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FRAUNHOFER INSTITUTE FOR FACTORY OPERATION AND AUTOMATION IFF, MAGDEBURG

2010
ANNUAL REPORT

ACHIEVEMENTS AND PERFORMANCE 2010 ANNUAL REPORT

CONTENTS

FOREWORD

Dear Ladies and Gentlemen,
Business Partners and Friends,

Obviously, a global financial and economic crisis is not surmounted overnight. Unsurprisingly, business was still feeling the effects, particularly in the first half of 2010. Yet, despite the hesitation to make new investments, which was still perceptible in many companies, the basic outlook everywhere was already optimistic again and increased demand for technological innovations was observable.

The Fraunhofer Institute for Factory Operation and Automation IFF weathered the economic turbulences connected with the crisis well. This is evident in the slight rise in total revenues and business revenue. We combined forces with our partners in business, research, academia and the public sector and were able to continue on our path just as purposefully as successfully. Thus, the Fraunhofer IFF's engineers have impressively demonstrated their strengths and proven that even crises can be withstood with an innovative attitude and technological excellence.

This insight reinforced our confidence in our capabilities and the Fraunhofer strategy of identifying and advancing regional potentials and developing cutting-edge technologies with applied research. The positive balance in the past year is evident in the results of our research in the fields of automation, process and plant engineering, logistics and digital engineering and reveals that the Fraunhofer IFF is driving innovation for business and industry. Even in difficult times, it delivers impulses for technological development and keeps our economy is globally competitive.

Interdisciplinary Digital Engineering

We regularly manage to attract new, well-known partners and clients. For instance, in 2010, we reached an agreement with LANXESS, a globally operating specialty chemical group, to digitally develop new high-tech membranes for water treatment systems. The Fraunhofer IFF's engineers collaborated with the Fraunhofer IWM, Martin Luther University Halle-Wittenberg and the Leibniz Institute of Polymer Research IPF in Dresden on one of the region's largest joint research projects of the past few years.

This work is challenging. In addition to the new filter system, we are also developing methods for the LANXESS factory in Bitterfeld-Wolfen, which simultaneously simulate various features of a product and its manufacturing technology on a computer. Clearly, digital engineering's interdisciplinary, cross-domain approaches, which we adopted some time ago, are a step in the right direction and cutting edge.

Transportation Concepts of Tomorrow

Although, the immediate transferability of the Fraunhofer IFF's developments to practice is always especially important, the institute's experts also work intensively on technical solutions, which will only play an important role in people's everyday life in the future. Since the opening of the Saxony-Anhalt Galileo Test Bed in 2010 and the kick-off of the project Harz.EE-mobility, the Fraunhofer IFF has been significantly involved in developing transportation concepts of the future, for instance in the domain of logistics.

The institute is collaborating with other established national and regional partners in the project Harz.EE-mobility to develop a new overall electric vehicle transportation concept for the future by 2011. One particular challenge will be to supply these vehicles predominantly with power from renewable sources. To do so, the Fraunhofer IFF's engineers are work-

Prof. Michael Schenk, Director Fraunhofer Institute for
Factory Operation and Automation IFF
Photo: Dirk Mahler

ing on a concept, which will not only assure future electrical grids' general security of supply but also make the vehicles themselves part of a distributed network of mobile electricity storage systems.

In the same way, we are also effectively uniting logistical networks and information and communication technologies (ICT) in the Saxony-Anhalt Galileo Test Bed. Jointly operated with Otto von Guericke University Magdeburg and others, the test bed was opened in early 2010 and supports the development of cutting-edge, high-precision localization and navigation technologies for reliable, secure and efficient freight and transportation flows.

Especially in light of the state of Saxony-Anhalt's position as an emerging region of expertise in transportation and logistics, the test bed is a particularly important source of impulses that combine research and application. DHL is but one important strategic partner that has already been recruited. The integration of regional small and medium-sized enterprises is also firmly part of our strategy to strengthen Central Germany's market position by developing particularly innovative solutions and to advance this project with fresh input.

Integrated transportation concepts, which supply complete solutions from one source, will be essential for the future upheavals of our transportation system. Our results thus far and the resoundingly positive response to them prove that we are following the right path. Even the Federal Ministry of Transport, Building and Urban Development has heaped accolades on the Fraunhofer IFF's developments. "The complete integration of advanced information and communications technologies, logistics and electrical grids is unique in all of Germany," observed Sate Secretary Rainer Bomba, praising Magdeburg's Fraunhofer Institute during his visit in December 2010.

Reliable and Resource Efficient Production

Under the rubric "resource efficient production", the Fraunhofer IFF is working to develop cutting-edge applications for energy and resource efficient manufacturing, such as optical 2-D and 3-D measurement systems that inspect quality in-line in real time. Our robotics experts, on the other hand, are increasingly examining safe human-robot interaction. They have designed a number of new intelligent safety systems, which will enable humans and robots to work safely hand-in-hand in the future. One of them is an "artificial skin" for robots, which immediately detects mechanical contact. The system is ideal for a multitude of new products in domains relevant to safety. In addition, it makes intelligent solutions for input devices possible and can give entire surfaces such as flooring individual functions, which are implemented in innovative applications.

This annual report only reflects select issues and projects from 2010. We hope that the following pages provide you interesting insight into our work and inspire ideas for future collaborative projects together with us.

Prof. Michael Schenk
Director of the Fraunhofer Institute for
Factory Operation and Automation IFF

GREETING

Dr. Keith Ulrich

Vice President of DHL Solutions & Innovations

When Adrian **D**alsey, Larry **H**illblom and Robert **L**ynn personally brought a ship's bill of lading from San Francisco to Honolulu by plane in 1969, the shipping documents were processed before the cargo actually arrived at its destination. Born of the idea to send supporting documents before a shipment, a document express service was established, which, after merging with the Deutsche Post over forty years later, evolved into the world's most profitable logistics company, Deutsche Post DHL. Today, over 470,000 employees work for us in a network of approximately 120,000 destinations all over the world.

In the twenty-first century, our customers expect more from us as a logistics provider than ever before. Advanced solutions and efficient logistics operations combined with state-of-the art technologies are in demand. As a globally leading mail and logistics company, Deutsche Post DHL wants to remain at the forefront of innovation in the industry. We therefore established our unit DHL Solutions & Innovations (DSI) in 2010 with the clear mission of creating innovative logistics of the future. To this end, we collaborate with companies and research organizations, which share our vision of tomorrow's logistics. We are collectively giving our all to organize our logistics operations to be efficient and trendsetting and to develop new solutions for our customers.

DSI arose from the corporate strategy for 2015, which gives priority to developing and marketing cross-divisional solutions, which will simplify the lives of DHL's customers. At the same time, DSI is researching the logistics solutions of tomorrow. Together with DHL's units, they are developing solutions from the idea through marketability. DSI provides teams of experts.

(www.dhl.de/solutions-innovations)

We are extremely pleased to have gained the Fraunhofer Institute for Factory Operation and Automation IFF as a new strategic partner in 2010. The signing of the cooperation agreement between DPDHL and the Fraunhofer IFF in June 2010 sealed the start of our successful collaboration.

In addition to our first joint development, an intelligent transport container called the Smart Box, we primarily intend to advance the full integration of RFID technology in DPDHL's global logistic processes in the future. Like barcodes, radio frequency identification or RFID can store information on products and inventories and also do much more beyond that.

RFID tags can store a large amount of data, which can be read later by radio signal automatically and without contact. Chips can store not only product information but also instructions on the handling of tagged cargo. They will largely replace conventional barcode in the future and make shipping and distribution in worldwide logistics chains significantly more transparent, reliable and efficient.

The Galileo Test Bed in Magdeburg furnishes ideal conditions for developing and testing the requisite technologies and infrastructures. DSI is collaborating here with the Fraunhofer IFF's specialists on just such solutions in order to further expand DHL's range of services for the logistics of tomorrow.

We will thus be banking on developments from Magdeburg in the future, too, and are looking forward to the continued collaboration between DSI and the Fraunhofer IFF.

Dr. Keith Ulrich
Vice President of DHL Solutions & Innovations

MISSION

The Fraunhofer Institute for Factory Operation and Automation IFF is an autonomous research unit in the Fraunhofer-Gesellschaft's network.

It is a partner to regional, national and international companies and governmental and municipal agencies. Its mission is to directly support business and benefit society with its applied research.

Technologically, the institute is oriented toward designing, engineering and implementing innovative and customer-oriented solution in the fields of

– logistics and material handling,
– robotics and measurement and testing,
– process and plant engineering and
– digital engineering.

The Fraunhofer IFF operates globally and market-driven. It aspires to develop holistic solutions. To do so, it relies on an international research network of partners from business, industry, research and academia.

The Fraunhofer IFF's work is actively supported by a network of academics from associated institutions of higher education and representatives of leading industries. Internal creativity and external impulses guarantee that knowledge and experience are exchanged continuously.

As a research institute, the Fraunhofer IFF is one of the influential organizations in Saxony-Anhalt. It represents its specializations on national and international committees and is thus notably shaping the innovation processes in the state. With its work, it is advancing economic development and boosting companies' competitiveness.

As a research provider in Saxony-Anhalt, one of its major concerns is to cultivate future generations of researchers. Its employees enjoy excellent starting conditions for future challenging position in business and research. The Fraunhofer IFF thus fulfills its corporate social responsibility.

Balancing economics and ecology and implementing the rules of excellent research and engineering are top priorities. They constitute the basis of our work and are a personal responsibility of every researcher at the Fraunhofer IFF.

The staff works on interdisciplinary teams and cooperates closely with clients. Mutual trust, integration on a partnership basis, practicability and user-orientation typify collaboration. The staff's combined know-how and soft skills are the hallmark of quality of the Fraunhofer IFF's products and services'.

*The main building of the
Fraunhofer Institute for
Factory Operation and
Automation IFF.
Photo: Viktoria Kühne*

THE INSTITUTE IN NUMBERS

Operating Budget and Earnings Trend

In 2010, operating budget expenditures totaled € 15.777 million. Total revenues were € 13.176 million. Of this, € 5.146 million were business revenues.

Investment Budget

Investments totaling € 832,000 were made in 2010.

Human Resource Development

At the end of 2010, the Fraunhofer IFF had 156 employees. Our researchers are primarily degree-holding engineers and industrial engineers. In addition, degree-holding computer scientists, mathematicians, physicists and business people also work at our institute in interdisciplinary research groups as well as administrative services.

Training and Qualification

In 2010, the Fraunhofer IFF provided advising for twenty-eight Diplom theses and ten doctoral dissertations. Over 267 student assistants and interns supported the institute's work. Six vocational interns completed their training here. In addition, our institute offers a wide variety of internships to students from continuing education institutions and high schools.

Development of the Fraunhofer IFF's operating budget from 2005 to 2010

Mill. euros

17
16
15
14
13
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11
10
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8
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1

2005 2006 2007 2008 2009 2010

■ Institutional support
■ Publicly funded projects
■ Industry and business

Facilities

The Fraunhofer IFF's main building on Sandtorstrasse has 5,000 m² of office space and high-tech EDP labs and conference rooms. Our testing facility of 1,000 m² houses diverse technologies for applied research and development, including state-of-the-art systems for RFID and telematic developments, industrial image processing, robotics and rapid prototyping.

The Fraunhofer IFF has another 2,755 m² of floor space (including testing facilities, labs and offices) at its Virtual Development and Training Centre VDTC in Magdeburg's Port of Science where innovative virtual and augmented reality technologies and process and plant engineering are concentrated. The heart of the VDTC is the Elbe Dom, a large-scale laser projection system with a cylindrical 360 degree projection surface of 327 m², a diameter of 16 meters and a height of von 6.5 meters.

Our hardware and software include tools and infrastructures for interactive factory and plant planning, efficient energy conversion plant development and testing, multimedia communication, information and communication management, geographic information system applications and software development.

Development of research staff at the Fraunhofer IFF from 2005 to 2010

Number

2005	2006	2007	2008	2009	2010

■ Number of employees
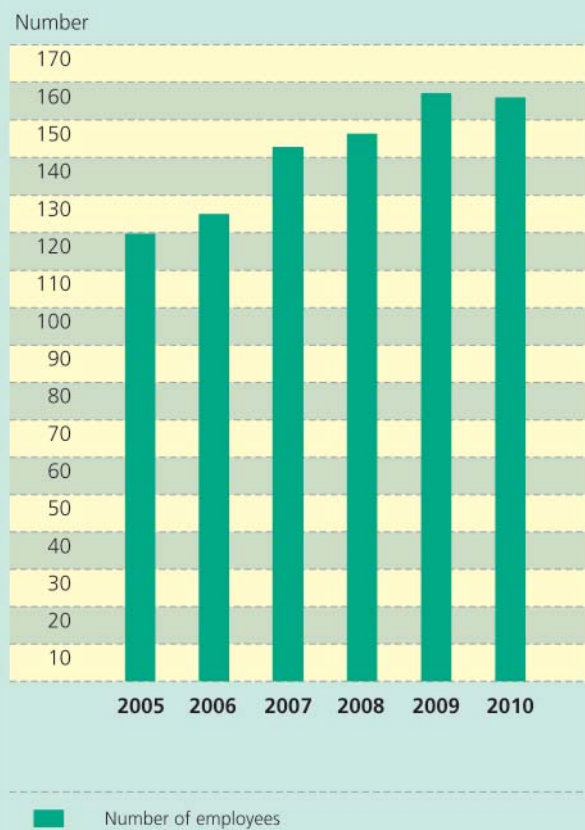
ADVISORY BOARD

The advisory boards of the individual Fraunhofer Institutes support institute management and the Fraunhofer-Gesellschaft's executive board in an advisory capacity. Members include prominent figures from academia, research, business, industry and government.

Prof. Burghard Scheel
Chairman of the Advisory Board

Dr. Frank Büchner
Siemens AG

Peter Claussen
BMW AG

Dr. Stefan Robert Deibel
BASF Polyurethanes

Prof. Jürgen Döllner
Hasso-Plattner-Institut für Softwaresystemtechnik GmbH

Felix Fiege
FIEGE Deutschland GmbH & Co. KG

Hans-Joachim Hennings
Saxony-Anhalt Ministry of Economics and Labor

Dr. Klaus Hieckmann
SYMACON GmbH

The attendees of the 2010 advisory board meeting in Magdeburg (bottom left to top right): Bernd Liepert, Michael Reinboth, Prof. Klaus Erich Pollmann, Dr. Jürgen Ude, Prof. Werner Schreiber, Richard Smyth, Dr. Keith Ulrich, MinDirig. Dr. Joachim Welz, Prof. Burghard Scheel, Prof. Peer Witten, Prof. Jürgen Döllner, Peter Claussen, Dr. Robert Ruprecht, Christoph Hanno Fischer (guest), Klaus Müller, Prof. Michael Schenk (Director), Prof. Alfred Gossner (guest), Andreas Hiltermann. Photo: Viktoria Kühne

Andreas Hiltermann
InfraLeuna Infrastruktur und Service GmbH

Bernd Liepert
KUKA AG

Klaus Müller
Kranbau Köthen GmbH

Klaus Olbricht
Magdeburg Chamber of Commerce and Industry

Prof. Klaus Erich Pollmann
Otto von Guericke University Magdeburg

Michael Reinboth
DHL Hub Leipzig GmbH

Dr. Robert Ruprecht
Forschungszentrum Karlsruhe GmbH

Prof. Dr.-Ing. Werner Schreiber
Volkswagen AG

Richard Smyth
European Institute of Cognitive Sciences and Engineering

Dr. Jürgen Ude
Innovations- und Gründerzentrum Magdeburg GmbH

Dr. Keith Ulrich
Deutsche Post AG DHL Innovation Center

Dr. Joachim Welz
Saxony-Anhalt Ministry of Education and Cultural Affairs

Prof. Peer Witten
Logistik-Initiative Hamburg

PROJECT REPORTS FROM THE FIELD OF AUTOMATION RESEARCH

*This system developed at the
Fraunhofer IFF automatically
scans the 3-D geometry of car
rims and accurately inspects
quality during production.
Photo: Berndt Liebl*

1

PRESSURE-SENSITIVE INTERFACES TEACH MACHINES TO FEEL

Motivation and Task

Long banished behind massive steel barriers, robots are now increasingly entering new fields of application as service robots and robotic assistance systems. Unlike classic industrial robots in manufacturing, which repeatedly follow a preprogrammed path in cordoned off robot cells, service robots and robotic assistance systems operate in direct proximity to humans and provide them support when their work is physically strenuous, hazardous or monotonous. The fields of application range from assembly assistants in industrial manufacturing to automatic guided vehicle systems in hospital, which deliver food and fresh linens to wards fully automatically.

These applications often enable or even require humans and robots to come into contact. Novel sensors and interfaces are needed to organize such direct collaboration between humans and robots efficiently and, above all, safely.

A pressure-sensitive robot skin for the laboratory robot LiSA was already developed in the project "LiSA: Assistant Robot in Life Science Company Labs" in 2008. It reliably detects contact and stops any dangerous robot movements.

In order to organize collaboration between humans and robots even more efficiently, interaction metaphors based on contact, which intuitively control real and virtual equipment, will be specified and implemented with the aid of the pressure-sensitive skin in subproject 4.2 of the project "Applied Virtual Technologies Focused Long-range on the Product and Production Equipment Life Cycle AVILUSplus".

Approach and Results

The subproject 4.2 "Novel Intuitively Operable Input Device Based on a Tactile Skin for AR and VR Environments and Real Machines and Robots" entailed the construction of two demonstration systems, which can be used to test the pressure-sensitive skin that controls real and virtual machines.

The LiSA robot was the substructure of the first demonstration system. The pressure-sensitive skin that detects collisions served as the basis. Its hardware and software were extensively reengineered and equipped with underlying algorithms that localize and evaluate contact. Building upon this, an intelligent control concept was designed, with which contacts can be interpreted as motion pulses. When contact is detected, the robot takes evasive action and moves in the direction of the force vector generated by the contact.

This enables humans to interact with robots directly without additional control units and to control positions and motion sequences easily.

1 *LiSA robot with pressure-sensitive skin.*
Photo: Uwe Völkner/FOX
2 *Tangible interface that controls virtual robots.*
Photo: Markus Fritzsche

2

In a first step, a virtual copy of the LiSA robot was created for the second demonstration system. The copy was coupled with the real LiSA robot, thus making it possible to initially plan the real robot's motion sequences with the aid of the virtual robot and then transfer them to the real robot. Since it reduces the downtimes of real machines, this type of offline programming improves resource use in industrial manufacturing.

In another step, a tangible interface based on the pressure-sensitive skin was developed, which controls the virtual robot. The tangible interface has pressure-sensitive control elements and an integrated triaxial accelerometer The fusion of the sensor data from both sensor systems allows implementing the control unit to control the virtual robot as a function of context and position. The control elements' pressure-sensitivity endows the input device with an additional dimension of force of interaction, thus making it possible to control the velocity of the virtual robot's movement as a function of force.

Outlook

Both demonstration systems have been tested successfully under real conditions. The use of contact-based interaction systems to control real machines and VR environments simply and intuitively and influence their performance was demonstrated. This constitutes a solid technological basis for further research and development projects.

Project Partners

The AVILUSplus project is part of the Virtual Technologies Innovation Alliance and is closely tied to the AVILUS technology network, a consortium of business and research partners developing efficient virtual and augmented reality technologies. The start of AVILUS quickly revealed the need for technologies that will require research over a longer period.

Nine well-known basic and applied research organizations are devoting themselves to this task in the project AVILUSplus being overseen by the Project Agency of the German Aerospace Center.

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BIONIC TRUNK KINEMATICS ARE MAKING ROBOT APPLICATIONS SAFE

Motivation and Task

Physical contact between humans and robots is unavoidable when they share a common workplace or work hand-in-hand. This often entails risk of injury to humans. Research at the Fraunhofer IFF in the field of physical human-robot interaction is aimed at eliminating potential hazards. Directly related to this research specialization, the joint project BROMMI involves the development, construction and testing of a safe robotic arm with an innovative kinematic concept that makes it safe for humans.

An elephant's trunk serves as a natural model for the robotic arm. Its highly flexible motion patterns are devoid of hazardous shear points and contrary motions. Furthermore, the robotic arm is being quipped with an image processing system, which enables it to detect and selectively grasp objects in a workplace with high positioning accuracy.

Solution

In the first phase of the project, numerous concepts for the design of a trunk-like robotic arm were developed and analyzed. The analysis of the motion patterns of a real elephant's trunk revealed that use of flexible elements, also called flexible joints, is the best solution for mimicking it. Flexible joints capable of moving actively around two axes are interlinked to produce robot kinematics that executes trunk-like movements and thus combines all of the movement's merits.

All of the concepts developed were extensively studied and evaluated to identify options for the integration of positioning sensors and different drive systems. Subsequent evaluation of the high positioning accuracy and durability required revealed that the robotic arm must have a rigid mechanical design. The combined results of the tests further revealed that, when other criteria such as size, workspace size and controllability are factored in, a multi-joint robotic arm is the best design. The Fraunhofer IFF developed and has filed a patent for an electrically powered articulated flexible joint.

Engineering and Modeling

The chief task in the second phase of the project was to engineer and mathematically model the compound joint. Since the deadweight causes the load born by each compound joint to decrease along the robotic arm toward the "tip of the trunk", three differently functioning and sized compound joints had to be engineered. The compound joint's direct, inverse and differential kinematics were mathematically modeled and unified in an abstract model. This model provides the basis for calculating defined speed and position curves for the compound joint, which are an elementary prerequisite for its control.

1 No fear of contact. Photo:
Marco Barnebeck/pixelio.de
2 Articulated flexible (compound) joint.
3 BROMMI demonstrator
with five compound joints.
Photo: Sven Kutzner
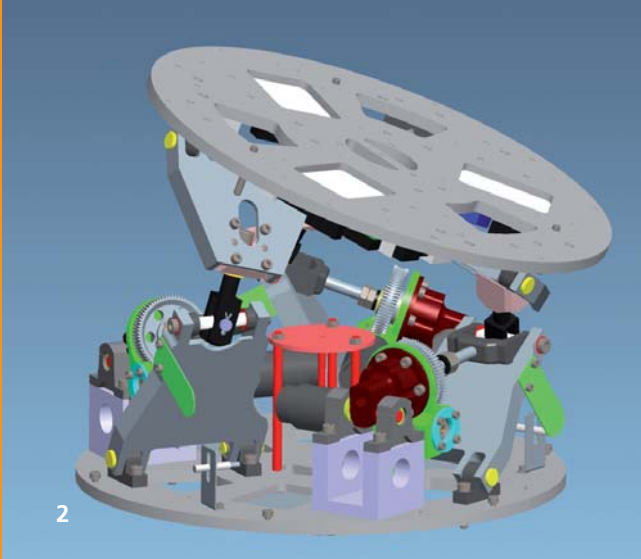
Prototype

In the third phase of the project, a demonstrator with five compound joints was constructed and tested. The work centered on producing the individual compound joints and designing the central control. At the same time, the compound joints' drive components were subjected to extensive methodical tests and optimized iteratively. A master computer and a real time capable embedded computer were programmed and connected to a common communication bus as the demonstrator's master control. Afterward, the distributed motion controllers were configured and connected. Once individual speed and position curves had been calculated, the demonstrator was able to execute pre-programmed movements.

Outlook

The second half of the project will focus on integrating image processing and adding three more compound joints to the demonstrator. At the end of the project, the robotic arm will be evaluated and demonstrated with a pick-and-place scenario. The robotic arm will be able to recognize objects, pick them up and place them in a designated spot by using image processing in the workplace. Image processing will additionally support the positioning of the robotic arm.

Project Partners

The Fraunhofer IFF is lead managing the BROMMI project. Together with the Technische Universität Berlin, the Fraunhofer IFF is in charge of the research in the project. Industry partners are project:syntropy GmbH inMagdeburg; Festo AG and Co. KG in Ostfildern-Scharnhausen and the Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung in St. Augustin.

