints on a great variety of materials: aluminum foil, paper, carton, plastic, or wood.

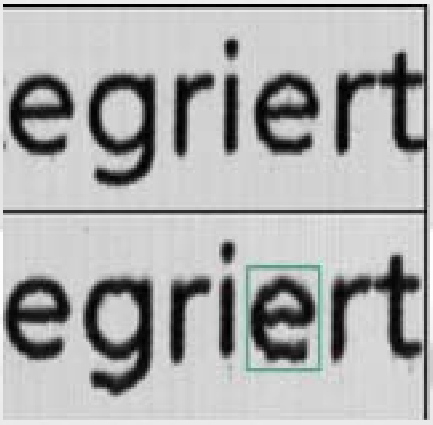
It can work with transmitted and reflected light and checks prints on flat or cylindrical surfaces as long as there is enough contrast in the image to stand out from the background.

Currently, PrintInspector works in gray scale. An expansion to monitoring of color prints is in the planning stages.

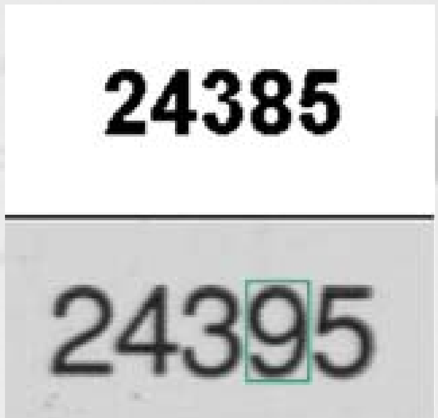
About the Technology

A prototype is being tested. A system delivery is planned for the fall of 2002.

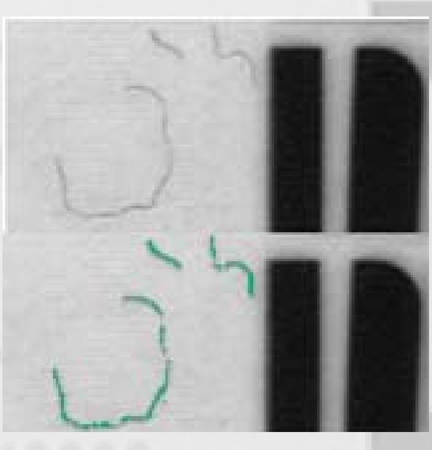
The system is based on a PC with Windows 2000 with the addition of a special board for image acquisition. Line scan cameras serve as sensors with 4096 pixels (gray scale) or with 3*2048 pixels (color) using traditional fluorescent light tubes for lighting. This is achieved in a throughput of 80 million pixels/sec at a spatial resolution of 50 µm at 200 mm test width (gray scale) or 100 mm test width (color).



Inferior print quality.



Verification error.


Impurities in the non-print areas.

Themes

Humanoid Robots

Intelligent Control Concepts Leading to

The IITB has been instrumental in the innovative development of measurement, control, and diagnostic concepts for industrial manufacturing processes, mechatronics, and robotic systems. The following text describes a new generation of robotic controls which allow humans safe and flexible cooperation with domestic and industrial production robots.

State of Development

More complex automation requirements in the area of production or in a domestic environment increasingly require the introduction of robots capable of communicating and interacting intelligently with their environment by means of various sensors. In the past, solutions which envisaged fully automatic planning, control, and monitoring systems did not meet expectations. They proved to be too inflexible, in particular with regard to meeting continually changing or tight requirements. Only tailor-made, partial solutions have been put into practice in industry so far, and their adaptation to even slightly modified tasks or their integration into an overall concept have resulted in considerable problems. Significant progress cannot be expected until it is possible for humans and robots to cooperate intelligently and to interact physically (e.g. manual guidance). This would open the door to the use of the superior perceptual, cognitive, and action capabilities of humans in an optimal synergy with the robot.

New Challenges

To be able to cooperate effectively with humans, the monitoring and control systems of the robot must meet much higher requirements with regard to reliability and error reduction than is possible using the robotic systems currently on the market. The operation of the robot in any given environment must be supervised continuously by a smart multi-sensory monitoring and diagnostic system for unexpected operation situations, possible dangers (e.g. collision), or component failures. The motion control of such a humanoid robot must be capable of independently adapting itself parametrically and structurally to unexpected deviations and problems (e.g. dropping of a part), i.e., it should be learning-capable. Man in his function as master or partner of a robust man-machine interface must be able to communicate safely and flexibly and interact physically