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VISUAL ASSISTANCE SYSTEMS FOR MANUAL ASSEMBLY OPERATIONS

Initial Situation and Motivation

Kolbus GmbH & Co. KG, one of the worlds leading manufacturers of bookbinding machines, manufactures individual parts on advanced CNC machines. Blanks are clamped in special modularly designed clamping systems and then fed to the CNC machines. Clamping systems are completely built by hand because their components vary and the lot sizes are small. Inattention or obsolete instructions can lead to collisions between the spindle and blanks or the clamping system. This not only causes costly damage to a machine but also long machine downtimes. Until now, the only way to prevent errors during assembly was to reduce speed during the first run, thus making it possible to stop operation whenever a potential collision was detected. Only parts produced afterward could be machined at full speed.

This project was therefore intended to find a solution that provides assemblers support to prevent mistakes when they assemble clamping systems manually and guarantees that assembly data is current.

Solution

Detailed preliminary analyses of interfaces to operations planning at Kolbus and systematic interviews with assemblers led to the selection of a system based on augmented reality (AR) technology. The AR system visualizes the type, position and orientation of every component. In addition, several workplaces were equipped with stationary cameras pointed directly at the work area. The cameras continuously take pictures, which appear live on TFT displays directly before the assemblers. The camera's position and orientation to a reference coordinate system specified by the workplace were additionally calibrated using photogrammetric methods.

The CAD data of assembled clamping systems were processed for operations planning so that it simultaneously incorporates the assembly sequence of the individual components. In the future, the CAD program will predefine the sequence of CAD data for new clamping systems when they are being designed.

During assembly, the CAD data for every specified work step are superimposed on the camera pictures. The position and orientation of the elements being mounted are presented with high accuracy. All of the CAD objects of the components being mounted are automatically extracted from the current work step and rendered from one camera position, which corresponds with the real camera's position exactly. Instead of the entire surfaces, only the contours of objects were selected for solid modeling to improve the visualization of the CAD models and make them clearer. The highly precise spatial orientation of the cameras to the workplaces ensures that the superimposition deviates less than 0.5 millimeters.

1 *Assistance system with five cameras and three monitors at Kolbus GmbH & Co. KG. Photo: Steffen Sauer*
2 *Components with superimposed red contours during a work step. Image: Jörg Niemann/Kolbus GmbH & Co. KG*
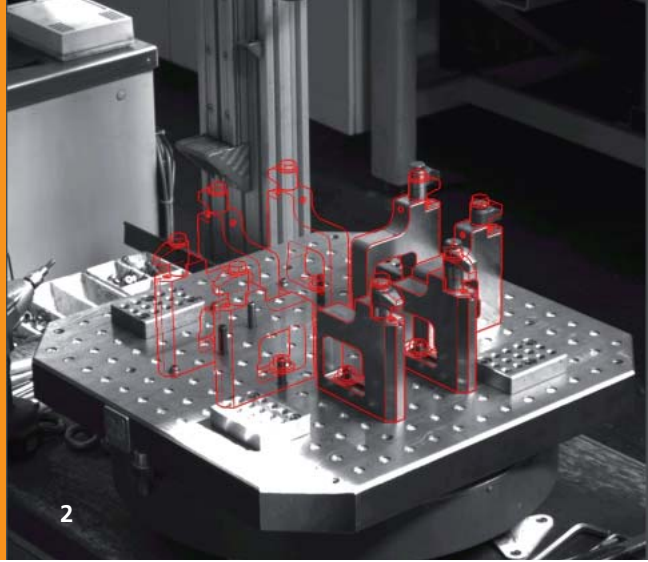
Assemblers additionally have the current CAD model of the clamping system at their disposal. They can navigate it freely and thus view the assembly interactively from all sides. Furthermore, parts lists, previously available in unreliable paper form, can now be extracted and compiled directly from the CAD data. Users interact with the system entirely through the displays equipped with industrial touchscreens.

Results

A total of four workplaces were equipped with the newly developed stationary AR systems on which over 8000 variants can be assembled. The sizes of the workplaces varied. One workplace (Unisign UniPro 5P) measured 0.6 square meters, two (Makino V77) measured 0.8 square meters apiece and one (Unisign UniPro 5L) was nearly one square meter. The new system was well received by the assemblers. The simple presentation and easy control enabled them to intuitively operate the assistance system intuitively after just a brief period of orientation. The assistance system proved to be easily and smoothly integrated in the process chain of individual part production in custom machine manufacturing.

Benefits

Since the assistance system reliably supported the assembly of the clamping systems, the CNC machines' first run was shifted to full speed already after a few weeks of test operation, . Production speed was increased significantly and the goal of the project was thus met. There was also a positive side effect. The assistance system enables workers to complete assembly jobs not only without errors but also faster.

Outlook

Since the results obtained with the assistance system were so positive, work is now being done to adapt it to another workplace where clamping systems for portal milling machines are assembled. The challenge here will be the surface area, which is twelve times larger than that of the previous machines.

The assistance system is interesting for more than just clamping system assembly. It can be used for any assembly job of great complexity and/or with a wide variety of parts.

Project Partner

Kolbus GmbH & Co. KG, Rahden

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1

OPTICAL QUALITY INSPECTION OF CAST IRON COMPONENTS

Initial Situation and Motivation

Large machines punch and grind metal, which has been melted and cast into a new component beforehand. The floor vibrates and dust is in the air. Such inhospitable conditions signify a major challenge to implementing optical measurement and inspection methods, which the Fraunhofer IFF has met with success.

Whenever cast components are manufactured, great efforts are made to ensure product quality and reduce energy and material consumption. Mold sand is randomly sampled, molten metal is subjected to spectral analyses and mechanical properties are tested to monitor the process. Since end users are increasingly demanding one hundred percent inspection, fully automatic in-process measurement and testing technologies are becoming increasingly important. They make it possible to detect defects at an early stage and promptly initiate countermeasures to assure the quality of products.

Task

Although many tests already run automatically, manually performed visual inspection is still the final inspection. Since this incurs high labor costs, usually only a few random samples are taken. Thus a large number of defective cast parts remains undetected.

Defects include deviations of geometric shape, breakouts and surface defects such as sand and casting residues as well as damage and open cavities. Automatic inspection is intended to detect and distinguish such defects and, in part, even document their dimensions. A foundry's complex ambient conditions, e.g. temperature fluctuations, dirt and vibrations caused by the heavy equipment being operated, constitute a particular challenge. .

Solution

For a long time, the Fraunhofer IFF has been collaborating with industry partners and other Fraunhofer Institutes to implement quality assurance systems in harsh industrial environments. Methods of optical 3-D measurement and industrial 2-D image processing are used for these jobs, too. They allow both precise inspection of dimensional shapes and geometries and rapid and reliable inspection of surfaces. For instance, a camera system is used to reliably detect shrink marks and indentations as well as casting residues, visible casting defects and other surface defects. In addition, in combination with precise 3-D laser light sectioning sensors configured specifically for the job, deviations of shapes from CAD nominals as well as misruns, excess or insufficient geometries, are automatically detected and their dimensions documented. Afterward, the test readings and instructions for action derived from them are fed directly back to the machine controller. This closes the production cycle.

1 *Combined camera and laser measurement system that inspects 2-D and 3-D features.*
2 *Three-dimensional detection of mold core position and location with the aid of methods of optical measurement.*
Photos: Christian Teutsch

2
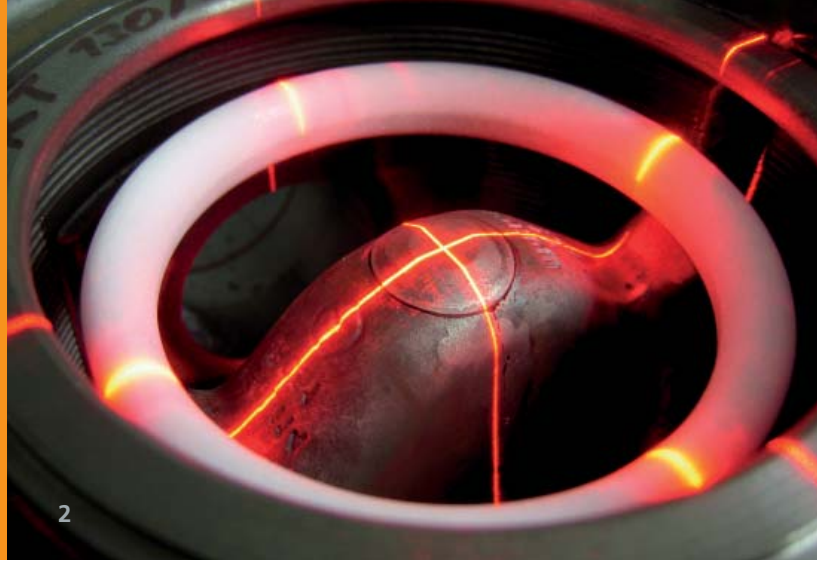
Approach

The measured data are continually captured and evaluated fully automatically. The adaptive algorithms tolerate changes in position and shape and thus accommodate permissible component tolerances. The measurement and inspection system obtains a product's specific parameters directly from the machine controller and the foundry's database system, thus automatically adjusting for slight modifications of product specifications. Such innovative inspection systems for reliable detection of surface defects can be implemented regardless of the product because they have been taught with hundreds of good and bad parts beforehand. Only the camera system must be adjusted to new products in order to ensure that every relevant area of an object is scanned. In order to keep up with the high clock rates required for 100 percent inspection, the algorithms employed are additionally highly parallelized, i.e., several computer processors are installed, which work on one inspection job simultaneously.

The inspection system is shielded from adverse external conditions. Its construction is dust-proof and extremely rugged. After all, dirt, vibrations and the system's use in-line directly in and at a machine affect the reliability of optical methods. An uninterruptible power supply with voltage filters and climate control systems complete the technical precautions that minimize adverse external influences.

Results

The measurement and inspection system developed was put through an extended evaluation phase and its performance was demonstrated. To do so, its was implemented in parallel with the manual visual inspection. Every significant defect was detected, ninety-five percent of the borderline cases were sorted out correctly and fewer than one percent incorrectly. Thus, it exceeded the requirements. It will support visual inspection for the present and replace it entirely later.

The technologies implemented are specialized for types and attributes of defects rather than individual components. They can thus be applied to a multitude of potential shapes and surface types and easily integrated in various manufacturing and reworking stations.
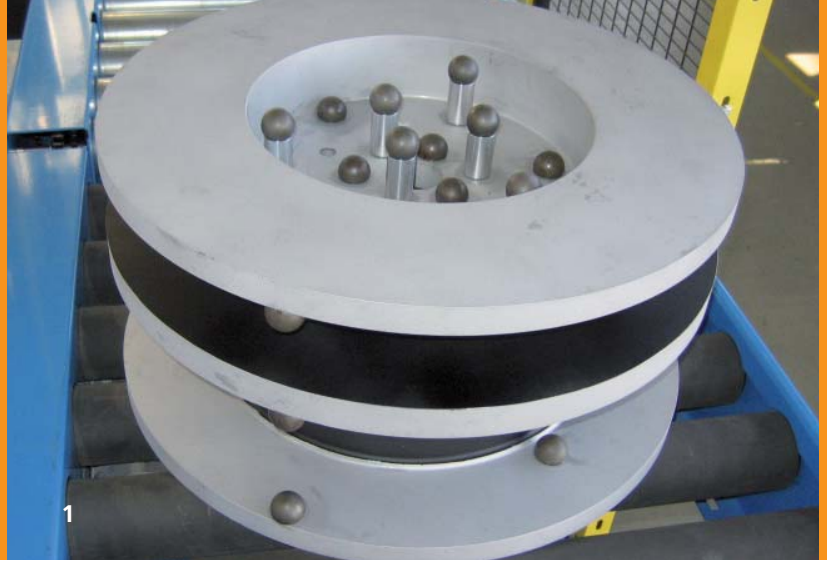
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PLANNING MODULAR SPATIAL ORIENTATION STRATEGIES

State-of-the-Art

The range of laser light-sectioning sensors (LLS) with various effective ranges for coordinate measuring and automated systems is very extensive. In principle, an LLS projects a laser line on the measured object, which a camera views from another angle. A measurement delivers a set of 2-D points, a profile line. This method of non-contact measurement is extremely well suited for automatic geometry inspection during manufacturing.

Frequently, 3-D features inspected on a component must be measured with several profile lines. The movement of either the component or the LLS is defined or several LLS are used. The position and orientation of the light-sectioning sensors to one another or the motion system must be ascertained so that the individual profile lines can be transformed into a common coordinate system. This procedure is called spatial orientation. While spatial orientation of light-sectioning sensors with appropriate matte calibration spheres is standard for coordinate measuring machines (CMM), applications that require only relative measurements at one profile line, e.g. weld, glue bead or gap inspections, dominate automation. The spatial orientation strategy for CMM utilizes the calibrated X-Y-Z positioning system and is therefore not transferable to other LLS applications without it. Established spatial orientation strategies or aids cannot be reverted to for inspection applications that use one or more LLS moving on axes to take measurements of profile lines at various points of a component, e.g. by rotating the LLS around the object, .

Solution

A model-based approach was selected as the solution. It employs only suitable measured calibration blocks for spatial orientation without any external instruments. The measurement system consisting of light-sectioning sensors and a motion system and the calibration block are modeled. The model contains the light-sectioning sensors' position parameters. Measurements are taken at the calibration block, which the model transforms into the calibration block's coordinate system. The proximity of the measured points to the calibrated object specify the model errors. The light-sectioning sensors' position parameters that minimize model errors are ascertained.

An upgradable Matlab™ class model models any measurement system. A simple simulation that does not incorporate masking effects generates synthetic measured data. Users with a good grasp of the class library can manipulate Matlab™ objects very flexibly.

The calibration blocks consist of simple geometric elements such as planes, cylinders and spheres. They can be created with a marginal deviation of shape and a matte surface. A coordinate measuring machine can measure the position of individual elements extremely precisely.

1 *Calibration block for the spatially orientation of a wheel measuring machine. Photo: Thomas Dunker*
2 *Wheel measuring machine with conveyor. Photo: Bernd Liebl*

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Results

This spatial orientation strategy has been implemented for a number of laboratory tests to measure glasses frames, window profiles and wheel hubs. It was also applied to spatially orient ASCONA GmbH's wheel scanners.

The wheel scanner scans aluminum wheels once the geometry of the bead seat, hub and bolt holes have been machined. Three light-sectioning sensors and a punctiform laser triangulation sensor rotate around the clamped-in wheel. The calibration block developed resembles a simplified wheel with two outer bead seats and is additionally furnished with spheres. It can be automatically fed in and measured. The wheel scanner has two rotary axes and seven feed axes so that wheels with differing diameters of up to 24.5 inches and differing widths of up to 17 inches can be measured.

Since the orientation of the axes had to be incorporated in the spatial orientation, a model was created, which has thirty-nine parameters that have to be ascertained for the wheel scanner and six others for the position of the calibration block. A suitable intermediate joint in the model prevented singular parameterization, which, for instance, consecutive Denavit-Hartenberg joints with parallel axes would produce. The analysis of the model error obtained determined that the LLS for the hub, which is used outside the specified standard effective range, exhibited significant systematic errors of measurement, which were correctable by recalibration.

Then, the ascertained parameters and the model can be used to transform the profile lines generated into a common coordinate system. Afterward, the features are extracted automatically and the geometric and position tolerances are analyzed.

Measured points of a wheel with automatically extracted features.
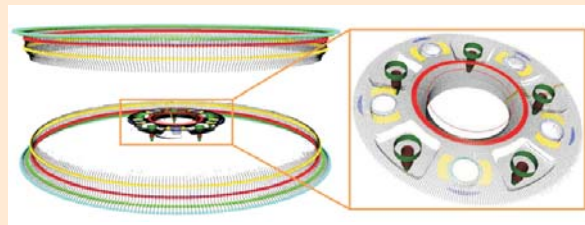
Outlook

In the future, software will simplify modeling and redundant and define the model's singular parameterization and determine the measured data's correlation to changes in the model parameters for a measuring strategy.

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Fraunhofer

OPTICAL MEASUREMENT SYSTEMS FOR ADVANCED CULTURAL HERITAGE MONITORING

Motivation

Environmental influences and natural decay wear away the substance of heritage sites. Preserving cultural heritage is one of conservators' top priorities. This requires tremendous labor and the success of conservation actions can often only be assessed after the passage of time. Prompt action requires detecting damage in due time and then monitoring it.

Task

The task was to develop efficient methods and strategies for preventive maintenance of cultural heritage. The focus was particularly placed on methods of monitoring with which damage near surfaces can be detected early, quantified and monitored.

Solution

The technological basis was established by combining 3-D surface laser scanning with active thermography. Surface information provides the basis for detecting geometric changes, e.g. cracks, protrusions and deformations,. Active thermography detects defects just below the surface and invisible to the eye, e.g. delamination, cavities and structures. The combination of both technologies allows correlating geometric changes and thermograms. This methodology can significantly help determine whether inner and outer damage are related.

Approach

An articulated measurement arm with a laser light-sectioning sensor (LLS), which was developed at the Fraunhofer IFF, was employed to capture 3-D data. The quantity of 3-D points generated was initially processed by filters and then the data was cleansed. Afterward, a geometric surface model was reconstructed by interconnecting the individual 3-D points with triangles. This delivers a precise digital model in which changes of even one tenth of a millimeter can be detected.

The active thermography, on the other hand, utilizes the systematic warming of the analyzed structure and the subsequent observation of its cooling with a heat sensitive infrared camera. Inhomogeneities such as cracks or cavities display different thermal characteristics than an intact environment. The camera detects this difference precisely and thermograms with suitable color scaling are used to evaluate the measured data qualitatively.

The fundamental innovation behind this measuring method is the integration of both measuring systems in one system and the direct fusion of the measured data because this makes it possible to rapidly, automatically, quantitatively and precisely

1 | 2 | 3 *Three-dimensional reconstructions of the "Madonna and Child" in Halberstadt Cathedral (1), with superimposed photo texture and (2) with superimposed thermogram (3).*

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scan a multitude of complementary measured parameters of the surface structure and topography. On the one hand, details detectable by thermography can be clearly assigned to spatial structures, thus facilitating the interpretation of the findings. On the other hand, minor and long range geometric changes such as expansion and contraction are detectable by thermography in the submillimeter range, thus making this methodology significantly different from hitherto common damage detection systems.

Results and Outlook

As part of the project, the parameters of the individual measurement systems were collected and adjusted to the specifications of applications for historic preservation. The tests were repeated in longer time intervals (one year) and performed under various basic climatic conditions.

Ultimately, the combination of a 3-D measurement system and active thermography was proven to effectively monitor cultural heritage, existing buildings and new buildings. Periodic monitoring based on these measured quantities makes it possible to detect damage at an early stage and evaluate it objectively. This additionally increases buildings' safety and stability and facilitates damage forecasting, lifetime assessments and environmental impact assessments.

The tests are repeatable without permanent stationary structures and fully nondestructive. Moreover, they eliminate major maintenance actions in the long term. This cuts costs and helps preserve the structure of historic buildings.

Project Partners

Institut für Diagnostik und Konservierung an Denkmalen in Sachsen und Sachsen-Anhalt e. V., Halle and the Federal Institute for Materials Research and Testing BAM, Berlin

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Bundesamt
für Bauwesen und
Raumordnung

INNOVATIVE METHODS FOR PROCESSING DIGITIZED MEASURED 3-D DATA

Motivation

Optical measurement systems that digitize surfaces in 3-D have replaced conventional, usually tactile methods in many applications. Whether they operate with point, line or planar sensors, vast quantities of measured 3-D data are generated in a few seconds. These measured data deliver a description of the digitized object's surface topography. Methods and software algorithms that evaluate and analyze measured 3-D data are needed, for instance, to detect deviations in dimensions, shape and position to verify a scanned object's dimensional accuracy or even completeness. More than just in-line measurements for quality assurance require a high level of automation. There is also great need for automatic measurement and inspection procedures for the tremendous quantities of data from laser scans for building and industrial systems.

Therefore, the research project AVILUSplus addressed this issue in the subproject "Automatic Analysis and Evaluation of Measured 3-D Data" and developed innovative methods to process large quantities of digitized measured 3-D data.

Task

The task entailed providing generic and simultaneously efficient software systems that analyze, process and evaluate measured 3-D data from different sensor sources. Existing systems were largely unable to handle the number of different scan technologies and the large quantities of measured 3-D data to be processed. New methods were therefore intended to form a basis for better integrating and processing measured

3-D data in virtual environments. Research work was particularly focused on measurement functions and operations that compare real measured 3-D data and geometries from virtual CAD environments.

Approach

First, the process of measured 3-D data generation was analyzed during the project, and systematic correlations were taken advantage of to significantly improve processing. Using information known by the system throughout the measurement operation allows the subsequent system to build directly upon equipment parameters such as scan sequence and sorting. For instance, a complex measurement operation's rotation parameters can be used from the start to determine which sections of different scans belong together. Since many suboperations make use of the measuring principle itself, this simplifies the evaluation of 3-D data significantly and additionally reduces the complexity of downstream procedures.

1 *Operation comparing measured 3-D data and a CAD model with color coded differences.*
2 *Semi-automatic approximation of geometric primitives in a scanned component.*
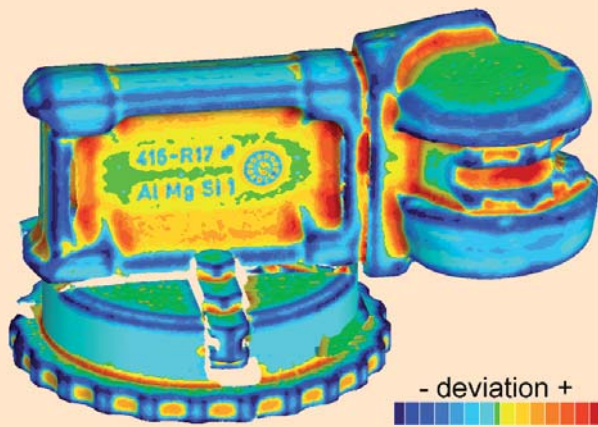
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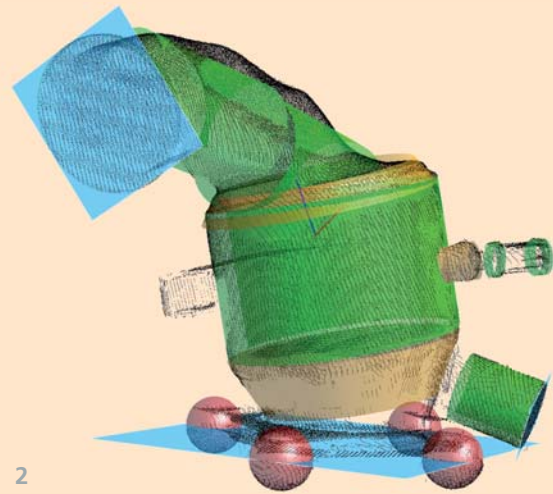
2

The generic and formal specification of scans derived from this analysis assigns additional and standardized meta information to the measured 3-D data. This served as the basis for the development of fully automatic 3-D data filtering systems and the reduction of measurement artifacts. These simultaneously adaptive methods serve as the basis for automatically reconstructing 3-D model data and comparing them with given CAD nominals.

The efficient comparison operation itself utilizes the additionally obtained information to compare geometry based on a classic measurement methodology. Future 3-D measurement technologies based on similar or refined measurement strategies and principles will profit from the formalism developed, which specifies the conversion of measured data into a general model to analyze geometry.

Results

The innovative software technologies were combined in a demonstration application and presented to the collaborating partners at the final project meeting. In addition to complete measurement systems with integrated data evaluation, software libraries can also now be implemented for both 3-D scan system manufacturers and users. The results achieved have additionally been presented at professional events and conferences and thus also made accessible to the public.

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DEVELOPING SMART GRIDS FOR FUTURE ELECTRIC VEHICLE NETWORKS

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Energy Sources Today and Tomorrow

In Germany, electricity is overwhelmingly produced in coal and nuclear power plants. The power mix in Germany is 23.7 percent lignite, 17.5 percent anthracite, 22.7 percent nuclear power, 13.5 percent natural gas, 17.3 percent renewable energies and 4.3 percent other sources [1]. In addition to the base load power plants operating at nearly constant capacity, there are reserve power plants, which supply so-called reserve power in order to match the production of power to the current load. This regulating power is controlled by special algorithms as required. The grid is operated and the power flows are regulated based on years of experience and are basically easy to manage. The daily, weekly and yearly rhythms of consumer loads are known and factored into the power calculation.

In addition to large conventional power plants, more and more small and medium-sized renewable power generation plants are going online. They convert wind, sunlight or biomass into electricity and supply it to the grid. In 2007, Germany set a goal of increasing the share of renewable energies in the power mix from approximately twelve percent to twenty-five to thirty percent by 2020 [2]. Eighty percent of all power is supposed to be generated from renewable energy sources by 2050 [3].

Renewable Power Generator Performance

The large number of distributed generators supplying renewable power has created a completely new situation in the electrical grid. Electricity is supplied to the grid from many locations instead of a few central power plants. The fluctuating supply of most of the renewable energy sources leads to greater complexity. Only hydropower and biomass in part are availably nearly continuously with relatively low annual fluctuations. Solar energy on the other hand is subject to daily and annual cycles, which are additionally also affected by the weather. Although significant benefits for the continuity of the

power supply can already be expected from future offshore installations coastline, wind energy is also not available all the time. Projects that will transport solar electricity generated in North Africa to Europe are also in discussion.

Existing Grid Structures

Electrical grids constitute the link between power plants, the generators of electricity, and consumers. They consist of low, medium, high and extra high voltage lines as well as the related transformer substations and stations. Underground and overhead lines are common in lower voltage ranges. Overhead lines are normally used for the higher voltage ranges.

In the course of technical development and in conjunction with market structures, the local grids originally isolated from one another evolved into today's electrical grids. They constitute a widely and deeply interconnected structure and are chiefly oriented toward the geographic location of power plants and industry consuming power as well as smaller consumers down through private end consumers. Therefore, electrical grids have different densities and topologies in individual regions.

1 *Wind turbine.*
Photo: P. Kichhoff/pixelio.de
2 *Residual timber chipped*
for biomass gasification.
Photo: Dirk Mahler
3 *Photovoltaic power sta-*
tion. Photo: MEV Verlag
GmbH

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Challenges for Future Grids

Conventional electrical grids have a unidirectional power flow from a few major power plants into the grid. The development of renewable energies has been progressing steadily. Renewable power generation plants, such as solar power plants and wind turbines, which supply electricity from distributed locations, are being built all over Germany. At any rate, the increase in the share of renewable energies is having a significant effect on the electrical grids in Germany.

In western and southern Germany, two major power plants currently supply the industrial regions and, in the north, the construction of offshore wind farms is being intensified to cover energy demand. The power lines will have to be extended or new high and extra high voltage lines will have to be built to transport the generated electricity from the north to the south. This additional widely distributed supply is giving rise to entirely new requirements for grid control.

Moreover, the options for storing power will have to be expanded considerably in order to be able to compensate the fluctuating supply of renewable energies. Until now, electricity has been stored in pumped-storage power plants in which water is pumped into high elevation reservoirs and electricity is produced by turbines as necessary. In the future, subterranean compressed air or battery energy storage systems will also be used.

Smart Grids

Distributed supply from fluctuating energy sources complicates grid operation and control. At present, only reserve power plants can still compensate the fluctuating supply from renewable energy sources.

In the future, instead of a few base load and peak load power plants, a large number of small generators will have to be integrated in the monitoring and control system. There are also options to influence consumption. Interruptible power consumers can be controlled so that they can be shut down temporarily as required, e.g. when demand for electricity from the grid is high. This requires being able to control consumers. Electrical grids will also have to be made smarter.

Conventional electrical grids are being turned into smart grids, which the European Technology Platform defines as "an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies." This will require equipping electrical grids with intelligence and developing them to be an "energy Internet" [4].

In order to control consumers, the current energy consumption in a region will have to be measured or forecast and combined with a continuous comparison of consumption and the forecast. To this end, all the end consumers' present electricity meters will have to be replaced by so-called smart meters. When such meters, e.g. phasor measurement units, are connected with a central control center, it will possible to integrate end consumers in the grid control system. The consumers' meters will have to have the requisite controllability.

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Control systems for the smart grids of the future
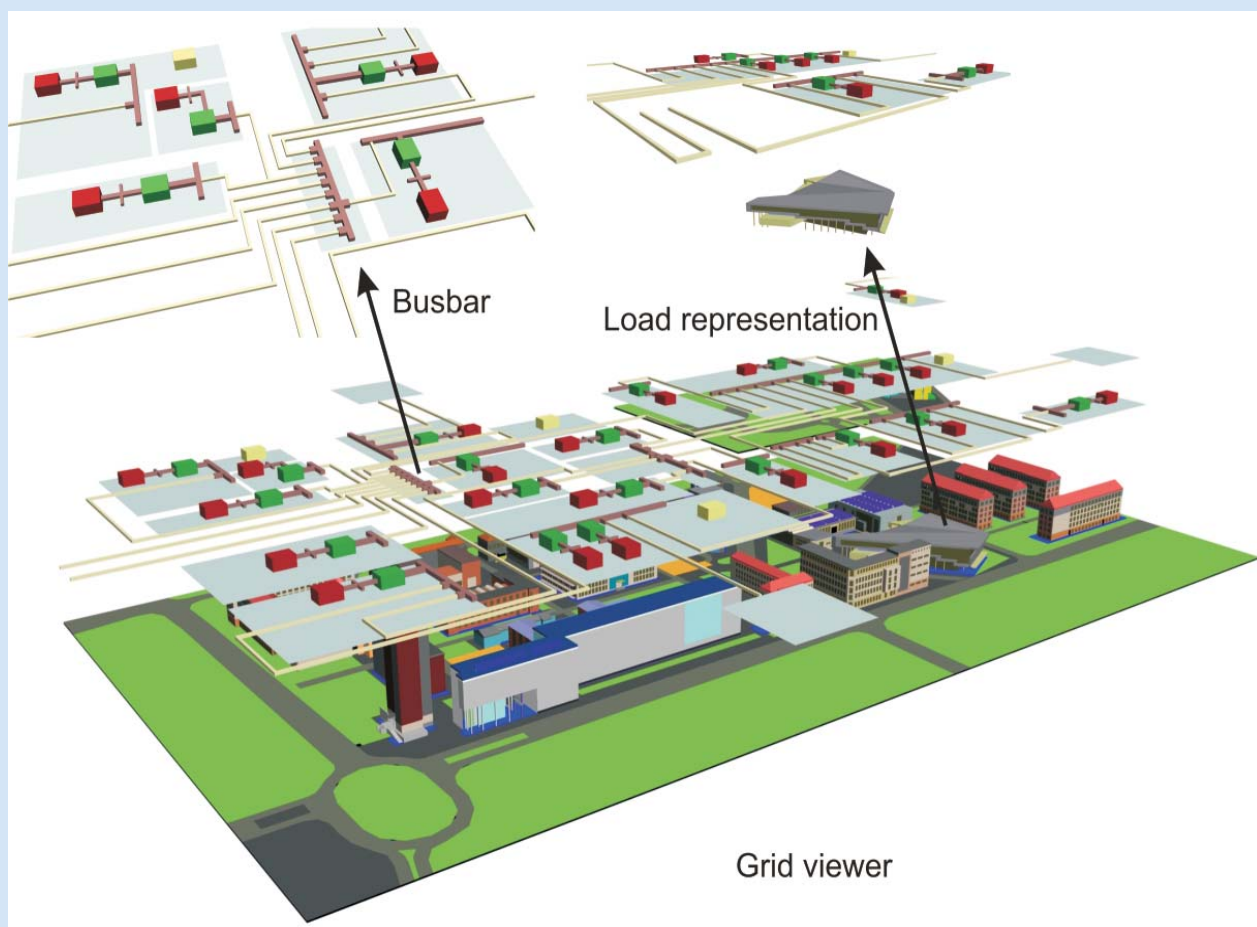
Busbar

Load representation

Grid viewer

Electric Vehicle Networks in Smart Grids

The increasing number of electric vehicles predicted in the coming years provides an interesting opportunity to store electricity on a daily basis and thus to support virtual power plants. Related studies are being conducted in the "Harz model region" with the involvement of the Fraunhofer IFF. Based on the percentage of electric vehicles the German government is aiming for in the entire vehicle population by 2020, the total connected load of 80 megawatts from the electric vehicles in the model region would theoretically be as high as the generating capacity of the pumped-storage plant in Wendefurth. This makes the significance of the electric vehicles' potential for storage clear.

Given their connected loads, a large number of electric vehicles could cause problems in the grid if they are fast charged (at higher load), especially when many vehicles start charging at the same time, for instance, in the evening after returning from work or shopping.

Vehicle charging adjusted to grid conditions, e.g. during periods of surplus energy, can relieve the electrical grid noticeably during light load periods. Resupplying power to the grid is also an option to support the grid. This will only be met with acceptance when drivers know their vehicles will be charged by the time they desire.

The Fraunhofer IFF's Activities

Converting electrical grids into smart grids and integrating electric vehicle networks in them holds great potential for research. The Fraunhofer IFF is involved in several projects researching this interesting challenge.

Among other things, the project "RegModHarz" is working on mechanisms that control the charging of electric vehicles in order to integrate them in the electricity supply system as part of a so-called virtual power plant. Control signals and tariff incentives ensure that supply is guaranteed for electrical power systems and electric vehicles are charged optimally using renewable energies, even when the number of electric vehicles is high and the supply of renewable energies fluctuates.

In the project "Harz.EE-mobility", research is being done to assure drivers' mobility by predominantly using electricity generated from renewable energy for the future era of electric vehicles. The different levels of the electric vehicle network, the electrical grid, the ICT system and the logistics system are being combined with one another intelligently to meet these demands. The system being produced will be not only for private but also for commercial transportation. Researchers from the Fraunhofer IFF are developing the hardware and software components, such as an electric vehicle network control center, necessary for both research projects.

In the Fraunhofer-Gesellschaft's joint project "System Research for Electromobility", Magdeburg's Fraunhofer IFF is clarifying issues of grid stability and certainty of supply for a large number of connected vehicles. In particular, uncontrolled fast charging was identified as a problem, which can have an impact all the way to medium voltage grids.

1 The smart charging station at the Fraunhofer IFF's VDTC, for which drivers may register. Photo: Viktoria Kühne
2 Electric vehicle network navigation system. Photo: Daniela Martin

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www.harzee-mobility.de

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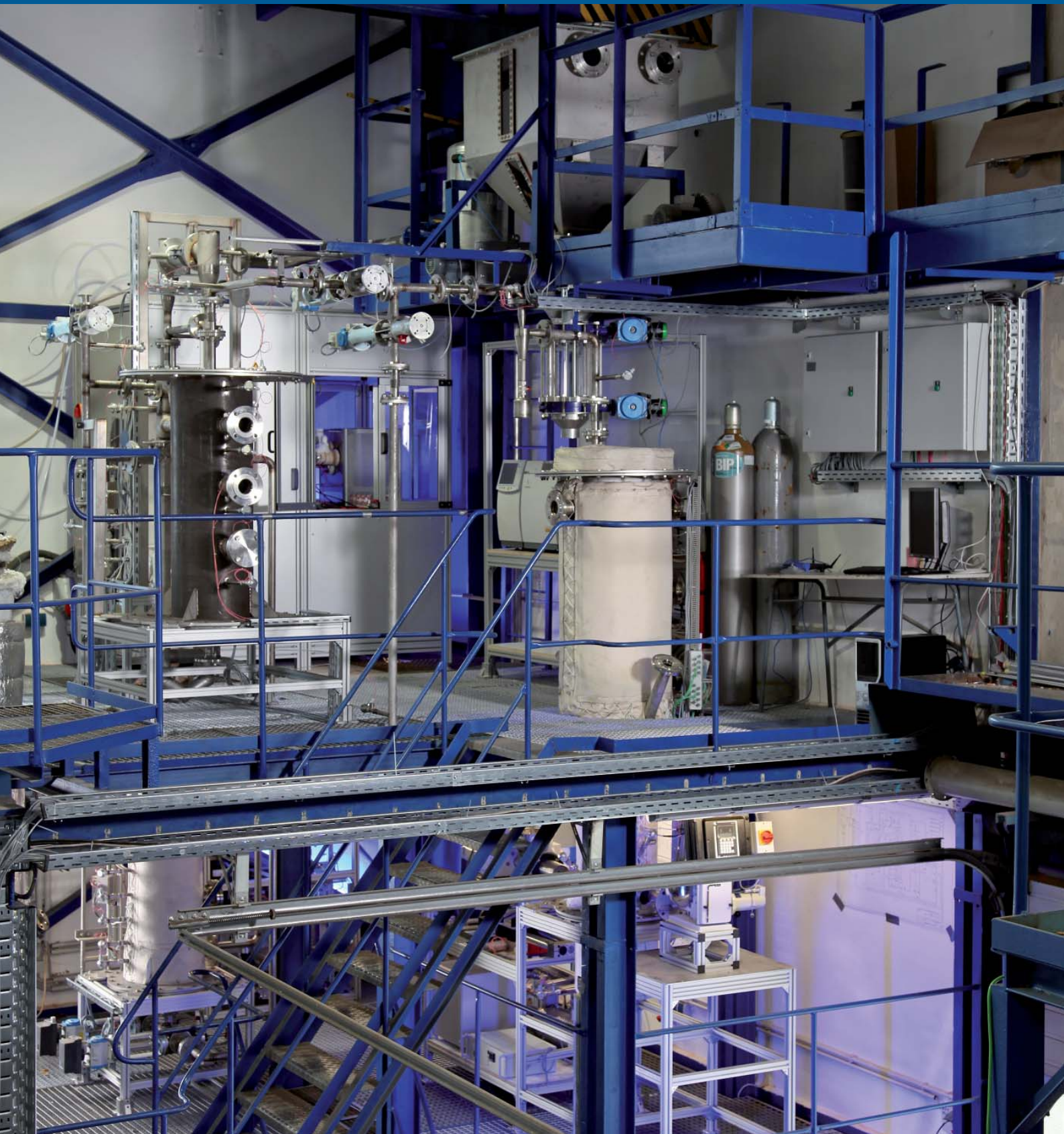
A system for testing com-
bined gasification and fuel
cell technologies.
Photo: Dirk Mahler

HARZ.EE-MOBILITY: A SMART VEHICLE
NETWORK CONTROL SYSTEM

COMBUSTION AND GASIFICATION WITH
MULTIFUNCTIONAL FLUIDIZED BEDS

EFFICIENT ENERGY CONVERSION:
BIOMASS GASIFICATION AND SOFC

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HARZ.EE-MOBILITY: A SMART VEHICLE NETWORK CONTROL SYSTEM

Motivation

The acceptance of electric vehicles will depend on unlimited mobility, reliability and ecological advantages over conventional motor vehicles. In the future, electric vehicles integrated in the grid as "mobile storage systems" will substantially contribute to compensating peak loads, optimizing and increasing the use of renewable energies and maintaining grid stability.

Solution and Approach

The Harz.EE-mobility project studied the integration of electric vehicles as mobile storage systems that balance renewable electricity in the Harz model region where renewable energy production is dominant. The resultant requirements for the overall system, the "smart" electric vehicle network replete with information and communication technology (ICT), were applied to define solutions that improve the integration of renewable energies in grid operation as well as public acceptance of the electric vehicle network and its market penetration.

A vehicle network control center will process data and projections from the logistics and power system and provide user services, navigation data and information. A central higher-level monitoring system will supply vehicles and charging stations the data necessary to coordinate and control the mobile storage systems in the electric vehicle network and to control charging.

The combination of logistical, electrical and ICT infrastructures in a modular, growing system with open electrical and ICT interfaces facilitated the development of an electric vehicle network control center with the requisite functions. Electric vehicles (mobile storage systems) located in the area of the grid at a certain time can be observed and the long and medium-term storage potential can additionally be determined with advanced ICT and forecasting systems. Furthermore, the tariff system resulting from the business models developed enables drivers to make their electric vehicles available for controlled charging. The control center is authorized to intervene in charging and systematically utilize incoming renewable energies to charge the storage system.

The experiences obtained were indispensable for optimizing and refining the overall system. Since the rural and urban regions with representative transportation and grid infrastructures and user profile are typical, model and regionally specific application scenarios were employed. Among other things, the focus was on developing new control center systems using the Internet to connect transportation and energy logistics.

1 *The test charging station and test vehicle are part of the electric vehicle network. Photo: Viktoria Kühne*
2 *The control center monitors controls and safeguards the electric vehicle network.*
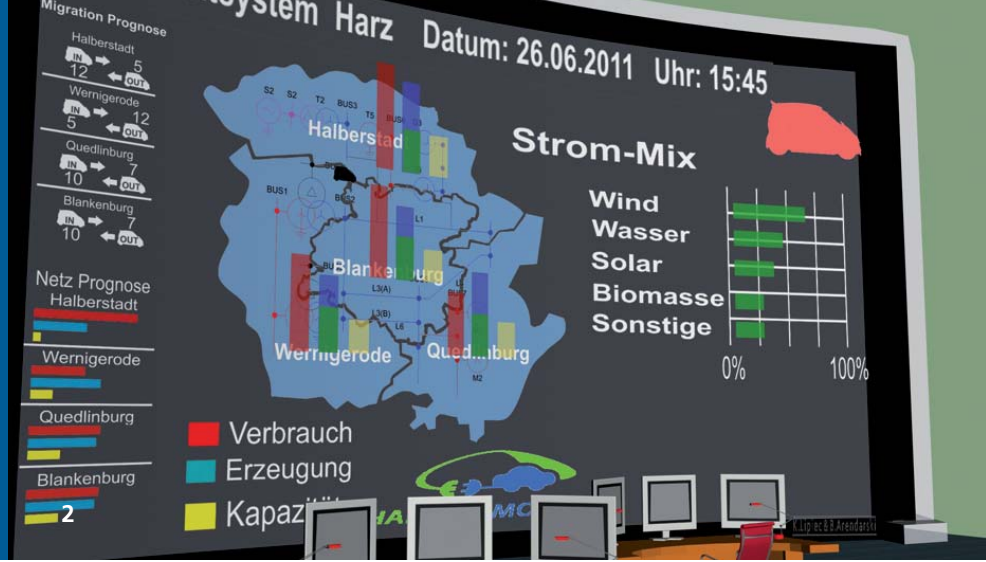
Results

Data communication over the electrical, ICT and logistical system's standardized, partly upgraded and open interfaces were used to create a standardized data model for a database system. This entailed developing the necessary converters, which make it possible to transform data from the different subsystems into the database structure in the first place. The data storage system developed by the consortium is the heart of the structure in which all of the properties, conditions and data from the vehicle network system's subcomponents converge and are available for processing or retrieval. This refinement of the information systems is the prerequisite for the vehicle network control center's entire range of functions. The data from traffic forecasts, renewable energy forecasts and charging infrastructure and mobile storage systems conditions enter into electric vehicle coordination, navigation and charging control in order to boost the efficiency of the services offered by systematically evaluating them. Users can access the services on an Internet portal, in navigation systems in electric vehicles or with a cell phone application. In addition, customized applications were developed for grid operators, vehicle fleet operators and charging infrastructure owners.

Benefits and Outlook

The ICT installed in vehicles makes all the data available, which are needed to control or support the vehicle network. Users thus have a route guidance system at their disposal for the charging infrastructure located in the model region. Proximity to a destination or tariff options at charging stations are some of the criteria that influence the selection of a destination.

The electric vehicle network system is being field tested in the Magdeburg and Harz regions and optimized. The findings being obtained are a motivation to continue research of the electric vehicle network.

Project Partners

Fifteen regional and national partners are collaborating in the Harz.EE-mobility consortium.

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COMBUSTION AND GASIFICATION WITH MULTIFUNCTIONAL FLUIDIZED BEDS

Motivation and Task

Supplying heat, power and syngas based on renewable energy sources is increasingly taking on importance. Renewable solid fuels, whether biomass or biogenic and industrial wastes, can also be employed in distributed use to cover base load power requirements. The development of highly efficient thermo-chemical conversion technologies is the prerequisite for the implementation of such processes.

Given their excellent heat and material transfer capabilities and resultant homogeneous temperature and concentration profiles, fluidized bed technologies establish ideal conditions for the utilization of fuels with a broad range of heating values, chemical compositions and geometric dimensions.

The group of young fluidized bed technology researchers at Otto von Guericke University Magdeburg is conducting fundamental research on fluidized bed processes that generate syngas from renewable fuels. To do so, they had to engineer and construct a reactor in which they can study such processes in test operation.

Since the Fraunhofer IFF's Process and Plant Engineering Business Unit has extensive experience developing, engineering and supporting the implementation of such processes and the related process control, it was contracted to engineer a suitable reactor and create the appropriate control software.

Solution

To verify simulation calculations, the experimental reactor was engineered and sized so that it can be used for both combustion and gasification. It was outfitted with a twin feeder unit in order to diverse fuels or fuel mixtures. Each of the two feed lines is equipped with different metering, transport and shut-off technologies, which are safe from burnback. Granulates, pellets, woodchips, shredded material and similarly processed fuels can be metered. Additives can be metered in as fines, e.g. ground limestone, or granulates. A separate hopper stores and replenishes the material for the actual fluidized bed. It may consist of quartz sand, similar inert materials or even catalytically active material. The fluidized bed reactor was sized for different bed heights and thus variable residence times for gases and solids.

Depending on the fuel, the reactor can produce around 100 kW of heat in combustion mode and up to 250 kW of heat in gasification mode. The vortex principle, i.e. the tangential inflow of secondary air and recirculated flue gas at different heights, has been implemented to blend gas well in the fluidized bed. A special patent pending cyclone separates entrained solids and ensures complete combustion in the gaseous phase. The flue or fuel gas with temperatures of 650 °C

1 *3-D design model.*
2 *Feed area of the multi-*
functional fluidized bed unit.
Photo: Toralf Winkler

to 900 °C produced in the reactor is cooled to around 200 °C in the waste heat boiler or conducted in the high-temperature bypass to a ceramic hot gas filter.

The reactor is equipped with extensive sensors and actuators. A process control system captures measured values and controls the reactor. In addition, every relevant gas concentration can be measured and recorded at two different positions, in the combustion chamber and at the end-of-pipe, at the reactor in both combustion and gasification modes.

Results

The reactor was built based on the planning documents from the Fraunhofer IFF. The control software created at the same time incorporates all of the equipment configurations. A process flow diagram visualizes and can be used to adjust the fuel chargers, auxiliary heaters and coolant system. Additive measurement systems, e.g. gas analyzers, weighing sensors and CAMSIZERS® for in-line particle size analysis, can be integrated in the process control system.

The reactor's operation has been tested successfully. Following signal checks and cold tests, the reactor was already charged with fuel on the first day of commissioning after a brief period of heating up and met the requisite operating parameters. The experimental unit was delivered to the client, now using it for proprietary basic research.

Project Partners

Dr. Weigel Anlagenbau GmbH, Magdeburg and Otto von Guericke University Magdeburg

Process flow diagram overview of the process control systems.
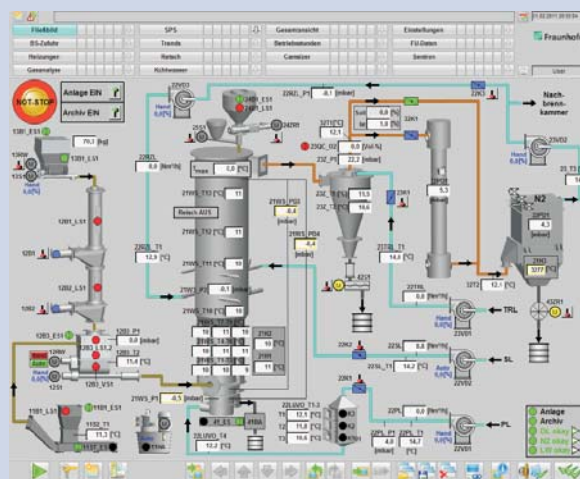
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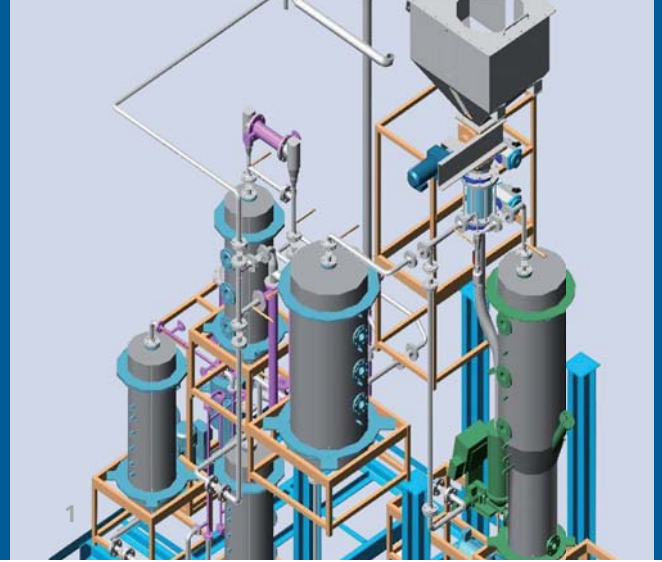
EFFICIENT ENERGY CONVERSION: BIOMASS GASIFICATION AND SOFC

Motivation

Renewable raw materials can cover a substantial share of our present energy requirements and will therefore continue growing in importance. While a multitude of technologies already convert chemically bound energy into power and heat, there is still considerable to boost these conversion technologies' efficiency.