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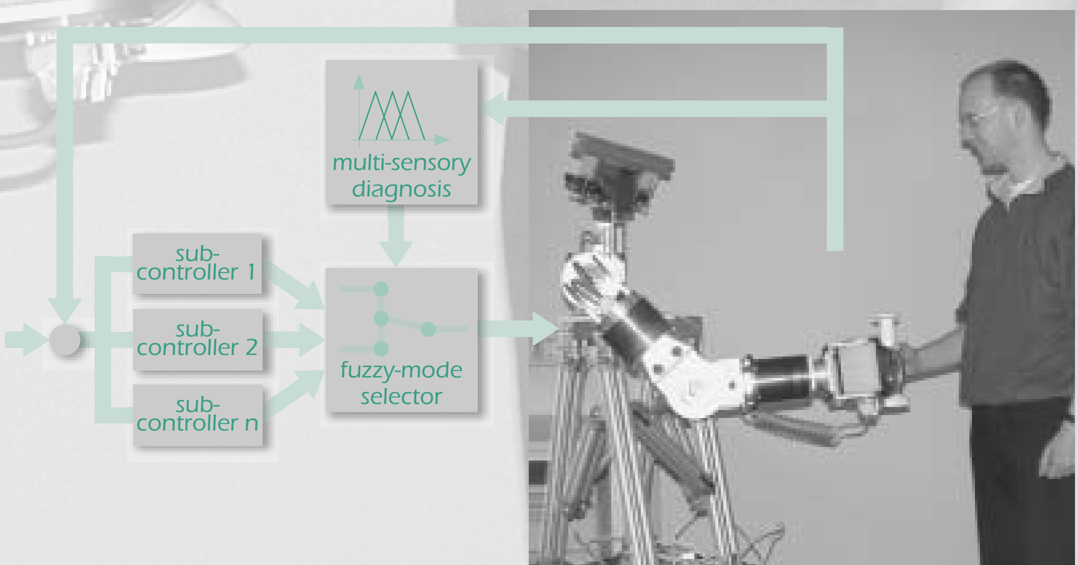
Human-Robot Cooperation

with the robot. Besides the interchangeable exchange of binary signals or linguistic information, this should also include physical interaction by means of continuous signals (e.g. physically pushing or pulling the robot).

The systems for industrial robots currently on the market cannot meet these advanced requirements. The reason for the much higher complexity lies in the fact that human and robot must no longer work in a separate spatial environment as is currently practiced for safety reasons; they must be able to perform complex tasks successfully and safely in close physical, power-sharing proximity and information-sharing cooperation.
For the monitoring and control system this means that robot and human should be viewed as a single unit. A simple illustration of this concept would be the cooperative carrying and horizontal balancing of a tray full of glasses.

Intelligent Monitoring and Control

The solution being currently developed as a prototype at the IITB as part of the new DFG-special research project 588 "Humanoid Robots" is a novel, structurally variable monitoring and control system based on neuro-fuzzy methods. The system combines a multi-sensory monitoring of the robotic environment with an on-line diagnosis of the ongoing type of motion as well as potential failures based on malfunctions of components. Routine control actions are activated dynamically based on ongoing diagnostic results in such a way that they best deal with the required motion type or specific failure class.
The cooperation of two experienced humans working effectively together serves as a model for this concept. Imitating or learning the supervising and controlling function of the human in a tactical situation using intelligent robot control is an essential goal of this project. Neuro-fuzzy-methods capable of representing heuristic knowledge (fuzzy logic) and and learning-capability (neural networks) play a central role. Early cooperation with manufacturers and users of robots and robotic components is desired.



People Making News

UNESCO Chair

Professor Hartwig Steusloff celebrated his 65th birthday this summer. He has served as managing director of the IITB since 1995, having previously headed the data processing department at the IITB. Luckily he is far from considering retirement. In addition to serving on numerous forums and committees and teaching at the University of Karlsruhe, he is an honorary professor at the Food Industry College in Wuhan and at the Northeastern University in Shenyang (People's Republic of China). Based on his extensive connections with China, he was recently named to the Fraunhofer/UNESCO Chair for„Information Technology for Industry and Environment", an initiative within the framework of the „University-Industry-Science Partnership Programme" of UNESCO. In this capacity he will lead workshops and seminars at universities and continuing education centers in various cities and provinces in China on selected topics relating to information, automation and systems technology, together with his Chinese co-chair, Professor Jin Guofan of the Tsinghua-University in Beijing. Clearly his experience and know-how acquired at the Fraunhofer Gesellschaft will play a major part in fulfilling the requirements of the UNESCO-professorship. Topics range from quality assurance and human – machine – systems interaction to resource management and control, environmental systems and international standardization. The goal is to make European technological experiences and viewpoints known in China and through this interaction to initiate cooperative ventures. The chair is planned for a three-year period.

Editorial notes

Josef Pauli

has been heading the department 'recognition systems' since September 1, 2002, succeeding Professor Link in this capacity.

Raised in rural south-east Bavaria, he completed his computer science studies at the Technical University Munich in 1986 with a thesis on ‚Machine Learning', focusing on 'Artificial Intelligence'. He started his research there as wissenschaftlicher Mitarbeiter (a pre-doctoral position) for another six years. During this time, he worked intensively on image and image sequence processing using practical, real world projects.

In 1993 he transferred to the University of Kiel as a post-doctoral assistant, where he continued his research with the goal of fusing image processing methods, machine learning, and robotics. In close cooperation with industry partners, he developed prototypes of, e.g., active camera systems for surveillance and camera-based manipulation robots . In 1999 this research led to his obtaining the habilitation to teach computer science at the University. His desire to combine marketable product development and research on image interpretation processes with machine learning encouraged him to change to the Fraunhofer Gesellschaft in 2002. In addition to his work at the Institute, he will lecture at the University of Karlsruhe on the topic of 'structure extraction and object recognition'.

He envisages exciting applications in the field of object recognition for interactive systems and cooperative, partially-automated production processes, routine technical maintenance, and in people-support in the household and leisure environments.

We are happy to welcome our new department head.

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