The Process and Plant Engineering Business Unit is working to develop efficient production of power and heat, among other things, by following the approach of cogeneration by gasifying solid fuels in fluidized beds and subsequently utilizing the reaction products in fuel cells. Thusly combined power and heat production utilizes the energy bound in fuel and thus boosts efficiencies.

Solution

Both individual components and the interplay between individual stages of the process can be analyzed and optimized with the aid of its experimental plant. In addition to testing steady states, suitable startup and shutdown procedures can be developed and optimal operating conditions identified. The data ascertained provides a basis to assess the industrial applicability and scalability of individual process alternatives for different use scenarios.

Approach

A modular semi-industrial experimental plant was built at the Fraunhofer IFF to research the coupling of biomass gasification with fuel cell technology. The pilot plant's basic elements are a fluidized bed gasifier, a high-temperature gas treatment system and a solid oxide fuel cell (SOFC).Thus, this plant can be used to study the complete chain of biomass utilization to convert chemically bound energy into electricity and heat.

The particular benefits of producing fuel gas with the aid of fluidized bed technology are the broad range of biomass usable as fuel and the high fuel efficiency attainable. Differing fuel gas compositions are produced as a function of the process parameters, e.g. pressure, temperature and gasification agent. The main constituents of the fuel gas produced are hydrogen, carbon monoxide and methane.

Since minor constituents such as dust and tars can jeopardize the reliability of a fuel cell's operation, they must be removed beforehand. To this end, a gas treatment system has been installed, which treats the combustible gases directly at high temperatures without intermediate cooling. This minimizes heat losses and prevents long chain hydrocarbons from

1 *3-D design model of the envisioned pilot plant.*
2 *A pilot plant that couples gasification technology with fuel cell technology.*
Photo: Dirk Mahler

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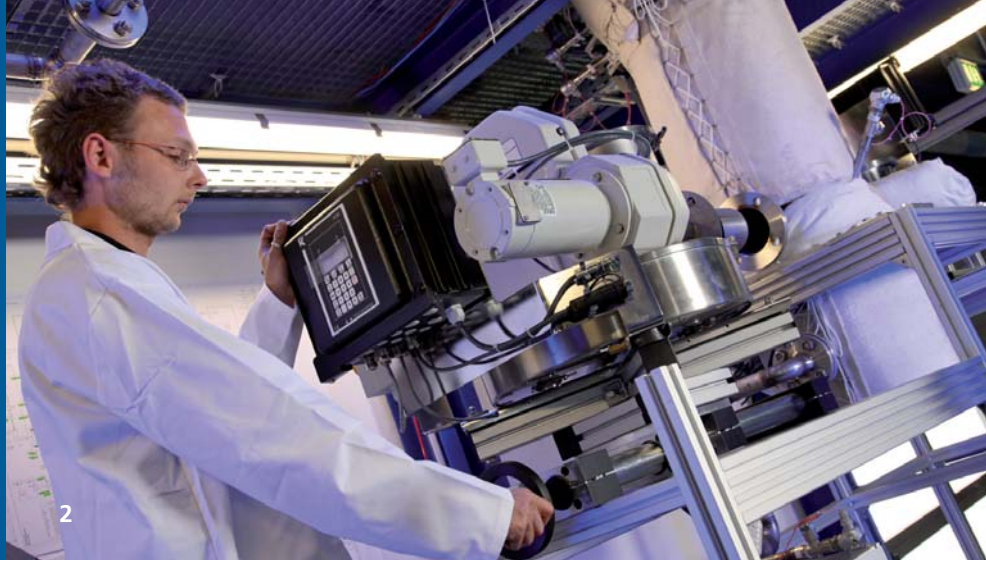
condensation. The gas treatment includes process stages that separate dust, reform tar and halogens and separate sulfur. Afterward, the thusly treated fuel gas serves as fuel for energy conversion with the aid of SOFCs particularly suited for this application. This type of fuel cell is insensitive to the pollutant gas carbon monoxide and can be operated with hot gas and under atmospheric pressure. Thus, the fuel gas needs no further treatment before the fuel cell and, consequently, energy losses are reduced. A heat recovery system returns the heat from the flue gas to the system through the fresh air.

Extensive gas analysis systems, e.g. gas chromatography, tar and dust measurement systems, mass spectrometers and in situ solid electrolyte probes before and after gas treatment, are available to monitor gas quality and optimize operating parameters .

Results and Outlook

The pilot plant has been built, the first components commissioned and the plant's control systems programmed. This year, the experimental plant will be commissioned step by step and the results of tests, for instance, the fuel gas quality or the treatment stages' separation efficiency, will be compared with those of the Fraunhofer IFF's other experimental plants in order to be able to optimize the individual stages of the process.

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Process flow diagram of the gasifier.

DEVELOPING TRANSPORTATION AND LOGISTICS APPLICATIONS WITH THE SAXONY-ANHALT GALILEO TEST BED

2

Farsighted Initiatives

The challenge of sustainably securing mobility in transportation and logistics was and is the focus of the state of Saxony-Anhalt's transportation and development policy. For a number of years, the Saxony-Anhalt Ministry of State Development and Transportation has been rigorously pursuing the goal of maintaining the performance of their transportation systems and boosting it by optimally exploiting existing and future transportation and IT infrastructures.

As it strove to implement this goal, the Saxony-Anhalt Ministry of State Development and Transportation began consolidating applied transportation research in a state initiative a few years 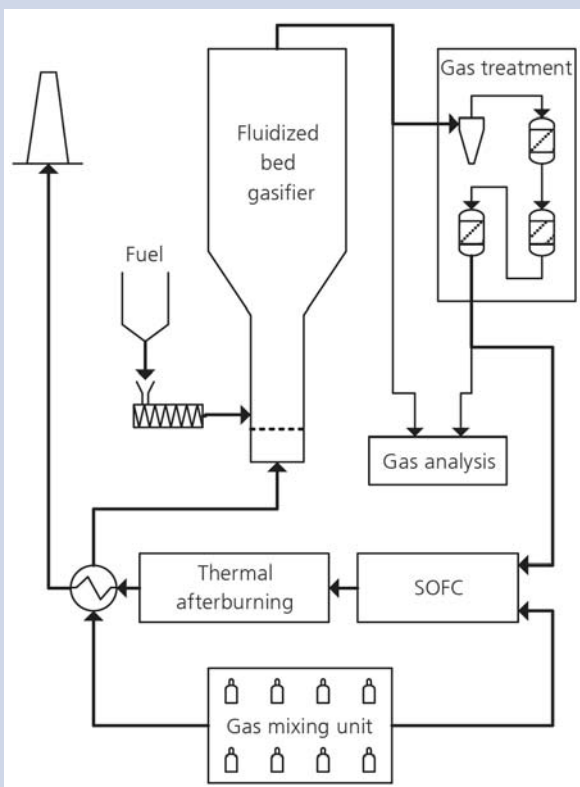ago. The development of the Saxony-Anhalt Galileo Transport initiative has top priority. The initiative is intended to support companies and research organizations in Saxony-Anhalt, which develop new technologies, products, applications and services for overland transportation and logistics, in order to create new jobs in this high-tech sector in the medium and long term.

The initiative is based on a three-stage concept:
1. Strategy development and evaluation
2. Support for product development
3. Integration of new applications in transportation and logistics systems

1 *RFID tunnel gate in the Saxony-Anhalt Galileo Test Bed's development laboratory.*
Photo: Dirk Mahler
2 *Container localization in Magdeburg Port's Hanse Terminal, Saxony-Anhalt Galileo Test Bed's logistics platform.*
Photo: Viktoria Kühne

Mainstays of the concept include building upon successful outcomes of national and European transportation and logistics research projects, pursuing the use of their findings in as much of the state as possible and acquiring new projects. These projects establish the framework needed to specify and develop GNSS (Global Navigation Satellite System) applications and supporting terrestrial systems, which are extremely important for the last mile.

Over the years, a capable expertise network of members from business, research and academia has also evolved, which completes sophisticated and complex research and development projects on transportation management, logistics, automotive or rail transport systems [1].

Galileo Transport: Telematic Platform and Test Bed for the Development of Applications

As part of the state initiative "Applied Transportation Research/Saxony-Anhalt Galileo Transport", the Development Laboratory and Test Bed for Localization, Navigation and Communication in Transportation and Logistics was opened in Magdeburg's Port of Science in March 2010 with the collaboration of the Saxony-Anhalt Ministry of State Development and Transportation, the Saxony-Anhalt Ministry of Education and Cultural Affairs, the Saxony-Anhalt Ministry of Economics and Labor and Otto von Guericke University Magdeburg.

The opening of the Saxony-Anhalt Galileo Test Bed, the Development Laboratory and Test Bed for Localization, Navigation and Communication in Transportation and Logistics has made a state-of-the-art development and testing environment available to integrate established and new localization and identification systems in logistics operations.

1

Nearly three million euros, financed from funds from the state of Saxony-Anhalt and the German Economic Stimulus Package II, have been invested in the Galileo Test Bed, which is coordinated by Otto von Guericke University Magdeburg

The partners in the development and operation of the test bed with its various facilities are the Fraunhofer Institute for Factory Operation and Automation IFF, Magdeburg, the Magdeburger Hafen GmbH, ifak Institut für Automation und Kommunikation e. V. Magdeburg and the Hallesche Verkehrs-AG (HAVAG).

A Smart Standardized Logistics Zone

Demands are mounting for automatic identification and localization of logistical assets to document and control logistical operations. This is the point of departure for important research at the Saxony-Anhalt Galileo Test Bed. Combined use of radio and image-based identification and localization technologies to automatically determine the status of logistical operations by motion and state analyses can be used to generate significant synergies for safety and security tasks in logistics. Agreed upon among the partners in the logistics value added chain, these modules define essential elements of smart standardized logistics zones.

Great attention is devoted to collectively analyzing workplace safety (to protect workers from workplace hazards), process reliability (to make production processes safe, available and reliable) and civil defense (to protect society):

The Fraunhofer IFF lead manages research specializing in "telematics and logistics" at the Galileo Test Bed's logistics platform, a productive testing environment in Magdeburger Hafen GmbH's Hanse Terminal, which provides numerous modes of handling for the implementation of localization and identification technologies in outdoor operations. This logistics platform prototypes logistics operations in nodal points of

intermodal transport chains, such as port premises and freight terminals.

The goal is to use new telematic technologies to modify terminal operations for the greater requirements of increasing, secure handling in order to boost productivity and thus create competitive edges.

Hanse Terminal is an advanced terminal for combined transportation (CT) and containers run by Magdeburger Hafen GmbH, a partner in the Saxony-Anhalt Galileo Test Bed. The equipment used at this trimodal terminal for inland waterways, railroads and roads is primarily used to handle and transport delivered cargo. Reach stackers, a gantry crane, crane trucks that load heavy cargo and forklifts are used for trimodal handling among inland vessels, trains and trucks. The companies located on the port's premises primarily handle containers and wind turbine components.

Once a wide range of terrestrial and GNSS localization systems had been compared, a radio system was installed in the Hanse Terminal. The miniaturized mobile transponders can be attached both permanently to large handling equipment and temporarily to certain cargo and additionally even be carried by individuals. With its high measuring rate of up to 1 000 hertz, this high-tech system guarantees a constant positioning accuracy of less than fifty centimeters and, under ideal conditions, even three centimeters.

1 INVENT telematics test bed, development laboratory. Photo: ifak e.V.
2 Saxony-Anhalt Galileo Test Bed's streetcar and bus. Photo: HAVAG

2

This enables application developers to effectively meet the challenges facing logistics, such as localizing freight with the accuracy of pallet storage positions or localizing individuals for maximum workplace safety. The high clock rate enables R&D engineers to continuously record motion trajectories under the conditions of a productively operating container terminal. Furthermore, using two antennas per transponder makes it possible to detect not only position but also to detect an object's angle of orientation clearly without inertial sensors. The testing and development environment in the port is completed by different camera systems and a WLAN for the entire terminal area.

Research Specializations in the Hanse Terminal

More precise analysis of nodal points is a crucial element of the continuously traceable freight throughout the transport chain. Anomalies can quickly arise wherever freight changes it mode of transport. Surveillance systems are increasingly being used even at transfer and warehouse facilities in order to produce consistently high transparency for a secure supply chain. Video monitoring systems have become standard equipment in internationally operating logistics hubs because of auditing compliance. The Fraunhofer IFF and its partners' approach to research and development is to make these infrastructures usable to identify and track objects in logistics control centers, too.

In 2010, systems for the near-real time documentation of processes and evaluation of process information from sensor readings were researched and developed in the R&D project "Port and More: Magdeburg's Inland Port as a Model of Enhanced Efficiency in Logistics Nodes" supported by the Investitionsbank Sachsen-Anhalt. The system developed processes identification and motion information from individual pieces of equipment and objects on the port's premises, which has been obtained by the video systems and the UWB localization system. This makes it possible to use motion curves to automati-

cally identify the equipment that is handling and transporting freight on the port's premises and to monitor the quality of actions. Automatic evaluation based on neural networks and soft topological motion skeletons extract attributes of specific equipment from the motion profiles, i.e. so-called kinematic fingerprints are generated [3]. Studies focus not only the equipment used but also reach stackers and gantry cranes in Magdeburg's port. The recorded and documented motion profiles of freight define a new form of transparency for the logistics providers and shippers involved and thus provide certainty that freight is handled correctly in keeping with a job order.

Specialized Video Analysis and VR Applications

Video analysis in a logistics hub's local environment is evolving into a precise method to localize coded, logistical assets in the centimeter range in a georeferenced environment in real time. The impacts of non-cooperative outdoor measuring environments, e.g. greatly varying illumination or weather phenomena, must be incorporated in the analysis algorithms in order to make technology industrially usable outdoors. Since it

Motion profile recorded in Magdeburg Port's Hanse Terminal.

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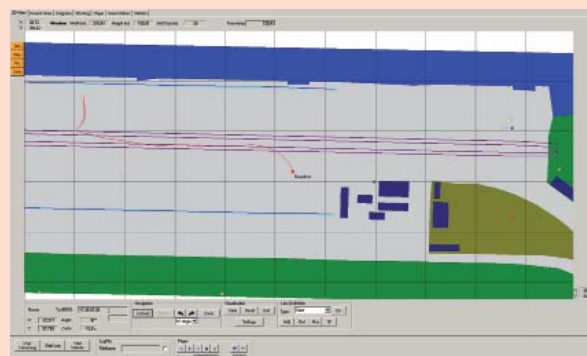
furnishes an outdoor environment and a productive process environment, the Galileo Test Bed's logistics platform serves as an important testing environment for the necessary research activities.

Virtual reality (VR) simulation systems with extensive material handling model libraries augmented by models of radio and imaging systems are an important tool for the evaluation of analysis algorithms. The VR model libraries are used to engineer video systems on the port's premises. The individual cameras' fields of view are simulated in a VR model beforehand and disrupted to optimize the camera arrays and lens selection.

The Federal Ministry of Education and Research is supporting this research work in the project "Virtual and Augmented Reality for Maximum Embedded System Safety, Security and Reliability ViERforES", which is part of its initiative for Cutting Edge Research and Innovation in the New States. The goal is to create and use virtual, georeferenced scenes based on knowledge of a real or planned logistical scenario including the surrounding situation, which support the assessment of an analyzed video system relative to a non-cooperative measuring situation. Virtual reality furnishes a freely manipulable testing environment for the evaluation of image processing algorithms.

The Hanse Terminal serves as a comparative environment to identify the problems of non-cooperative measuring environments for video analyses and for reference tests to evaluate the image analysis algorithms developed. The productive process environment facilitates iterative improvements of VR applications and image analysis.

Future Identification, Localization and Condition Detection Technologies

Galileo Test Bed's logistics platform furnishes a state-of-the-art applied development environment for research and development of internal logistics, demonstrated by the R&D projects "ViERforES" and "Port and More". Technical developments from the Galileo Test Bed, such as the patented RFID Gate, have already been implemented in the apparel and automotive industries' long process chains supported by RFID or in internal logistics applications. One of the latter is the newly developed localization system for forklifts at the world's largest aluminum rolling and remelt plant, Alunorf in Neuss.

Closely combining the development work in projects with the refinement of the Saxony-Anhalt Galileo Test Bed constitutes the basic strategy for the test bed and of all the research partners involved. In concert with the operators of international logistics hubs, a road map was developed when the Saxony-Anhalt Galileo Test Bed opened, which specifies future standards for telematics suppliers and integrators of logistics nodes, for instance, greater use of imaging technologies to validate radio applications.

In principle, the preparation, execution and evaluation of tests both under laboratory conditions in the Saxony-Anhalt Galileo Test Bed's development laboratory and under real conditions must be systematic, standardized and reproducible. Therefore, tests particularly focus on the:

1 *Magdeburg Port's Hanse Terminal.*
2 *Two-antenna transponders in use at the Hanse Terminal.*
Photos: Dirk Mahler

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– reliable operation of radio and image solutions under differing non-cooperative conditions, e.g. movements and moving barriers,
– verification of time and error characteristics, e.g. factors of uncertainty, quality of service and real time proximity,
– coexistence of different radio and image applications and
– suitability of radio and image systems for functional applications with reliable IT for security and protection.

With its technical systems in its development laboratory and its partners' technical expertise, the Saxony-Anhalt Galileo Test Bed establishes outstanding conditions for the development and testing of reliable radio and image solutions. The logistics platform in Magdeburg's Hanse Port, the development laboratory in Magdeburg's Port of Science and the other Galileo Test Bed facilities cover diverse aspects of holistic transportation and logistics operations to extensively develop and test solutions for clients [2].

Thus, the industry, research and qualification partners are jointly developing highly innovative solutions for

– reliable and energy efficient city logistics,
– near-real time process approval in internal logistics and
– interference-free communication in transportation and logistics.

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PROJECT REPORTS FROM THE FIELD OF LOGISTICS RESEARCH

ECONOMICALLY AND ECOLOGICALLY EXPEDIENT BIOMASS LOGISTICS CONCEPTS

Motivation

The depletion of deposits of fossil energy sources such as coal and crude oil is making new approaches to energy production essential. Rising timber prices reveal that classic biomass is also growing scarce. Using biomass on a grand scale for energy recover cannot be the solution. Intensifying the recovery of energy from biomass would generate too much competition with agriculture and forestry consumers. Environmental impacts such as lasting forest damage could not be ruled out.

Agriculture and forestry residues hitherto considered to be unusable or compost at best could prove to be valuable in the future. The focus is increasingly shifting toward developing and utilizing residual biomass. Utilizing it is quite challenging, not only in terms of the technology but also because the sometimes small yields, which, collectively constitute the real residual biomass potential however, are often widely dispersed. Locating, structuring, collecting and supplying it for maximally effective utilization is therefore a highly complex logistical challenge. In the end, no more energy and money may be expended to develop and supply the residual biomass than its utilization produces.

Task

The project Best4VarioUse is researching innovative solutions that utilize woody wastes and residues from landscape conservation, agriculture and forestry. Initiated and lead managed by the Fraunhofer IFF, the project is specifically analyzing the regions of Saxony-Anhalt in Germany and Valencia in Spain. Saxony-Anhalt has hitherto unutilized residues and wastes from forestry and landscape conservation. This bestows a particular regional significance on the project. Residual biomass in Valencia, on the other hand, comes not only from forestry but also largely from the cultivation of olive and orange groves. These plant residues are a tremendous potential of biomass for both regions.

Until now, processing these varieties of residual biomass for industrial use, i.e. recovering material or energy in a standardized and efficient process, has been difficult. In addition, developing and suppling it is technically complex and costly. The project therefore is aimed at finding solutions for a number of open technical and economic as well as ecological challenges.

1 Chipped residual biomass.
Photo: Dirk Mahler
2 Chipping equipment field test after full tree harvesting. Photo: Hans-Georg von Engelbrechten, Landesforstbetrieb Sachsen-Anhalt

Approach and Results

Ecological and economic aspects of variants of conventional and innovative technologies and methods for harvesting, storage, transport and utilization were analyzed in various field tests and compared. Furthermore, developed prototypes such as a special chipper that processes material or luminescent nanoparticles used to mark and label biomass, are being used. The field tests serve not only to test and demonstrate the technologies but also to generate recommendations that can be used in the field in the future. Special importance is attached to identifying and evaluating best practices and technologies in the field for the organization of economically and ecologically efficient material flows.

The project's findings will deliver important impulses to safeguard competitiveness and thus also protect future jobs long-term, among other things, by.:

– demonstrating innovative overall concepts that ensure a positive energy balance,
– preventively minimizing the environmental impacts of supply operations,
– identifying economic and ecologic potentials that eliminate barriers to development and utilization,
– perceptibly increasing the share of biomass residues from which material and energy are recovered,
– outlining options for sustainable refinancing to preserve designated protected areas in Europe,
– developing service industries that create new jobs and
– generating sustainable impulses for regional development.

International networking with Spanish partners and integration in European networks will not only transfer impulses outwardly but also draw external experiences and findings into the project. Thus, in addition to being extremely significant for climate policy, the project is also at the forefront of intensifying interregional collaboration in Europe.

Project Partners

Thirteen partners from Germany and four partners from the region of Valencia, Spanien.

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OPTIMIZED PLANNING BASES FOR CAMPAIGN-DRIVEN SUPPLY CHAINS

Initial Situation

The logistical challenges for the wind energy sector have risen considerably as the number of offshore wind turbines erected before the German North Sea and Baltic Sea coastlines has increased. The financial, technical and logistical dimensions of wind farm projects necessitate the development of new production structures and transport chains over great distances. Significant factors are the transparency of the logistics costs and the effects of specific parameters on supply chain planning and control, such as supplier network complexity, campaign building, meteorological influences and deadline pressure and bottlenecks for scarce and costly resources.

Solution and Results

As part of the project, a demonstrator of a simulation application was produced, which plans and controls the logistical operations of offshore wind farm construction. It is based on methods and tools for the organization of logistics networks and the management of supply chains. For the first time, the specific features and requirements of offshore wind energy logistics have been incorporated in a comprehensive model. The tool developed enables logisticians to map, plan and simulate supply chains from suppliers to the site of a wind park's construction. Great value was attached to a user-friendly interface to model networks and the acquisition of product, network and process data. Thus, the tool can be used even without any knowledge of programming.

First, once the basic product and network data have been entered, an automatic draft of a master plan for a wind park project is generated to support planning. It includes all essential handling and logistics operations. Afterward,users can modify it and it serves as input information for the simulation. An automated interface exports the master plan to the simulator. The simulation starts at the same time and the results are exported to a special analysis interface.

Taking static planning as the starting point, the simulation is used to assess the potential impacts of various disturbances on the supply chain, such as weather data modeled as a statistical function, and already evaluated concretely as rescheduling, inventories and budgets during the planning phase and project period. Analyzing the network holistically is always a priority to elucidate the effects of influencing factors and structural changes in the overall network in order to optimize all schedules and budgets.

Basically two groups of potential users are being addressed. The first group is logistics providers that organize individual transports between sites in the supply chain or are service

1 *Incorporation of increased space requirements for a smooth material flow.*
2 *Allocation of space for loading.*
3 *Planning sufficient transport capacity.*
Photos: LSA Logistik Service Agentur GmbH

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providers or project managers placed in charge of coordinating transport and logistics operations at a wind farm by its future operators. The results, practices and simulation tool developed directly support their logistics operations.

The second group is companies in the supply chain such as component manufacturers, carriers and end producers. They receive input to plan the operations and resources relevant to each of them. This may include schedules and quantity structures for produced and transported units timed for a building campaign. Companies have difficulty collecting all of such complex information on their own. Companies can use the tool to assess the effects of changes in their operations on the entire chain and respond in good time.

Benefits

The results of the project are universally and thus fundamentally applicable to any campaign-driven supply chain, even in other sectors, including agricultural and forestry operations, such as sugar beet processing, and the supply of paper factories and biomass cogeneration plants.

The simulation tool supports wind farm builders and operators, manufacturers and suppliers' basic project objectives and customer demands. These may include:

– implementing wind farm projects within specified budgets and schedules
– verifying timely and full availability of every component and resource required
– reducing expenses for unplanned and expensive ad hoc logistics activities and
– cutting project and unit costs.

Logistics in the wind energy sector is thus increasingly evolving into a competitive factor and will contribute to more cost effective development of offshore wind technology.

Project Partners

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AiF
Ideen eine Zukunft geben

INNOVATIVELY MANAGING FLEXIBLE PRODUCTION FACILITIES

Motivation

Jobs in manufacturing sectors in high wage countries can only be protected when superlative production concepts are developed. The trend toward relocating German production facilities to Eastern Europe or Asia can be countered best when their productivity is internationally competitive.

The German automotive industry reduced work requirements per job and individual to exploit potentials for streamlining. This approach is suited for more than just manufacturing companies, which profit from their flexible product portfolios and production systems as well as their employee know-how. However, flexibility does not inevitably produce a profitable and stable production system. Manufacturing companies and small and medium-sized enterprises (SME) in particular must find the right management and implementation strategy for the antithesis between a stable production system with optimized targets and highly flexible manufacturing operations.

Solution

Since German manufacturing companies lack options to systematically flexibilize and control their production facilities and production portfolios, a holistic flexibilization tool is being developed for them in the joint project FlexPro: Innovatively Managing Flexible Production Facilities. The goal is to generate methods for the organization of flexible production systems for SMEs. Therefore, the Fraunhofer IFF is developing a modular, practically oriented set of methods, which allows for company specifics.

Approach and Results

The sequential set of methods includes the following stages: First, both the static and the dynamic levels of the production system are analyzed and potentials for enhancing flexibility are identified. A demand analysis that follows identifies the system targeted and compiles the appropriate organizational actions and fields of action in a structured form. Based on this, a concrete flexibilization plan is formulated and the appropriate methods are selected in order to implement them in the production system afterward and monitor their performance with routine checks.

A quantitative analysis, taking the form of an empirical study in which a total of 1,221 companies participated, was performed among the pilot users along with qualitative analyses to fully identify the characteristics of flexible production systems. The principle questions in these analyses addressed methods and strategies for the organization of flexible production systems.

The results of the analyses clearly revealed that the capability to act flexibly constitutes an important competitive edge for companies. Next to product quality, flexibility is the most important means of setting oneself apart from competitors and compensating for cost disadvantages. A breakdown of the results by company size reveals a difference in terms of

A team meeting before the start of production.
Photo: Dirk Mahler

flexibility requirements and potentials and the importance of flexibility: Flexibility has great importance for micro and small enterprises in particular. Every third company of this size endeavors to generate a competitive edge with flexibility as a top priority. The great importance of flexibility is reflected in these companies' self-assessments as well, which revealed great potential for flexibility. While small companies assessed themselves as more flexible than large companies, they implement fewer actions to boost flexibility.

Outlook

This diametrical relationship between the self-assessment and the methods implemented has different causes and raises different issues:

1. The self-assessment of flexibility may be unreliable.
2. A level of awareness of methods implemented to boost flexibility in the smaller companies needs to be established.
3. Other analyses need to determine the extent to which companies with comparatively little complexity need methods to boost flexibility in the first place.

Project Partners

Institute of Industrial Engineering and Ergonomics IAW, RWTH Aachen University; Department of Organizational and Social Psychology WISO, Friedrich Alexander University Erlangen-Nürnberg and RKM GmbH, Munich

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IMPROVING COLLABORATION AND COMMUNICATION IN SMES WITH ICKEWIKI

Motivation

Web 2.0 applications and technologies in general and Wikis in particular are held to have great potential to improve companies' communication, collaboration and knowledge exchange internally and externally. Principles of Web 2.0, such as free communication, joint generation of contents and networking of users unacquainted with each other, often function on the Internet without specified structures and central control. However, they cannot be transferred to companies without modification. Their use and their requirements in small and medium-sized enterprises (SME) have hardly been researched.

Solution and Approach

The objective of the project ICKE 2.0 was to develop an enterprise wiki for SMEs. The wiki platform DokuWiki was employed. Since wikis provide few options aside from thematic categorization to structure contents, the project's approach assigns a company's organizational structures to namespaces in the wiki and exports them to a central, graphically supported navigation system.

Companies have large quantities of structured data, for instance, on products, projects, customers or organizational units. The newly developed ICKEwiki was intended to facilitate correlating freely compiled wiki texts with such schematized data. These data can be automatically aggregated in other domains. Overviews for projects or compilations of wiki users' own data, e.g. on projects, assignments, customers, etc., can be created.

The requirements for the enterprise wiki were compiled from a large scale study of approximately 250 SMEs in the manufacturing sector, on the one hand, and an analysis of three pilot users, on the other hand. Building upon the technical concept devised, CosmoCode GmbH developed a prototype wiki. Three pilot users implemented and tested the prototype ICKEwiki at length. The Fraunhofer IFF provided the pilot users active support during the implementation phase in order to eliminate potential barriers to the use of this technology new to the companies. In the final stage, the pilot users evaluated the ICKEwiki. Test users, executives and IT managers were surveyed. Overall the results of the evaluation of the ICKEwiki were extremely positive. As a follow-up to the project, Cosmo-Code converted the prototype into a stable version.

Results

The ICKE wiki developed met the central requirements for the use of wikis in SMEs:, namely they

– map corporate structures,
– support business processes,
– assure the quality of the wiki,
– integrate authentication systems and
– can be used intuitively.

Photo: Sergio Donà/Fotolia.de

In addition the system has functions such as:

– templates for reusable content structures
– form-based wizards for wiki layouts
– quality feedback for users
– integrated authentication systems (AD) ,
– digital signatures and
– lists of tasks

The ICKEwiki is available online as a demonstration system and can be downloaded for free (open source) from www.ickewiki.de. Screencasts briefly introduce its use. In addition, the findings of the study "Web 2.0 in Manufacturing SMEs" (ISBN 978-3-8396-0099-3) have been published by the Fraunhofer-Verlag.

Benefits

The evaluation of the new functions was extremely positive. The ICKEwiki creates value added by exchanging information better and searching and processing information faster. The pilot users therefore intend to actively continue using the ICKEwiki. Bernd Molter, head of development at Kristronics GmbH, a pilot user, is certain that "we will use the ICKE wiki to improve collaboration among units in our development projects. Our wiki will additionally enable us to draw on past experiences."

Outlook

Further need for development of enterprise wikis was identified during the project. Among other things, this includes developing a modular and user-friendly processing concept for sites and complex structures, such as meta data, "wizards" and templates, and upgrading the quality mechanisms for the entire wiki.

Project Partners

CosmoCode GmbH, Berlin; Fraunhofer Institute for Software and Systems Engineering ISST, Berlin, Berlin University of Applied Sciences; Kristronics GmbH, Harrislee-Flensburg; Sumida Components GmbH, Neumarkt and BJB GmbH & Co. KG, Arnsberg

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THE EBCT IS PAVING THE WAY FOR EUROPEAN COMPANIES IN INDIA

Motivation

India is a land of contradictions and superlatives. It is poised to surpass China as the world's most populated nation. Just like its neighbor China, India is one of the world's largest and fastest growing markets. The country has experienced economic growth of nearly nine percent in recent years. Even the global economic crisis slowed this growth only slightly. India's gross domestic product between 2008 and 2009 was approximately € 794 billion. At this pace, the sheer size of its economy and its demography alone will make its gross domestic product the third largest in the world after China and the USA halfway through this century. Unlike its, northern neighbor, India has stimulated this growth by encouraging domestic demand.

Thus, it is also offering European companies outstanding opportunities to transact successful business. Nonetheless, European business activities with India presently account for only 1.8 percent of the EU's total volume of trade. Moreover, Europe's market share in India has been dwindling for some time.

The Indian market's development has engendered enormous demand for logistics services, which is continuing to grow. Tremendous potential to increase efficiency and improve cost effectiveness also exists. The expertise of European and, not least, German technology companies is in great demand to develop the sector effectively and, above all, sustainably and environmentally compatibly, .

The formerly centrally planned economy has been undergoing successive deregulation and privatization only since 1991. Although the Indian government has been confronting the challenges of globalization aggressively since then, a multitude of bureaucratic hurdles, complicated tax laws and even government partial to "special favors" are still impeding economic development.

The Project

Since, on the one hand, European companies have displayed an extremely hesitant and wait-and-see attitude until now and, on the other hand, there has been great demand for technological know-how, a number of initiatives have been launched in recent years, which are intended to more intensely promote European companies' activity on the subcontinent.

One such project is the European Business and Technology Centre or EBTC in Dehli. It was established in 2009 for four years for the present and is part of the European Commission's Global Europe Strategy and Small Business Act. It is intended to promote the technological expertise of small and medium-sized European enterprises (SME) in the globalized market.

1 | 2 *Everyday traffic on India's streets. Photos: Bettina Rohr-schneider*

The EBTC's headquarters in Dehli, concretely in New Dehli, was selected very deliberately. Although most of the center's employee are more frequently in Bangalore, one of the Indian subcontinent's most important technology and business centers, Dehli is located directly in the center of the giant country. It is also India's political center with its agencies and ministries.

Since the Indian market is still not always easily entered by European firms, the EBTC considers its central job to be to facilitate small and medium-sized European enterprises' entry in the Indian market. It acts as a contact point, coordinator and adviser for European companies and research organizations desiring to establish fruitful business contacts there. The project is particularly focused on biotechnology, energy, the environment and transportation.

The Fraunhofer IFF is heading all transportation activities. Like the project's other themes, the focus here is on in initiating collaboration between Indian and European companies and research organizations in order to help European organizations access the potentials in India profitably and simultaneously to transfer know-how from Europe to India.

Results

In 2010, diverse market studies were conducted as part of the EBTC project and a European trade delegation of thirteen companies from seven different European countries was assembled to travel to New Delhi. A conference was organized for the trade delegation and many individual B2B talks were held. The trade delegation established several successful business relationships.

Outlook

In 2011, the Fraunhofer IFF will again be involved in organizing a European trade delegation and will additionally host a conference to establish collaborative research relationships.

Project Partners

The EBTC project is being lead managed by Eurochambres and has a consortium with over thirty collaborating European organizations.

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CONTINUOUS FREIGHT TRACKING FOR LOGISTICS COMPANIES AND CARRIERS

Background

Germany's most advanced development laboratory for localization, navigation and communication in transportation and logistics is located in Magdeburg on the Elbe: Saxony-Anhalt Galileo Test Bed's development laboratory was officially opened in the Port of Science in March of 2010.

This nationally leading center of excellence for innovative transportation and logistics systems will have been installed in Saxony-Anhalt by the end of 2011. The Saxony-Anhalt Galileo Test Bed consists of the development laboratory in the Port of Science, the logistics platform in Magdeburger Hafen GmbH's Hanse Terminal and the telematic test beds in Magdeburg and Halle (Saale).

The Development Laboratory's Systems

State-of-the-art satellite applications and identification and communication technologies are tested and refined at the Galileo Test Bed for the transportation, logistics and mass transit industries. The long range goals of this research are the interconnection of the various technologies and the design of smart, environmentally oriented transportation systems for Saxony-Anhalt. The work at the test bed to achieve these goals is broken down into the fields of

– telematics and logistics,
– communication and transportation and
– navigation and transportation.

The development laboratory has state-of-the-art equipment to research radio coexistence and to test and develop identification technologies as well as extensive material handling systems and mobile assets to test technologies under real conditions during operation.

Smart swap body equipped with RFID and communication technology for continuous freight tracking.
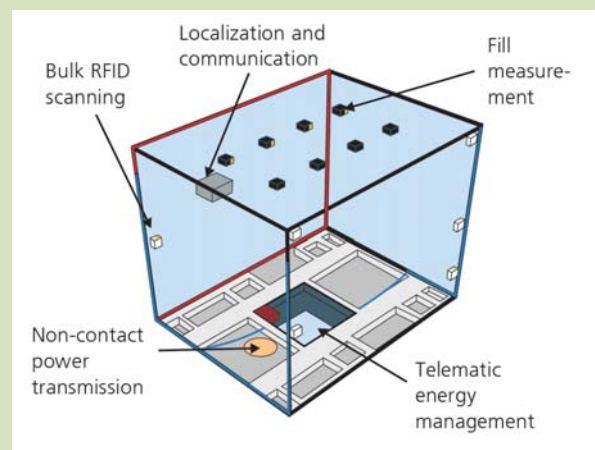
Saxony-Anhalt Galileo Test Bed's development laboratory. Photo: Dirk Mahler

Research Specializations

The Fraunhofer IFF's research in the field of telematics and logistics is focused on continuous freight tracking for logistics companies and carriers. Since existing storage capacity is increasingly being relocated to the road, both the number of shipments and the value of freight are rising. Continuous availability is being attained by combining different technologies for indoor and outdoor localization, automatic identification and the communication of transport information.

RFID is a key technology for systems that automatically identify freight in supply chains. Numerous test applications are being developed and tested for this at the Galileo Test Bed. By tagging goods with RFID transponders, shipments can be monitored throughout transport chains by means of appropriate infrastructures.

The Fraunhofer IFF developed its patented electromagnetic reverberation chamber (ERC) system as the heart of infrastructures that continuously monitor freight and goods throughout the supply chain. It can be employed in different types of transport equipment (smart load carriers) or gate solutions (smart infrastructure). This technology can be used to furnish load carriers, such as swap bodies for light duty commercial vehicles in urban areas, with intelligence with which they continuously inventory loaded freight and communicate shipment data enriched with localization data to central control centers.

Another core application of ERC technology is the RFID Tunnel Gate. It continues tracking and monitoring freight on the premises of manufacturing companies and logistics nodes without interruption. In addition, it reliably scans incoming and outgoing bulk freight. The gate's size can be scaled to the application, from a tunnel that scans packaged tagged items in bulk to a gate that scans entire truckloads.

Outlook

Once the test infrastructures are completed in the course of 2011, the Galileo Test Bed will be fully usable. Not only the exchange among the individual development units but, above all, the research partners's joint projects will link the Galileo Test Bed's individual locations more closely.

In the field of telematics and logistics, the interlinking of the development and testing environments at the Fraunhofer IFF (LogMotionLab) and the university (ILM's material handling building) with the Galileo Test Bed will be continued. The goal is to increasingly integrate these institutions in the university's academic programs.

Project Partners

ifak Institut für Automation und Kommunikation e.V., Magdeburg, Hallesche Verkehrs-AG (HAVAG), Capital City of Magdeburg, Magdeburger Hafen GmbH and Otto von Guericke University Magdeburg

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EFFICIENT AND SECURE LOGISTICS OPERATIONS IN CENTRAL HUBS

Background

Saxony-Anhalt Galileo Test Bed's logistics platform was opened in Magdeburger Hafen GmbH's Hanse Terminal in June of 2010. Following the opening of the Hallesche Verkehrs-AG's satellite traffic control systems and the opening of the development laboratory in Magdeburg's Port of Science, the opening of the logistics platform in the Hanse Terminal completed the Saxony-Anhalt Galileo Test Bed. The Hanse Terminal is an advanced terminal for combined transport (CT) and the containers of the Magdeburger Hafen GmbH, one of the Saxony-Anhalt Galileo Test Bed's partners. It is a trimodal terminal for inland waterways, rail and road.

It is a productive testing environment for research specialized in telematics and logistics with numerous handling modes for the use of localization and identification technologies in internal outdoor operations. Logistics operations can be prototypically tested in major nodal points of transport chains, such as port zones and freight terminals, and used for test applications.

The Logistics Platform's Infrastructure

Freight delivered to Magdeburger Hafen GmbH's terminal is primarily handled by reach stackers, a gantry crane, a heavy duty crane truck for heavy freight and forklifts and transported between inland vessels, trains and trucks.

The Hanse Terminal already has a local UWB localization system, with which assets tagged with transponders, e.g. equipment such as a reach stacker, can be localized and tracked highly precisely at high frequency. A camera system and a WLAN for the entire terminal premises were additionally designed in 2010 and will be installed and put into operation in 2011.

Research specializations

Among other things, assuring accurate and continuous communication is part of the development of technological solutions, which make logistics operations in central hubs more efficient and reliable The WLAN system in the Hanse Terminal is used to research WLAN communication in the container terminal's dynamic environment with constantly changing interruptions of individual access points' signal reception and to integrate the effects in a proactive monitoring system. This system, which documents processes and evaluates process data in real time, will be researched and developed in the coming years in the project ViERforES (Project Ref. No.: 01IM10002A) supported by the Federal Ministry of Education and Research. In addition to WLAN information, the system will additionally also process identification and motion data on

1 *Reach stacker and gantry
crane in the Hanse Terminal.
Photo: Viktoria Kühne*
2 *VR planning for camera
systems in the Hanse Terminal.*

2
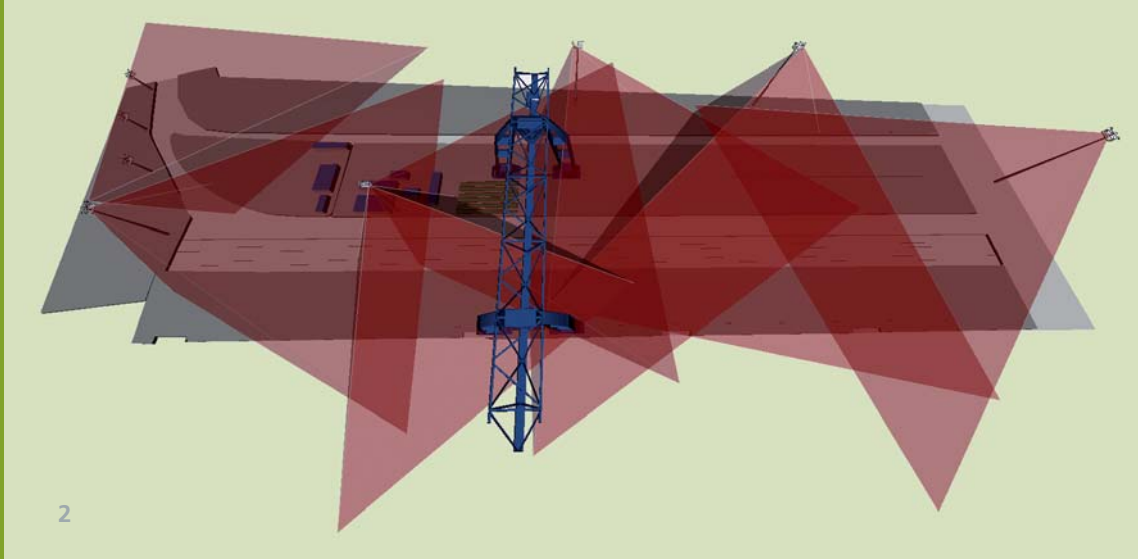
individual equipment and assets in the port zone, which have been obtained by the video system and the UWB localization system. The foundation for the analysis of such motion patterns in the port was laid in the project Port and More (Project Ref. No.: 6060140101) supported by the Investitionsbank Sachsen-Anhalt.

Knowledge of port operation will make it possible to use a model analysis to automatically determine which equipment should be used to handle freight in the port zone with what quality based on motion characteristics. Automated analysis based on neural networks will extract attributes of specific equipment from the motion profiles, i.e. generate kinematic fingerprints. First, two applications will be differentiated and refined for the reach stacker and gantry crane used in Magdeburg Port.

It will also be just as important to link data from the local systems with data from the upstream and downstream transport chains for the logistics platform in the Hanse Terminal as for the applications in the development laboratory. In the terminal area, telematic monitoring systems will not solely use GPS localization data since the accuracy of localization they deliver is inadequate for the analysis of logistical transport, handling and warehouse operations. Therefore, new hybrid localization systems will be developed and tested at the Galileo Test Bed. They will, for instance, combine different systems' localization and identification data, such as pre- and on-carriage by GPS, local video system or UWB localization. The motion profiles of the freight will not only make all of the logistics operations transparent for everyone involved but will also ensure that it is reliably handled as ordered.

Outlook

In addition to recording the motion curves of individual pieces of equipment, the video system in the Hanse Terminal will primarily be used in the future to refine video-based localization and identification of mobile assets. The appearance of a non-cooperative measuring environment in the analysis of the video information will have to be incorporated in the outdoor environment elementarily. The goal is to establish video-based analysis as a reliable system that is an alternative to radio-based systems despite challenging ambient conditions, e.g. changing light throughout the day or other weather effects.

The Galileo Test Bed's logistics platform provides an excellently equipped development and testing environment under productive conditions for the Fraunhofer IFF's other future research and development projects.

Project Partners

ifak Institut für Automation und Kommunikation e.V., Magdeburg, Hallesche Verkehrs-AG (HAVAG), Capital City of Magdeburg, Magdeburger Hafen GmbH and Otto von Guericke University Magdeburg

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INVENTORYING TAGGED ARTICLES WITH RFID TUNNEL GATES

Motivation

The garment manufacturer GERRY WEBER completed its RFID rollout at the end of 2010. Since early 2011, all of the manufacturer's garments have been tagged with a UHF RFID transponder, which is sewn into a garment during production. GERRY WEBER intends to use these transponders to enhance transparency and security in its global supply chain from its production facilities to its stores. The sewn-in transponders also replace other article surveillance in stores.

DHL, one of GERRY WEBER's international logistics providers, supplies an overview of all the items in boxes in real time whenever it accepts shipments in China.

To scan articles of clothing, DHL Solutions & Innovations – DHL's innovation unit – and DHL Global Forwarding contracted the Fraunhofer IFF to integrate the RFID tunnel gate in DHL's international DHL transport operations, which it developed based on the principle of the electromagnetic reverberation chamber (ERC), .

Solution

Bulk reading of transponders, densely packed atop one another in a box, presents major challenges to the scanning equipment used whenever every transponder has to be detected reliably in any direction or position and solely in relation to one box. The power density, the homogeneity of the field strength distribution and the electromagnetic wave's polarity are crucial parameters.

The principle of electromagnetic reverberation had been developed for UHF RFID applications in 2007. Electromagnetic reverberation originally played a role in EMC test equipment, taking measurements of electromagnetic emissions and immunity relatively easily with a minimum of instrumentation. In such electromagnetic reverberation chambers for EMC measurements, an array of variously aligned metallic reflectors is "tuned" in order to alter the electromagnetic boundary conditions. Continuous alteration of the boundary conditions produces a multitude of modes, which distribute field strength evenly over a defined period.

Instead of using the mechanical tuners in ERC test chambers, the Fraunhofer IFF's patented principle electronically switches between so-called "apertures", in this case RFID antennas, to alter the boundary conditions. Consequently, applied as a UHF RFID gate with a frequency of 868 MHz, the same field strength in every potential polarization exists in the precisely defined read range (bounded by reflectors) anywhere. Unlike conventional UHF RFID gates and employing a minimum of reading performance, it can do the following:

1 *Otto von Guericke University Magdeburg's electromagnetic reverberation chamber with mechanical mode tuners. Photo: Dr. Hans Georg Krauthäuser*
2 *DHL's RFID tunnel gate for Gerry Weber. Photo: Martin Kirch*

2

- By evenly distributing field strength, it increases the read performance of one or more transponders in the electromagnetic reverberation chamber regardless of their location.
- It ensures that the transponders' readability is fully independent of their spatial orientation.
- Its exactly defined read range prevents misreading (false positive readings) of transponders in the immediate vicinity.

Results and Benefits

Employing the aforementioned principle, an electromagnetic reverberation chamber was developed for light duty gravity roller conveyors, which makes it possible to detect every tagged garment located in one box.

To do so, every box labeled with a barcode box is identified by a handheld barcode scanner before it enters the ERC. Afterward, the content of a box, which has been detected in the tunnel gate by automatic non-contact RFID scanning, is allocated to that particular box and transmitted to a central database.

By already compiling a complete box-by-box inventory in the country of production, GERRY WEBER is enhancing the transparency of its supply chain from its manufacturer's facilities to its individual warehouses and distribution centers and finally to its stores. An ERC can be used in logistics operations to document incoming and outgoing articles in a warehouse fully automatically without much additional effort. Thus, for instance, items missing from boxes packed by hand are already detected in the country of production and the globally available inventory is updated in real time.

Outlook

Integrating the patented ERC principle in load carriers and gate applications makes transport operations and supply chains more reliable, more transparent and faster since it eliminates tedious manual inspection and documentation. The ERC principle can be scaled to different applications – from reading boxed shipments to scanning entire truckloads.

As a partner for applied research, the Fraunhofer IFF provides support to regionally and globally operating companies integrating and applying the ERC principle in their operational environments as well as consulting on the use of RFID systems in transport and supply chains.

Project Partners

DHL Solutions & Innovations, Bonn, 7iD Technologies GmbH, Graz, Austria and Oracle, Prague, Czech Republic

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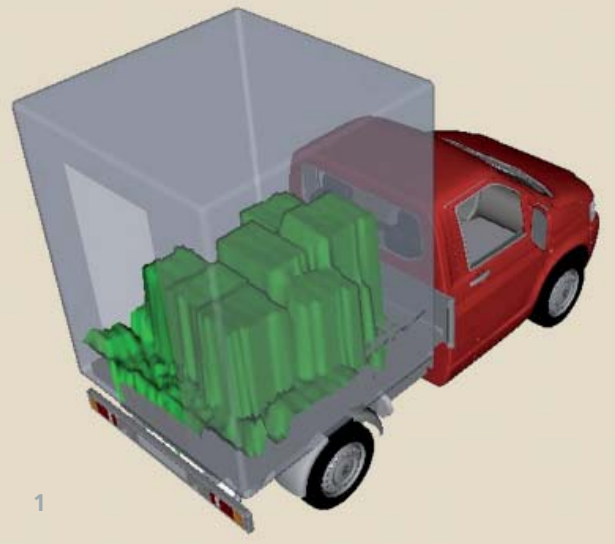
EFFICIENT TRANSPORT LOGISTICS BY CONTINUOUSLY MONITORING CARGO SPACE

Motivation

The project TransMat is intended to create a transport software platform that covers everything from automated material planning through negotiations for free capacities to haul freight. This requires measures and procedures to identify free transport capacities. Continuous cargo space monitoring, i.e. recording cargo space bookings and freight volumes, generates novel approaches to optimizing commercial shipping, which can, among other things, minimize operating costs by utilizing vehicles more efficiently and optimize routing.

Solutions

An extensive range of widely varying freight and freight containers led to two different approaches to monitoring filling levels. Ultrasonic modules were developed to measure the filling of vehicles for large volume, e.g. pallet-sized, freight. Novel commercial time-of-flight cameras based on optical measurement were employed for higher and more precise resolution of the cargo space required by small-volume freight like that usually found in courier, express and parcel logistics.

Results

Since they require considerable investments of hundreds to thousands of euros in hardware and substantial computing power to transmit and analyze data, such optical systems were previously largely unsuited for transport logistics.

Both systems essentially consist of the control unit connected with a GPS/GSM module. Shipment data is linked with container positions to localize shipments. A GSM transmits data to a Web service for storage. Only the measurement systems used differ.

The ultrasonic sensors measure a transport vehicle's loading from its roof in a periodic cycle. Level and load structure are ascertained from a defined raster. The size of the raster in the vehicle, i.e. the resolution, is proportional to the sensors' distance to the floor. This delivers the dimensions of the measured load.

Small-volume freight requires higher resolution of the vehicle interior. Time-of-flight cameras enable this system to deliver far more detailed resolution at far lower cost than ultrasonic systems. The 3-D image sensor's data format consists of a matrix of scalar depth data with a resolution of 640 to

1 *Multi-dimensional loading profile to calculate volume.*
2 *Ultrasonic modules that scan load height.*
Photo: David Terlinden
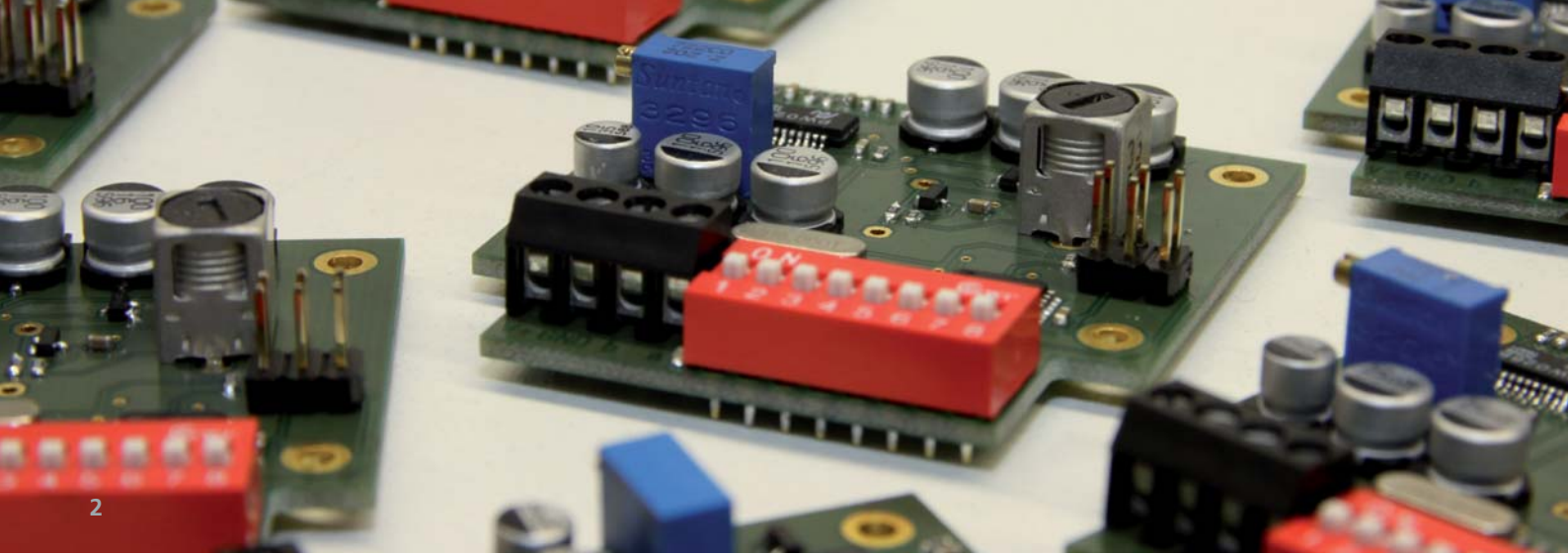
480 points. The coordinates of these surface data must be transformed relative to the sensor's angle. Image processing operators correlate the image of the unloaded vehicle and its current loading to compute the useful area available and the potential height of objects in the cargo space. Both the load structure and the general filling of the cargo space can be determined for low capacity vehicles with extremely accurate resolution.

Benefits

A permanently available overview of a vehicle's current utilization and the data on the structure of cargo space's packing furnishes far reaching potential to optimize routes and vehicle utilization. A logistics provider can additionally assign ad hoc orders to a delivery vehicle while it is still underway. These actions also reduce fuel consumption and CO_2 emissions.

In addition, linking shipment data with container positions makes it possible to localize shipments. In the future, this will generate new convenient options for receivers when freight is transferred.

Project Partners

M-Bis GmbH, Biederitz, Magdeburger Flitzer GmbH, LSL Logistik Service Lüneburg e.K. and Bingen University of Applied Sciences

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PROJECT REPORTS FROM THE FIELD OF VIRTUAL ENGINEERING RESEARCH

*Review of a chemical plant's
design in the VDTC's Elbe
Dom. Photo: Dirk Mahler*

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AVILUSPLUS: ACQUIRING EXPERIENCE FROM THE FUTURE

Motivation

The project Applied Virtual Technologies Focused Long-range on the Product and Production Equipment Life Cycle AVILUSplus is part of the Virtual Technologies Innovation Alliance funded by the Federal Ministry of Education and Research. In close collaboration with the AVILUS technology network, virtual and augmented reality technologies have been developed. The AVILUS consortium's industry partners specified the priorities of technology development based on current market assessments. The AVILUSplus team also had to factor in technologies, which, although they promise long-range success, entail high development risk. The first applications of new tools developed in contract research with industrial companies have demonstrated that more than just long range success is attainable. Initial experience with these technologies, some of which will become common only in the future, has been acquired.

Key Fields

Virtual and augmented reality technologies and the digital engineering methods that build upon them are a central field of research at the Fraunhofer IFF and, in addition to the Central AVILUSplus Office, staff from five of the institute's business units and expert groups are involved in this work. After two and a half years of research, the results of the project are now available and outlined here.

In the field of simulation, different simulation tools used by the industry partners in the field were interconnected. The goal was to model functional features, e.g. the performance of pneumatic drives, better virtually and thus commission new products even more realistically virtually. Such work is especially relevant to custom machine manufacturers that frequently modify their machines' control software. A real time interface was implemented to simulate pneumatic drives and SM Calvörde Sondermaschinen GmbH & Co. KG incorporated the moving components in its collision analyses of NC machining programs.

Research in the field of interaction made augmented reality (AR) technologies more accessible for industrial use. This technology is only useful when AR overlays are blended into

1 *Augmented reality(AR) goggles open a variety of possibilities. Overlays project desired real and virtual information directly before one's eyes. In industrial settings, the principle is used, for instance, for quality assurance in manual assembly operations. Users thus always have both hands free. Photo: Uwe Völkner*
2 *One further development of geometry scanning technology is an AR assistance system, which presents the next step of assembly to a worker and monitors the correctness of its execution. Photo: Dirk Mahler*

2

goggle systems in the correct position. A one-step method of calibration was developed to reduce the complexity of the calibration necessary. It is nearly as accurate as currently common multiple-step methods of calibration. Furthermore, technologies were researched, which detect and compensate slippage of AR goggles on a user's head.

Originally developed to control robots, interaction systems based on tactile sensors can be used in virtual environments to develop novel concepts for the control and operation of machinery and systems. A tangible user interface based on a space and force resolved sensor enables users to interact especially intuitively by pulling, pressing, pushing or turning.

A basic prerequisite for the visualization of virtual environments is the availability of 3-D data on the represented objects. Whenever these data are unavailable, they are scanned by a laser scanner. Several millions of measured data can be generated in a few seconds. The individual measured 3-D points must be compressed, e.g. by approximating standard geometries describable by parameters, so that they can be represented in virtual environments interactively. A variety of algorithms that do this were developed and tested, thus making it possible to automatically capture the enormous quantities of data from laser scans of entire building and industrial complexes. These in turn can be employed for a variance analysis of a projected virtual facility and the facility really built.

Project Partner

Fraunhofer Institute for Industrial Engineering IAO, Stuttgart, Fraunhofer Institute for Experimental Software Engineering IESE, Kaiserslautern, Fraunhofer Institute for Computer Graphics Research IGD, Darmstadt and Rostock, Fraunhofer Institute for Production Systems and Design Technology IPK, Berlin, Fraunhofer Institute for Machine Tools and Forming Technology IWU, Chemnitz, German Research Center for Artificial Intelligence DFKI, Saarbrücken and Kaiserslautern and the Technische Universität München TUM

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NEW DEGREE PROGRAM AT THE CENTER FOR DIGITAL ENGINEERING

Motivation

The increasing use of embedded systems in complex products requires new methods of product development. Existing testing and inspection systems are unable to concretely inspect and thus evaluate the quality of software, for instance. This is where the research project ViERforES starts: Virtual systems are intended to give three-dimensional form to features, which are normally invisible, and visualize the performance of the software integrated in machinery and devices. This is the root of the project's goal of increasing the security and reliability of complex technical systems. After two and a half years of research, the first phase of the project concluded at the end of 2010.

Key Fields

The Fraunhofer IFF took over the coordination of the research network. Five of its expert groups and business units were involved in the research of applications in the fields of industrial engineering, logistics, medical engineering, power engineering and automotive engineering. The following concrete results were achieved:

– For industrial engineering, projected overlays and monitoring of safe areas around robot workplaces was developed as the basis for cooperation between humans and robots.
– In logistics, areas of radio and camera coverage can be represented in virtual environments in order to evaluate safety-critical infrastructures at logistics nodes.

– A testing environment that simulates minimally invasive procedures was created for complex medical instruments.
– The control center of the future is used in power engineering to organize condition monitoring for distributed power producers more manageably.
– In automotive engineering, a quality inspection system for embedded software systems was developed by combining mechatronic models with distributed simulation.

Digital Engineering Master's Program

Another outcome of the project work was the insight that technical experts with solid knowledge of both engineering sciences and computer science are needed as embedded systems increasingly proliferate in products in nearly every field of application. That was the motivation for establishing the Center for Digital Engineering now under development at Otto von Guericke University Magdeburg. In 2010, the participating researchers devised the eponymous Master's program, supported primarily by the Schools of Mechanical Engineering

1 *Projected augmented reality is used to monitor dynamic safe areas around robot workplaces.*
2 *A virtual testing environment for safe minimally invasive procedures.*
Photos: Viktoria Kühne

and Computer Science. Students in the program enroll in the School of Computer Science. A Bachelor's or Master's degree in engineering or computer science is required for admission.

The first semester gives students from different engineering and computer science programs a common basic level of knowledge in interdisciplinary subjects in addition to the specializations they already have in a field. Approximately half of the main part of the Master's program consists of project modules in which methodological expertise is acquired in digital engineering projects in teams. The other half consists of technical modules that teach digital engineering technologies.

Intensive work on projects prepares students optimally for the specific challenges of interdisciplinary research and development. In addition to knowledge about current technologies for the development and operation of engineering solutions,one basic goal is to teach methodological knowledge, which is an important prerequisite for the use of such technologies.

Select parts of the curriculum are offered in consultation and in collaboration with industry research partners. The Fraunhofer IFF is also involved in this.

Other key expertise taught in the program is focused specifically on interdisciplinary communication and project work, which will enable graduates to assume leadership and interface positions using their interdisciplinary knowledge.

The new degree program will be offered at Otto von Guericke University Magdeburg as of April 2011.

Project Partners

Fraunhofer Institute for Experimental Software Engineering IESE, Kaiserslautern, Otto von Guericke University Magdeburg and the Technische Universität Kaiserslautern

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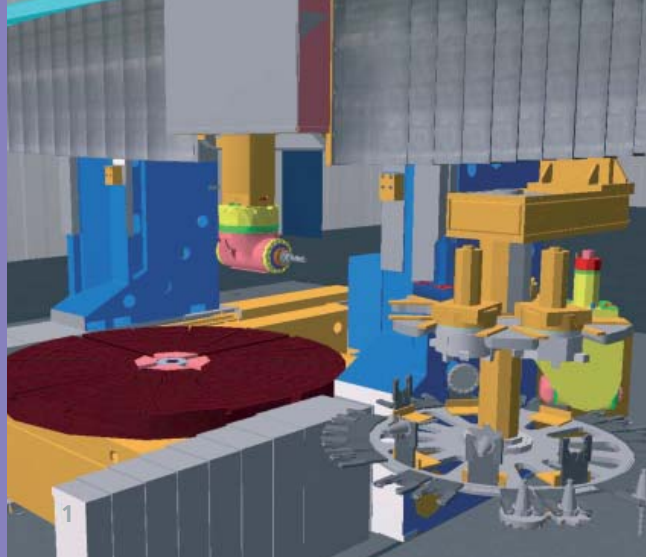
THE VIDET INNOVATION CLUSTER'S ACCOMPLISHMENTS

Motivation

The use of virtual technologies is crucial to the development and production of innovative products. They are digitally designed, engineered, tested and refined. This reduces not only the time required for and the costs of their development and production but also the existing risk. Virtual engineering is therefore an important resource in international competition.

In the pact for research and innovation, the Fraunhofer-Gesellschaft took on the job of creating and implementing an innovation cluster in which regional economic strengths are consistently supported by applied research and developed further. Therefore, the Fraunhofer-Gesellschaft and the Saxony-Anhalt Ministry of Economics and Labor established the Virtual Development, Engineering and Training Innovation Cluster VIDET, which allows small and medium-sized enterprises from the machinery and plant manufacturing industry to start developing products virtually. It is intended to facilitate access to innovative research services. Companies profit from the research institute's developments and further increase their own competitiveness.

Methodology

All research and development work in VIDET was done on three technology platforms: Virtual Product Development, Virtual Process Engineering and VR Training and Qualification.

The technology platforms are based on the V model established in the VDI Guideline 2206, which VIDET is logically extending to the entire process chain by applying virtual engineering methods. The integration of development and process data management is particularly important for all of the technology platforms.

Work

During the project period from 2007 through 2010, the innovation cluster completed forty-eight projects with forty-four partners in Saxony-Anhalt alone. Another twenty-three projects are currently in the preparatory stage. An additional twenty-six projects with twenty-five partners were completed nationwide and another six are in the works. Altogether, the projects had a budget of eight million euros.

Model Projects

Virtual Product Development and VR Training
Virtual development of large tool machines uses diverse simulations to validate and optimize product features. Practically every machine is one-of-a-kind and belated discovery of

1 Virtual product development and VR training for a large machine tool.
2 Virtual process planning for electron beam welding.
3 Virtual interactive learning environments for the maintenance of high voltage equipment.

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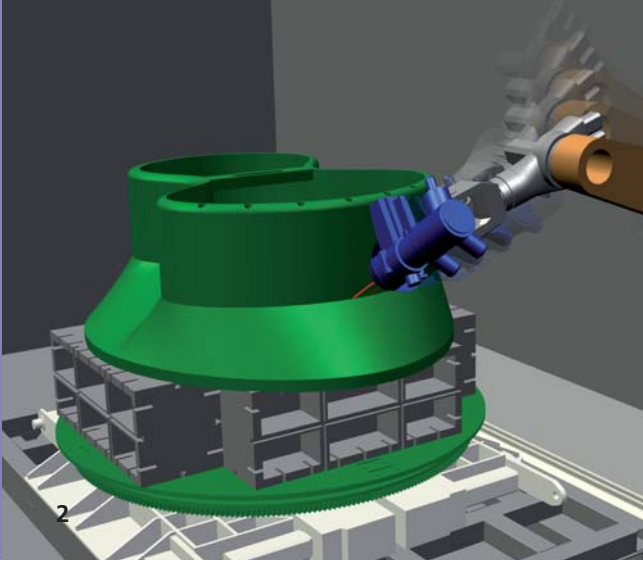
design error holds financial risk. Simulations bring certainty to design. The control program can already be designed based on the virtual machine model long before the machine exists physically. This shortens development times drastically and the client receives fully developed and extensively tested software. Moreover, early availability of the control system makes it possible to already train a client's operators on the virtual machine model. The tool machine can thus be used productively much earlier and operating errors during the learning phase do not cause any damage. Since the virtual machine models also simulate material removal, a client can even develop and test its product line's range of parts before the machine even exists. Clearly, the consistent and integrated application of VE and VR technologies delivers benefits in every phase of the product life cycle.

Virtual Process Engineering for Electron Beam Welding
Electron beam welding is a highly effective technology, which however is very complex to prepare. A robot with seven degrees of freedom must be programmed to follow the desired weld path. Since welding is done in a vacuum, the process is difficult to control directly. Using the CAD data of the welding chamber, the robot and the welded workpiece, a virtual planning and programming system was developed, which generates the robot program fully automatically. This reduced the setup time of several hours to half an hour.

Virtual Interactive Learning Environments for High Voltage Equipment Maintenance
The qualification of maintenance experts requires a methodology to responsibly prepare maintenance jobs, which is maximally oriented toward practice. In reality, the functions and modes of operation of equipment, e.g. high voltage circuit breakers, are invisible and only their effects are evident. A virtual interactive learning environment visualizes technical operations and physical processes. When they are combined with the representation and practicing of procedures, a signifi-

cant improvement in learning success can be expected. The learning system is used by both basic and advanced trainees and service technicians. It thus serves as a learning system and simultaneously constitutes a technical infrastructure for know-how transfer. An easily controllable, self-explanatory user interface and intuitive interaction systems make it easier for users to use a multitude of application scenarios.

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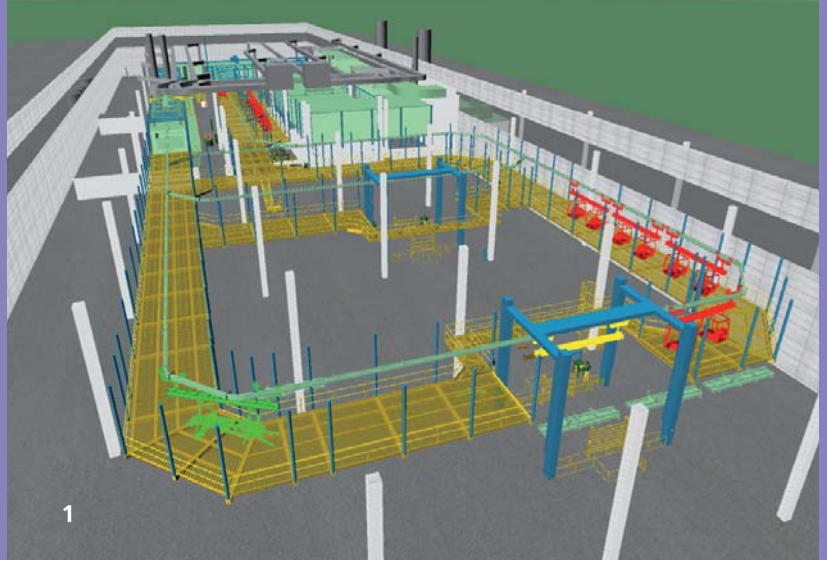
EVALUATING MATERIAL FLOWS THREE-DIMENSIONALLY WITH REVIEW3D

State-of-the-art

Material flow simulation is an established tool for validating the planning and operation of complex production and logistics systems. Simulation models of differing size and detail are employed, depending on the task at hand. Two-dimensional animation is the tool commonly used to visualize simulated processes and simulation results. Its information suffices for a large number of applications.

Digital factories and plants are already frequently laid out with the aid of 3-D CAD tools. Their three-dimensional data also ought to be employed in downstream planning processes in order to improve the sustainability of all of the planning. Depending on the application, interactive 3-D visualizations and animations generate different benefits and improvements. Models combining 3-D layout and animation can be used, for example, to support the analysis of potential collisions of different tools and manufacturing equipment during production or to clearly visualize complex systems. In addition, the use of three-dimensional data can also meet the digital factory's need for scalable models, which may also have to include detailed simulations of assembly and ergonomics as the level of detail increases. In keeping with the sustainability required of the digital factory, such models can naturally also be employed beyond the planning process for marketing, training or operative planning, for instance.

Initial Situation

Successful in the agricultural machinery industry, Deere & Company produce tractors and harvesters and more. To plan and monitor its production processes, the company's simulation experts use different simulation tools modified for the specifics of each of its production units such as welding, parts manufacture, body construction, painting and intermediate and final assembly. All of these units have one thing in common. They use a 2-D animation tool to represent and validate generated simulation results.

Task

If 3-D visualization and animation are to be considered an attractive technology and, above all, a cost effective tool for material flow simulation, their generation may not cause any or only relatively slightly more work than 2-D animations. Specifically, the manual creation of 3-D objects ought to be avoided as far as possible. Instead, existing layout and

1 *Animated material flow of a paint line as a 3-D animation.*
2 *Review3D in the Elbe Dom: The immersive presentation of planning layouts and simulation results facilitates interdisciplinary and collaborative validation of production systems.*
Photo: Dirk Mahler

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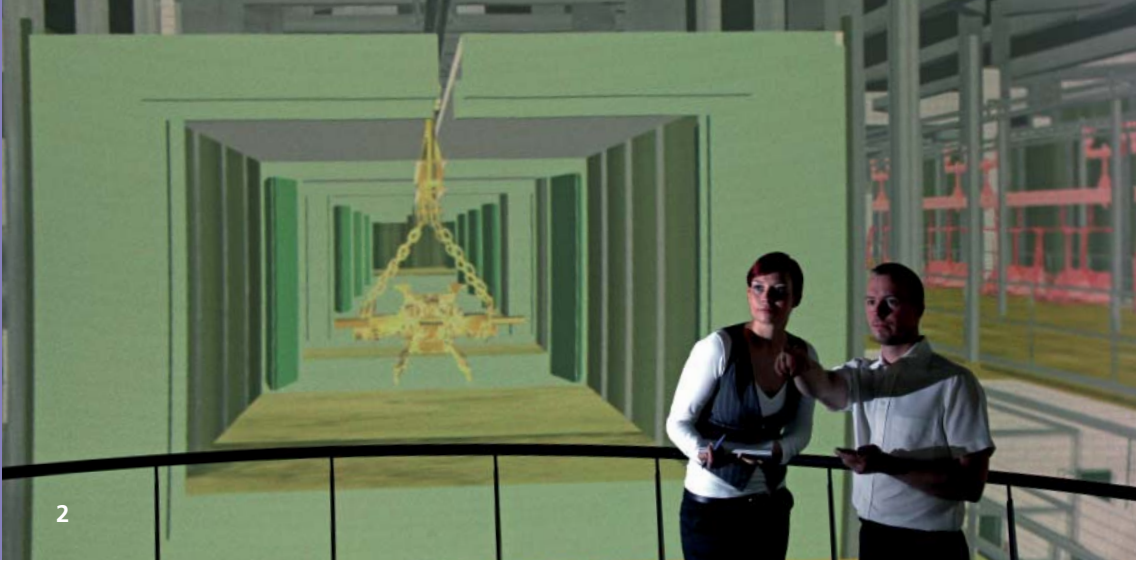
product planning data ought to be reusable as the basis for 3-D visualization. A connection to a company's specific digital production planning interfaces is essential. The drawback of such planning data is their high level of detail. Consequently, automatic and manual simplification procedures had to be considered, too. In addition to providing 3-D models, the extraction of additional animation information also had to be incorporated.

Approach

The Fraunhofer IFF developed the 3-D visualization system Review3D to create 3-D animations of material flows. It has interfaces to formats for 3-D CAD transfer and simulation results. The most important interoperability format for the exchange of CAD data is JT. However, a standardized format for simulation data does not yet exist. In order to minimize the manual labor required to create and update the model, the necessary data are compiled from the available sources auto-matically and optimized for an interactive visualization system's real-time specifications. Manual labor only becomes neces-sary when the available data are insufficient. The high level of automation ensures that individual data layers are exchanged smoothly when there are new plans.

Results and Benefits

Review3D has already used successfully for design reviews and presentations of different site plans several times. Deere & Company's technology center also has a Review3D installation in a CAVE, a multi-sided immersive work environment with projectors. The manual work required to switch from 2-D to 3-D has been demonstrated to be manageable.

Outlook

The development of Review3D in collaboration with Deere & Company is continuing and, in addition to the animation of paint lines, also being extended to the detailed animation of mechanical assembly, welding and machining operations as well as manual jobs. This will necessitate the integration of more planning data and simulators. Fully linking simulation and animation online will also be the object of research in the future. What is more, the successful collaboration with Deere & Company has attracted new parties interested in Review3D.

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SAFE TRAINING IN THE CHEMICAL INDUSTRY WITH VIRTUAL REALITY

Motivation

Although the chemical industry has been able to reduce the number of reportable accidents drastically in the past few decades, accidents remain part of the work routine. The Raw Materials and Chemical Industry Professional Association BG RCI is constantly searching for new solutions to continue reducing their number. The BG RCI supports over 13 400 member companies from the chemical industry. Every year, BG RCI trains technical assistants, mechanics, executives, maintenance technicians, safety officers and other experts from its member companies in some 200 seminars at its qualification center in Maikammer. Since practical training at the qualification center in Maikammer was sometimes very costly and not very realistic, the conventional educational modules needed to be upgraded with authentic training methods closer to reality.

Initial Situation

Virtual reality technologies open possibilities to design three-dimensional work areas in which procedures can be demonstrated and trained realistically and safely. They eliminate the need for real experimental setups and safety systems that prevent accidents and damage. The Fraunhofer IFF and the BG RCI collaborated on the creation of a three-dimensional environment of a virtual factory, which allows users not only to view demonstrations in a 3-D environment but also to complete tasks, try out procedures, work interactively with certain devices and tools in training scenarios and acquire experience safely. A model workplace where flammable liquids are transferred was integrated in the virtual factory as a training scenario. In various lessons, users learn how to set up and take down a workplace where flammable liquids are transferred,

how to transfer them and what personal safety equipment they need.

As part of the BG RCI's campaign "RISIKO RAUS" to eliminate risk, the virtual factory is being expanded with a training scenario for internal transportation. The goal is to demonstrate and provide training on the dangers of hazardous materials and the correct handling of filled drums when they are loaded and transported from a explosion protection zone to a storage site.

Approach

The qualification center installed the training scenario as a stereoscopic interactive user environment with the aid of the "powerwall and 3-D input device" visualization system. In this training environment, trainees use the proper training scenarios to enter virtual factory buildings interactively.

Implementing the training objectives for safe transport and transportation necessitated developing and representing an ideal procedure based on real processes. Workshops were held with experts from BG RCI to design an authentic scenario from

1 *The visualization system at the BG RCI's qualification center. Photo: Alexander Kroys*
2 *Training module for the transfer of flammable liquids. Photo: Dirk Mahler*

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prior events and present knowledge. In particular, the focus was on correctly guiding the pallet jack as an industrial truck, correctly securing the drums and safely unloading and storing them. Based on the findings, a script for the training scenario was developed in consultation with the BG RCI. It describes the jobs, workflows and potential errors as well as their consequences in detail. This concrete specification was ultimately used to develop the training scenario and integrate it in the virtual factory.

Results and Benefits

The interactive training module developed allows chemical technicians to practice procedures central to a chemical factory realistically without endangering themselves or their environment or having to implement elaborate test setups. Thus, the virtual training scenario is an optimal medium for motivating seminar attendees, producing sustainable curricula and assuring quality. The new technologies described especially provide support in the basic and advanced training of safety officers and safety specialists and in technical seminars on explosion protection.

Outlook

The plan is to refine the training scenarios by 2012 to augment the widely varied offerings of the BG RCI's training center in Maikammer and enhance the seminar program. Future qualification will necessitate implementing and upgrading the new options from the virtual interactive technologies in basic and advanced training in keeping with needs and requirements. Diverse opportunities for seminars for different target groups will be created based on the system implemented at the training center in Maikammer. Supporting continuous evaluation in the seminars will deliver insights into the use and the value adding elements of virtual 3-D training scenarios in qualification.

The next step will entail integrating training scenarios on nitrogen inerting and safe gas cylinder handling. The BG RCI will present these training courses as an exhibit at the 2012 ACHEMA trade show.

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QUALIFICATION AND TRAINING WITH VIRTUAL REALITY TECHNOLOGIES USING VIREKON

Motivation

Demographic change in Germany is one of the fundamental and ongoing challenges our society is facing. This has consequences for all sectors of society and even affects the skilled labor market. Effectively countering this will require taking measures that cover the future need for technical experts. Ensuring the transfer of advanced technology to Saxony-Anhalt's small and medium-sized enterprises is therefore tremendously important. However, many companies' efforts to acquire the expertise they need fail, whether because they have too few partners, insufficient funds or structural disadvantages.

The practically oriented transfer of tried and tested virtual reality (VR) technologies in the project ViReKon is intended to provide companies in Saxony-Anhalt support to acquire expertise. Their application can facilitate the acquisition and retention of usable technological expertise significantly. Small and medium-sized enterprises are receiving a technological edge, which will enable them to compensate for structural disadvantages, increase their competitiveness and protect jobs in the long term.

Solution

In the ViReKon project, the Technologie- und Berufsbildungszentrum Magdeburg gGmbH and the Schweisstechnische Lehr- und Versuchsanstalt Halle GmbH are qualifying engineers and mechanics on virtual machinery. Together with these training centers, the Fraunhofer IFF is designing virtual training scenarios and qualifying staff from the research and development units of the companies involved to use VR technologies. RKW Sachsen-Anhalt GmbH is coordinating the project.

Results

The qualification courses provided at the Fraunhofer IFF was intended to impart basic knowledge about virtual reality and knowledge about the use and creation of VR scenarios by using the Virtual Development and Training (VDT) Platform as a model. The VDT Platform is an interactive visualization system developed by the Fraunhofer IFF. So far, staff from fifteen companies have attended the courses. The attendees who have completed the qualification courses agree that the knowledge they acquired will help them improve operations in individual units of their companies. Above all, the use of VR technologies cuts the time required for manufacturing and assembly. Additionally, the associated times in companies are reduced and the convenient presentation options of virtual reality technology support sales talks.

As part of the knowledge transfer, operational tasks were developed with and implemented in companies. Interactive knowledge transfer was planned in detail and implemented in the companies. Specifically, this involved the following steps:

Virtual training in a CAVE.

Photo: Dirk Mahler

- creating and converting the 3-D machine/plant model,
- describing machine/plant performance,
- creating additional elements of the virtual environment,
- formulating a didactic concept to teach curricula,
- describing tasks and solutions,
- designing learner feedbacks and
- integrating the VR solution in the company's operations and organization.

Benefits

The transfer of VR technologies to qualify technical experts efficiently and systematically will make new and sustainable technology accessible to the region's companies and residents. The technology ensures a high level of sustainability. Integration in regional networks assures wide use. The interdisciplinary team of capable partners guarantees that universally valid solutions are produced and the capabilities and limits of the application of VR technologies are defined objectively.

Outlook

The VR solutions developed are implemented by the training providers long range. The companies involved in the project are applying the solutions long range in various parts of the product life cycle, for instance sales support, assembly planning and qualification and assistance systems.

Project Partners

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SACHSEN-ANHALT

1

PROGRAMMING AND VIRTUAL COMMISSIONING OF A SPOT WELDING SYSTEM

Initial Situation and Motivation

SM Calvörde engineers, manufactures and installs machinery, plants and equipment for various branches of industry and offers custom and innovative solutions from one source. The company produces technically sophisticated, customized and complex complete solutions based on certified and proprietary systems or client specifications.

The project analyzed machinery developed by SM Calvörde to weld large components. The machining operation consists of approaching a large number of points specified by an NC program, which is usually written by hand by a programmer beforehand. Given the wide variety of types and the low quantity of welded parts, the work required for programming is excessive.

Since such machining is often very complex, a simulation run of the NC program is advisable to verify that the points are welded correctly and to check that the motion sequence avoids collisions. State-of-the-art simulation normally runs before the post-processor and fails to fully incorporate cycles of specific machinery. Currently, simulation environments do not fully integrate all phases from planning through the testing of the real NC program cycles of all of the specific machinery.

Task

A "tool" had to be developed, which supports NC programmers when they create and test a machining program for a concrete welded part. It would enable them to already generate a machining program for a specific machine fully with 3-D geometries of the workpieces and extensively test the machine in their offices.

Solution and Approach

Software was developed, which is used to enter weld points and to parameterize the welding parameters in a 3-D representation. Additional processes such as complex evasive movements or parallel measurement of contours can be specified and assigned to the actual machining process. In addition, 3-D component geometry can be imported from CAD data to the programming environment. A number of tools were developed to enter a very high number of weld points effectively. Complex machining operation can be grouped and assigned to recurring component structures.

1 *Simulation of the NC program on the real controller. Photo: Dirk Mahler*
2 *3-D representation of a welded part in the programming system to generate an NC program for a specific machine.*

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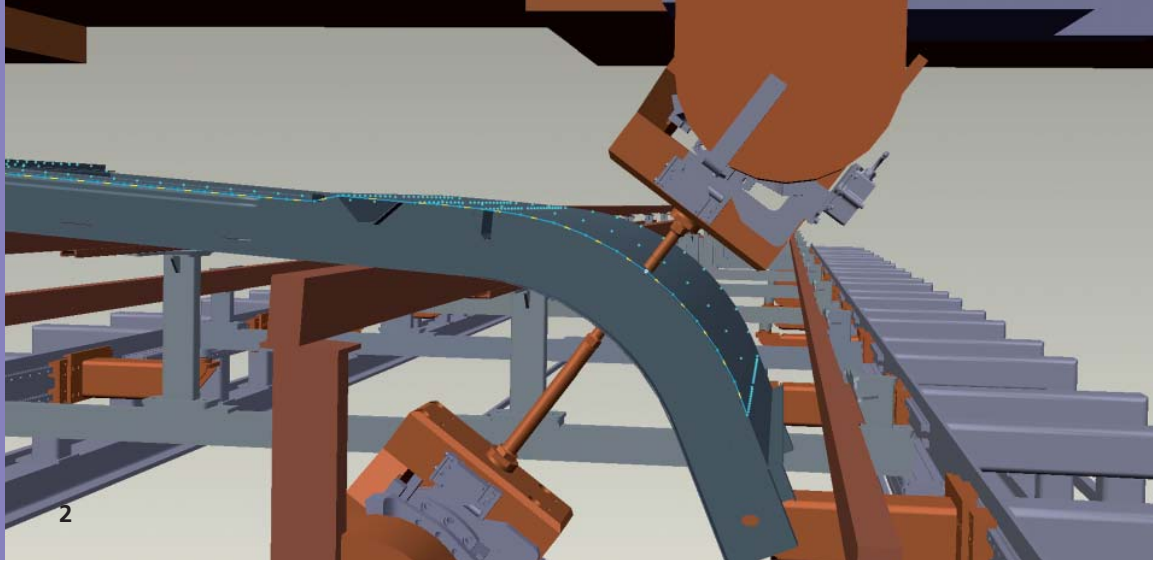
Machine tools and machining cells frequently combine several functionalities, which are processed in parallel and independently in different channels of an NC controller. Therefore, dynamic safe zones were created with SM Calvörde, which, on the one hand, allow several tools to collaborate and work in the same work area in parallel and, on the other hand, prevent internal collisions that would destroy machines. Related wait markers automatically separate the safety zones from one another.

Before the source code is generated for the NC controller, the plausibility of the input is verified. The loaded machine and workpiece geometries are tested in real time for physical penetrations. Collisions are visualized and thus detected early on. The NC code is generated automatically from the input data and it correctness is subsequently verified by various stages of simulation. A performance model is introduced in the machine description to represent the intended machining path three-dimensionally. This analysis requires no other hardware. The soft simulation mode does not yet use manufacturer cycles for specific NC.

The hard simulation mode couples a model of the custom machine model to the SINUMERIK 840D, which executes the generated control code. The controller is instructed to operate with virtual axes. The process interface equipment's performance is simulated in the programming system in real time and reconciled with the controller. Thus, the generated NC code can be tested fully on the fully configured machine controller.

Benefits

The integrated incorporation of the offline programming up through the simulation of the NC machining provides users a software that effective automatically creates and realistically tests an NC program. The benefits include:

– reduced programming work by efficient machining planning with interactive and intuitive features, which allows defining an extremely large number of weld points,
– parameterized patterns of movement weld points, thus circumventing obstacles,
– less risk when commissioning custom machines by simulating the machining program while simultaneously detecting collisions and
– software usable at both SM Calvörde and its customers' facilities

Combining the NC programming environment with NC code simulation produced an effective package that supports both machinery engineers and operators. Specially modified licensing models for machine manufacturers make it possible to deliver the code generator together with a custom machine.

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REAL TIME CROSS-DOMAIN SIMULATION OF AUTONOMOUS ROBOTS

Initial Situation

New products' functionalities increasingly require embedded systems. New technologies for product developments are needed to maximize the safety and reliability of key components of complex technical systems. The evaluation of system features requires an integrative analysis of the mechanics, electronics and the probability of a software malfunction. Since embedded components affect a system's safety, the reliability of individual hardware and software modules and their coupling play a role critical to safety. The growing number of embedded components and shorter product life cycles are making it nearly impossible for developers to fully test all aspects of safety in one physical prototype.

Approach and Results

A converter converts engineering data into a structure suitable for a simulation. A Modelica model is created from this automatically. This reduces the time required for modeling at the Fraunhofer IFF significantly. A virtual test bench is configured independently from the features of the modeled system and the goals of modeling. The functional principle always remains the same however and is implemented in a distributed simulation of several components with maximum real-time capability. The entire modeled system is reproduced. Individual virtual components are replaced by real prototypes or vice versa and tested.

The Fraunhofer IFF created a virtual test bench for the autonomous vehicle RAVON (Robust Autonomous Vehicle for Off-road Navigation), an electric all-wheel drive vehicle with a gross weight of over 850 kilograms. It is equipped with a multitude of embedded systems for both its navigation and control. The model was divided into three basic components:

– the performance control, which dictates vehicle performance as a function of the environment and destination (MCA-RAVON),
– the chassis, which also establishes the vehicle's mechanics and its interaction with the environment (Modelica/Dymola) and
– the electromechanics, which models the electric drives, control system and power supply (Matlab/Simulink/xPC) .

Networks connect these system components in simulators on several computers and they are simulated in soft/hard real time. Thanks to the model-in-the-loop simulation system, some virtual components can be replaced by real prototypes in a real-time capable simulation. Such hybrid experiments can be performed on different domain levels and also used as a test bench for real components. The distributed heterogeneous simulation environment combines both Matlab/Simulink and Dymola model parts in a complete real-time capable model. During the RAVON simulation, the model performance was observed and analyzed in several domains under the influence of variable external factors. Vehicle performance was visually observed in a 3-D demonstrator that furnished a closer look at the electromechanics. The simulation model can be extended with other real-time capable components.

The all-wheel drive
vehicle RAVON.
Photo: Martin Proetzsch

Uses and Benefits

Advanced simulation tools and methods can represent a mechatronic system realistically regardless of its complexity. Distribution on several computers can increase the level of detail of some models and algorithms. Other systems can only be helped by increasing the computing power or optimizing the model/code optimization. Despite a few limitations, virtual models furnish more insight into process physics, make model modification and optimization more flexible and facilitate safe and differing complex analyses. In batch mode, they can even deliver statistical information on certain model parameters or a complete system's performance. Individual virtual components, e.g. control algorithms, can even be pretested in a realistic prototype. Replacing virtual components with real prototypes smooths transitions from a virtual environment to a real device.

The concept can be employed to develop advanced vehicles for instance. The automotive industry's work on electric vehicles is essentially dictated by the energy sources available. The development process focuses on their engineering and related tests, above all, tests performed with the most realistic load profiles possible. They can be performed with a model-in-the-loop simulation system that directly interacts with realistic batteries. With a few qualifications, a real vehicle no longer has to be used.

In principle, these concepts are helpful when configuring a versatile fully or semi-virtual test bench for complex mechatronic equipment in order to boost the flexibility of development and reduce costs and time.

Outlook

The RAVON simulation includes somewhat simplified models from mechanical and electrical domains for rough functional testing. However, it also has thermal and hydraulic domains and other modeled parts, which fundamentally affect vehicle performance and technical safety. Future work is intended to close these gaps in order to increase the simulation's level of reality. In addition, research will be done on the model-in-the-loop simulations to determine whether they can be used as a test bench for system components.

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MODELING AND SIMULATION OF A CARDIAC SUPPORT SYSTEM

Motivation and Tasks

Pulsatile pneumatic cardiac support systems are employed to support the pumping of a human heart's left and/or right ventricle short or long term. Such a system already exists for the treatment of adult patients with life-threatening illnesses. It has been refined for use in all of the Berlin Heart GmbH's EXCOR® pumps and thus for the treatment of children as well. The challenge was to develop a simulation model that analyzes this complex system, which has a pneumatic piston pump that operates synchronously with the blood pump, and synthesizes its controllers. Since the closed pneumatic system must regulate the enclosed air precisely, different control algorithms are needed to adjust the pump volume to the blood return at different loads.

Solution and Approach

A complex system of interacting mechanical, electrical, magnetic, pneumatic and hydraulic components had to be analyzed. Therefore, a model was developed in the object-oriented modeling language Modelica, which facilitates multi-physical modeling. Modelica's object-oriented description approach allows the use of acausal models. Further, extremely effective simplification of the system of equations shortens computing time significantly. All of the models are verified by experiments.

To model and simulate the entire cardiac support system, it was divided into its subsystems, namely the pneumatic drive unit, the blood pump and the human body. The pneumatic drive unit's job is to produce a specified pneumatic pressure profile with low and high pressure to control the blood pump.

An electric piston provides the pneumatic pressure necessary to operate the pumps. The pressure profile is parameterized to match the physiological conditions and later executed by the controller. To do so, a model was developed, which specifies the conversion of electromechanical energy into pneumatic energy. The blood pump constitutes a coupled mechanical-pneumatic-hydraulic element and the most complex element

Hydraulic diagram of the cardiac support system.
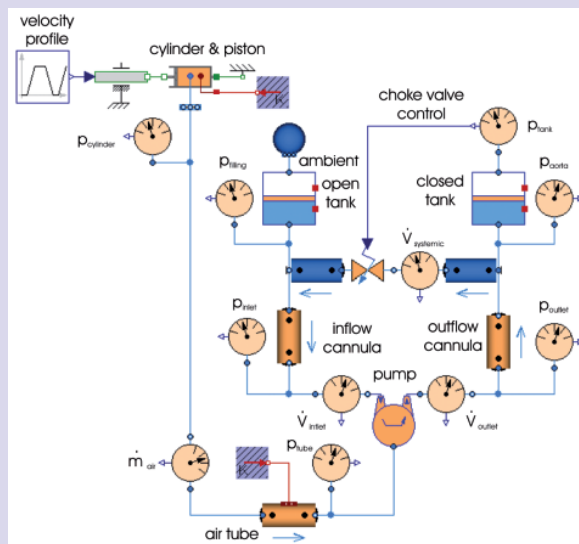
Comparison of measured data (left) with the results of simulation (right).

| p_drive in mmHg | p_tube in mmHg | p_inlet in mmHg | p_outlet in mmHg | p_fill in mmHg | p_Aorta in mmHg |
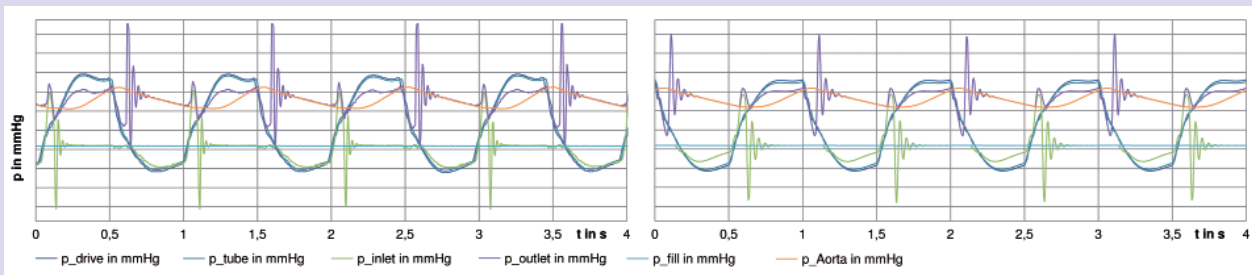
modeled. The input side is acted on by the pressure curve specified by the drive unit as a function of time. Based on the dynamic load, the output side produces a flow velocity as a function of time and volume, which determines the quantity of blood pumped into the body per beat. The multitude of potential parameter combinations during pump operation necessitated extensive laboratory tests to define the physical parameters. Once they had been evaluated, approximation functions were formulated and incorporated in the model. A dynamic model of the blood pump was produced, which also incorporates the elasticity of the pump diaphragm and housing and the dynamic effects of the cannula volume and the inertias of the flowing media. The body's fluid dynamic drag constitutes the load, which the drive-blood pump system has to control. In the project, a model of the human circulatory system was adopted from Berlin Heart GmbH and implemented in Modelica language. The body model represents the left ventricle with the adjacent blood vessels. A hydraulic virtual circulatory system was configured and integrated in the model to validate the it. Subsequently, extensive experiments effectively verified the validation of the model.

Results and Outlook

A complete model of an electro-pneumatic drive and all of the pumps implemented was created in the project. The drive's parameters can be altered and their effect on performance tested on this model. Specifically, the regulation of the operating parameters will have to be optimized to use this drive for the treatment of children. This will require modeling a controller design essentially based on the models created.

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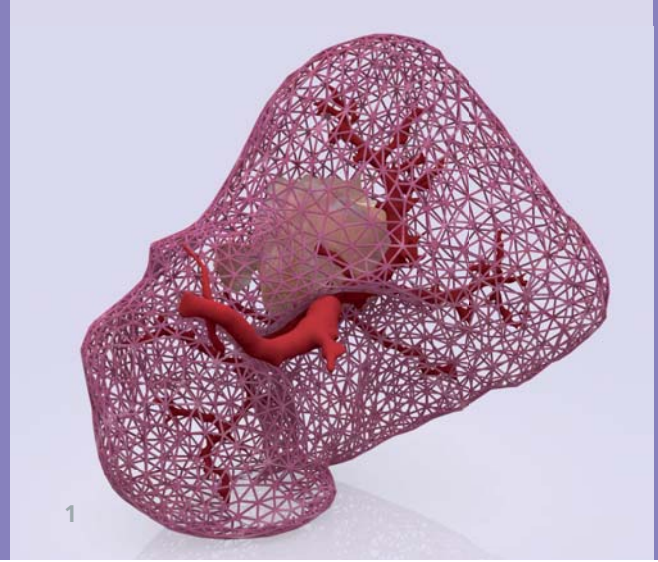
SIMULATION MODELS AND METHODS FOR MINIMALLY INVASIVE PROCEDURES

Motivation and Initial Situation

Patients in hospitals are increasingly being perceived as customers. They want to be subject to a minimum of risk during a necessary procedure and hope for a quick recovery and a good cosmetic outcome from an operation. For economic reasons, hospitals must utilize operating rooms to full capacity and minimize patients' stays, thus ensuring that many patients can be treated cost effectively.

Minimally invasive surgical methods can help achieve these goals. Surgeons use endoscopes to operate through small incisions in a patient's abdominal wall. In addition to the instruments, a special endoscope with a video camera is employed for orientation. The image is transmitted on a monitor. The development of new methods and instrument is making it possible to perform such minimally invasive operations in more and more domains. Operations on regions that are particularly difficult to access require smaller and more complex instruments and confront surgeons with greater challenges.

Virtual models support not only training but also the development of new methods and instruments. Detailed organ simulation facilitates the testing of prototypes of surgical instruments on virtual model. Surgeons' experience can enter into the development process at an early stage.

Solution

The models for a virtual simulation are obtained from medical imaging data, CTs and MRTs. A simulation is based on real patient data, which advanced visualization methods represent realistically in a virtual model realistically.

Physical characteristics have to be reproduced in detail in order to be able to use organ simulations to develop new methods and instruments. The simulations are highly accurate because they are based on measured values of real organs. Another priority is the level of detail of the organ simulation, especially the number of simulated structures and their causal relationships.

Not only the organs but also the vessels are critically important for a surgical procedure. Frequently, certain vessels must be severed, while immediately adjacent vessels, which may supply other organs, may not be damage. However, minimally invasive surgical procedures in particular require moving vessels to reach the structures behind them. New systems of vessel simulation, which enable interacting with complex vessel structures in real time, are being developed for this. In the future, these systems will reproduce the effects of an injured vessel on the organs dependent on it, which, for surgeons, are crucial to the outcome of a surgery.

1 *A liver with hepatic portal vein and inner tumor.*
2 *A rigid model of a patient's vertebrae based on CT scans.*
3 *A physically based vertebrae model can be moved anatomically plausibly.*
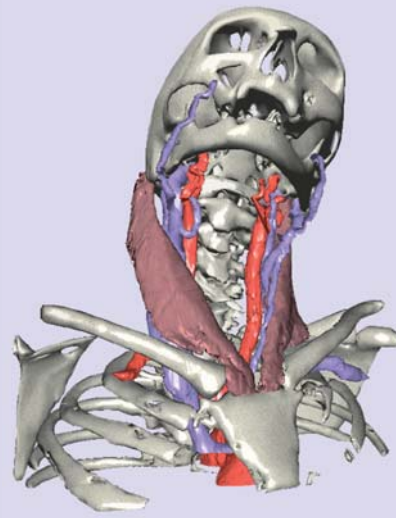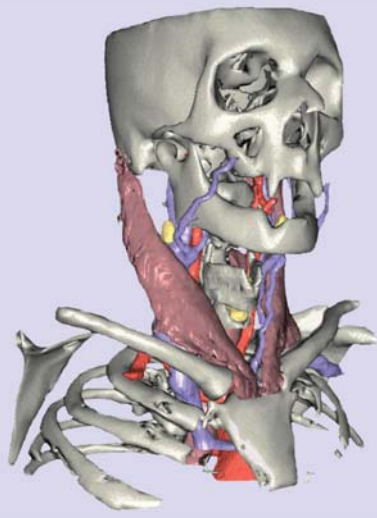
Results

Systems were developed, which simulate complex surgical scenarios as well as organic tissues and vessels. Methods that combine simulation elements give the simulation a high level of detail. The effects of an instrument and injuries can be tested during a simulation.

In addition to developing scenarios for testing prototypes of virtual instruments, since the simulation can also reproduce the effects of injuries, the systems developed can also be used to develop simulators with which correct actions in risk situations can be.

Benefits

The methods developed have a wide range of uses. The simulation of surgical procedures can provide surgeons support when they are learning new methods and handling new instruments. The simulation can also record motion paths, thus making it possible to monitor learning progress.

During the development stage, instrument manufacturers can use the simulation modules to evaluate instruments as virtual prototypes in early phases of design in order to already incorporate the feedback early on.

Until now, rigid virtual models have been used to document surgical procedures and to brief patients. The simulation methods allow these models to move anatomically plausibly. ENT surgeons can explain the effects of procedures to patients on personalized anatomical models of vertebrae in which not only the skeletal structure reacts but the muscles and vessels also adjust during movement.

Project Partners

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1

CITY DEVELOPMENT OF THE FUTURE WITH VIRTUAL INTERACTIVE TECHNOLOGIES

Motivation and Task

Numerous municipalities are currently facing the challenge of developing intelligent and sustainable city profiles. Typically, municipal development projects are increasingly growing in complexity, have increasingly differentiated basic conditions and require interdisciplinary collaboration. Developing holistic solutions that combine city planning, tourism and business is particularly challenging.

The city of Sangerhausen is breaking new ground in its approach to this demanding challenge and using innovative new developments from the field of virtual reality (VR), including novel virtual interactive systems like those developed at the Fraunhofer IFF, which can be implemented expediently in the different domains of urban development. The project described below focused on both the area of Sangerhausen's Europa-Rosarium relevant to tourism and the new premises of the South Harz Industrial Park under development to the city's southwest.

Approach

Virtual interactive technologies operate with extremely vivid 3-D representations of real objects. This helps users quickly and accurately understand visualizations without requiring detailed prior technical knowledge.

Only clear and comprehensible communication of a presentation's or project's contents generates understanding of the plans presented and acceptance of a project idea. Interactive design options in a virtual model environment and the provision of further background information additionally enhance their practical utility and informational value.

The largest rose collection in the world, the Europa-Rosarium has enabled the mining and rose city of Sangerhausen to establish a nationwide reputation as a popular destination. Therefore, one of the top priorities in the project was to visualize this tourist highlight. The raw data needed to process the premises were obtained from the city's base of geographic data and data measured during an earlier flyover. In addition, detailed pictures of the vegetation and situation were taken on site and integrated in the virtual 3-D environment. Aesthetically and realistically representing the vegetation covering large areas was particularly challenging. New algorithmic solutions from 3-D computer graphics combined with stereoscopic 3-D rendering systems are being used systematically to do this.

1 3-D visualization of the Europa-Rosarium Sangerhausen for the city's public image.
2 | 3 3-D visualization of an alternative plan (1) of South Harz Industrial Park (2) and a detailed view (3) that supports marketing of the premises. Photo: Dirk Mahler

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The newly planned South Harz Industrial Park constituted another focus of the project. The intention was to take advantage of the potentials of VR technology to activate the site's commercial development and business development. The range of the VR presentation extends from undeveloped plots to future plans through already existing factory buildings and plants. The intention was to enable investors, planners and builders to visualize future projects three-dimensionally and develop them effectively. Above all, the combination of a realistic virtual environment and options for interactive work, which also include the retrieval of technical and background information on planned objects, can simplify site planning and marketing significantly. For instance, lot sizes, prices, existing infrastructure and soil conditions can be loaded from a plot database as needed and displayed by clicking a mouse. The quality of a site is dictated just as much by investors as by peripheral site factors such as companies already present. Background information on firms, such as their sectors and product portfolios, as well as information on surrounding infrastructure can therefore be deposited in the 3-D model and retrieved interactively as needed.

Results

The city of Sangerhausen served as a model that demonstrated the successful implementation of virtual interactive systems in different domains of urban development and their generation of significant value added for the city of Sangerhausen from a variety of standpoints. Business development in Sangerhausen was focused on presenting siting opportunities and communicating business opportunities in the local market. Those in charge of tourism have been able to use the results of the project to enhance the city's public image.

The project's distinctiveness was manifested in the synergy generated by the collaboration among different professions. The coordinated project approach did more than just keep costs down in the modeling phase. At the commercial property trade fair EXPO Real in October of 2010, it enabled the city of Sangerhausen to convey to visitors to its informational stand a holistic and extremely vivid picture of the city, which reflected not only factors relevant to business but also the mining and rose city's quality of life and its attractions for tourists.

The approach described revealed the full impact of the potentials of virtual interactive technology in the field of urban development and effectively laid the foundations to use the project results sustainably in the city's other specialized applications.

Project Partner

City of Sangerhausen, Saxony-Anhalt

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LOOKING BEHIND THE SCENES: HYPERSPECTRAL IMAGING AND ANALYSIS

Initial Situation

A look behind the scenes usually reveals things or relationships, which remain hidden to a normal viewer. Rather than simply making more elements visible, for example more details by enlarging the field of view to magnify them or increase their scale, the intention is to add a new dimension to viewing.

The term dimension is usually associated with the three spatial dimensions in which humans move. Time, also called the fourth dimension, is not entirely unfamiliar in this context. Although humans are unable to travel though time at will, it is still perceptible. What else is there? Color. Physically, color is radiation with different wavelengths. We humans are able to perceive a spectral range of approximately 400 to 800 nanometers as color. The perceived color of an object basically depends on the molecular structure of its surface, which variously reflects incident illumination. A whole number of correlations between material composition and color have been established. For instance, the green of living plants stems more or less from their chlorophyll content.

Enhanced human color perception attainable with special spectral cameras principally entails enhancing the wavelength range perceptible by humans and involves increasing the spectral resolution from one to several hundred spectral channels. This turns a two-dimensional image into an image stack with a third dimension that represents perceived wavelengths. Every pixel of an image is represented by a high-dimensional vector that contains the local reflection in the perceived spectral channels.

Solution and Results

The Biosystems Engineering Expert Group uses this technology to quantify the material composition of biological objects noninvasively, i.e. without elaborate laboratory analyses. The images recorded in relevant spectral channels are less important than the evaluation of these complex and high-dimensional spectral image data. Since classic mathematical methods are only of limited use, methods of artificial intelligence and machine learning are employed, which had to be enhanced or modified for these applications. These modified self-learning methods can extract relevant information from the recorded spectral image data, which is unobtainable with conventional imaging systems or classic methods of data analysis.

In addition to addressing novel issues in research and acquiring knowledge, this system can also be applied to a large number of concrete jobs, thus creating considerable valued added for businesses and, to an extent, the economy.

1 *Three-dimensional data structure of hyperspectral images. The spatial resolution's two dimensions are supplemented by the spectral resolution's third.*
2 *Representation of a few select pixel ranges: The large number of spectral channels produce the impression of a continuous reflection spectrum.*
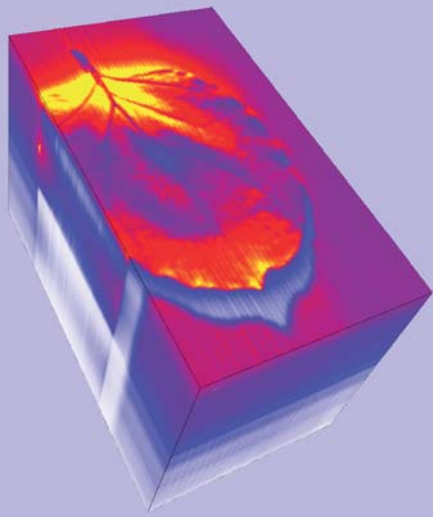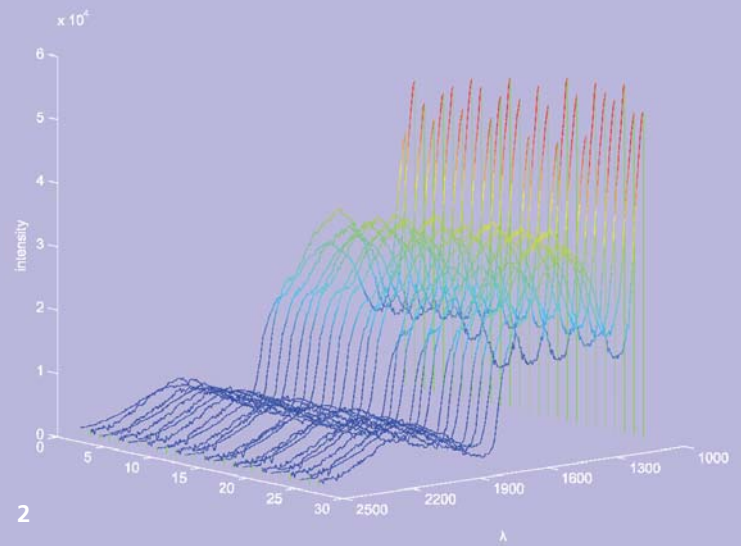
Together with clients from the agricultural industry, the Fraunhofer IFF is developing technical systems that ascertain the nutritional status and health of field crops either by land or by air and model a map to precisely apply supplies such as fertilizer, crop protection and the like. Market demand for such systems that increase the productivity of farmed land and also minimize the presence of undesired chemicals in crops or soil and groundwater is growing steadily. Furthermore, the optimal harvesting time and the expected quality of a harvest can be forecast. These systems can be excellently integrated in existing agricultural equipment and in routine operations of agricultural production.

Cultivating special crop plants that feed humans and animals, the production of energy or the production of biomaterials entails the challenge of ascertaining relevant plant proper-ties (phenotype) of a multitude of classically bred or geneti-cally modified lines (genotypes) statistically validated in high throughput. Methods of noninvasive analysis are in great demand to increase the number of analyzed properties, especially material composition, and simultaneously minimize the laboratory tests required. Together with industrial seed producing clients and academic plant research organizations, the Fraunhofer IFF is developing analysis methods capable of precise phenotyping based on the aforementioned technolo-gies.

Outlook

This technology is being used increasingly to develop custom-ized quality assurance systems for food producers. The Fraun-hofer IFF's clients and development partners include meat processors and coffee producers. Common to all of these applications is their revelation of previously (optically) invisible information by hyperspectral imaging and its evaluation by methods of artificial intelligence – a look behind the scenes.

Project Partner

Leibniz Institute of Plant Genetics and Crop Plant Research IPK, Gatersleben

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HIGHLIGHTS, EVENTS AND TRADE FAIR PRESENTATIONS (SELECTION)

January 14, 2010, Magdeburg

VDI-AK Produktionstechnik (lecture event)

Organizer: VDI Magdeburg Local Chapter, Production Engineering Local Group

Presentation: Optical Component Inspection in Foundries

Contributor: Dr. Dirk Berndt

January 28, 2010, Magdeburg

Effective Order Processing in Plant Manufacturing (company workshop)

Organizer: Fraunhofer IFF

Presentations: Plant Engineering Demonstrator Platform: What Can SMEs Expect?; Business Model and Options to Fund the Demonstrator Platform

Contributor: Thomas Schulze

1 *Visitors, young and old, made many exciting discoveries at the Fraunhofer IFF during the "Long Night of Science". The hands-on model of the "artificial skin" captured viewers' attention. Photo: Dirk Mahler*

2 *Press conference at the opening of the conference on Plant Engineering of the Future in Magdeburg on March 4, 2010: (l. to r.) Dr. Ralf Sick-Sonntag, Senior Vice President/Head of Engineering Bayer Technologies GmbH, Dr. Manfred Wittenstein, President of the German Engineering Federation VDMA, Prof. Michael Schenk, Director of the Fraunhofer IFF Magdeburg and Dr. Stefan Robert Deibel, Group Vice President Technology and Production Coordination PU Basic Products, BASF SE, Brussels. Photo: Viktoria Kühne*

3 *For two days, some 150 attendees from industry, academia, research and government exchanged views on the plant manufacturing industry's latest trends and prospects at the conference on Plant Engineering of the Future. Photo: Viktoria Kühne*

The company workshop "Effective Order Processing in Plant Management" was held with the support of Zweckverband zur Förderung des Maschinen- und Anlagenbaus Sachsen-Anhalt FASA and the Fraunhofer VIDET Innovation Cluster. Presentations and discussions of research findings, technical developments and trendsetting concepts foster networking of future research and development work between industry and research organizations.

March 2 – 4, 2010, Stuttgart

LogiMAT 2010 (trade fair)

Organizer: EUROEXPO Messe- und Kongress-GmbH

Booth

Exhibits: LogProtector; container management; condition-based maintenance strategy for vehicles

Contributors: Sven-Uwe Hofmeister and Sergej Serebranski

March 4 – 5, 2010, Magdeburg

Plant Engineering of the Future (conference) "Efficiency in the Plant Life Cycle"

Organizer: Fraunhofer IFF

Presentation: Efficiency in the Plant Life Cycle: Prospects for Digital Plants

Opening remarks: Dr. Reiner Haseloff, Saxony-Anhalt Minister of Economics and Labor and Prof. Dr. Ulrich Buller, Fraunhofer-Gesellschaft Senior Vice President Research Planning

Contributors: Prof. Michael Schenk and Andrea Urbansky

The Plant Engineering of the Future conference entitled "Efficiency in the Plant Life Cycle" was held in Magdeburg on March 4 - 5, 2010. Around 150 attendees from industry, academia, research and government took advantage of the German plant manufacturing industry's central event to exchange views on the industry's latest trends and prospects. They learned about innovative technologies and gathered impressions of successful industry models at the accompanying exhibition. In addition, the Fraunhofer IFF organized a job fair for highly qualified graduates as part of the event.

March 10, 2010, Magdeburg

Official Opening of the Saxony-Anhalt Galileo Test Bed's Development Laboratory

Organizer: Otto von Guericke University Magdeburg

Contributors: Prof. Michael Schenk, Prof. Klaus Richter and Holger Seidel

The Saxony-Anhalt Galileo Test Bed's development laboratory was officially opened on March 10, 2010 in the presence of representatives of the government of the state of Saxony-Anhalt and regional and national businesses. The test bed is run by Otto von Guericke University Magdeburg and was developed in close collaboration with the experts from the Fraunhofer Institute for Factory Operation and Automation IFF Magdeburg. The university's and Fraunhopfer IFF's regional partners in the test bed's operation include ifak Institut für Automation und Kommunikation e. V. Magdeburg, Hallesche Verkehrs-AG (HAVAG), the city of Magdeburg and Magdeburger Hafen GmbH.

In the future, state-of-the-art satellite applications for the transportation and logistics industries and mass transit, telematics and radio communication will be tested and refined at the development laboratory. The long-range goal of research is to link the various technologies and develop intelligent green transportation systems.

March 11, 2010, Magdeburg

18th Meeting of the Technical Committee on Factory Planning

Organizer: VDI Production and Logistics Society

Contributors: Holger Seidel and Thomas Dengler

March 18, 2010, Erlangen

Image Processing: Quo Vadis?
Farewell Colloquium for Dr. Norbert Bauer

Organizer: Fraunhofer Vision Alliance

Presentation: Optical Dimensional 3-D Manufacturing Measurement Systems of Tomorrow

Contributor: Dr. Dirk Berndt

March 23, 2010, Lucknow, India

Rolling Stock & Railway Infrastructure (Seminar)

Organizer: Research Design & Standards Organisation

Presentation: Automatic In-process Wheelset and Wheel Profile Measurement

Contributor: Dr. Dirk Berndt

March 24 – 25, 2010, Magdeburg

Jugend forscht State Competition:
Discovering New Worlds

Organizer: E.ON Avacon

Contributors: Prof. Michael Schenk, Dr. Frank Ryll, Dr. Uwe Klaeger, Steffen Masik, Holger Althaus, Justus Hortig, Tobias Lietz, Jost Schnee, Sven-Uwe Hofmeister,. Sergej Serebranski; and Sebastian Möser

1 *Prof. Klaus Erich Pollmann, President of Otto von Guericke University Magdeburg (l.), and Dr. Karl-Heinz Daehre, Saxony-Anhalt Minister of Building and Transportation (r.), at the opening of the Saxony-Anhalt Galileo Test Bed's development laboratory in Magdeburg's Port of Science on March 10, 2010. Photo: Viktoria Kühne*

April 8 – June 10, 2010, Magdeburg
13th Logistics Guest Lecture Series:
Logistics as a Field of Work of the Future
Organizers: Fraunhofer IFF and the Institute of Logistics and Material Handling Systems ILM, Otto von Guericke University Magdeburg,
Patron: Dr. Karl-Heinz Daehre, Saxony-Anhalt Minister of State Development and Transportation
Academic committee: Prof. Michael Schenk, Prof. Hartmut Zadek, Prof. Dietrich Ziems, Prof. Klaus Richter and Jun. Prof. Andre Katterfeld (all Institute of Logistics and Material Handling Systems ILM, Otto von Guericke University Magdeburg)
Contributors: Tobias Reggelin and Annegret Brandau

April 13, 2010, Magdeburg
Development of High Resolution Microscopy: Requirements and Prospects (workshop)
Organizer: Fraunhofer IFF
Presentation: Options for EU Funding
Contributors: Prof. Udo Seiffert and Katrin Reschwamm

April 13 – 14, 2010, Bad Godesberg
DWT Research and Technology Forum
Organizer: Studiengesellschaft der Deutschen Gesellschaft für Wehrtechnik mbH
Exhibit: Innovative Equipment Maintenance
Contributors: Dr. Frank Ryll and Tobias Lietz

April 13 – 14, 2010, Hundisburg
Timber Logistics Workshop:
Collaborate and Profit
Organizer: Fraunhofer IFF and Waldbesitzerverband Sachsen-Anhalt e. V.
Presentation: Trends and Approaches in Timber Logistics
Poster presentations: Best4VarioUse; Intelligent Wood: RFID in Timber Logistics; WoodValue: Value Creation In Wood Supply Chains
Contributors: Dr. Ina Erhardt and Mike Wäsche

Jointly hosted by the Fraunhofer IFF and the Waldbesitzerverband Sachsen-Anhalt, this year's workshop again attracted numerous forest owners, service providers, haulers and timber processors to Hundisburg. At the workshop, researchers and businesspeople discussed the latest timber logistics trends and solutions, focussing on efficient logistics to supply the wood processing industry with quality timber as required as well as the growing market for fuel wood and increasing direct marketing.

2 Many interesting examples of technical innovations were on display at the exhibition at the opening of Saxony-Anhalt Galileo Test Bed's development laboratory. Photo: Viktoria Kühne
3 At the opening of Saxony-Anhalt Galileo Test Bed's development laboratory, Prof. Richter from the Fraunhofer IFF demonstrated freight monitoring in a newly developed intelligent swap body for urban commercial traffic. Photo: Viktoria Kühne

April 15, 2010, Magdeburg
Logistics Day
Organizer: Fraunhofer IFF and Institute of Logistics and Material Handling Systems ILM, Otto von Guericke University Magdeburg
Presentation: Intelligent Resource Management
Contributors: Prof. Michael Schenk, Holger Seidel, Tobias Reggelin and Annegret Brandau

April 15, 2011 was Logistics Day nationwide. At the initiative of the German Logistics Association BVL, logistics companies and research organizations throughout Germany opened their doors to the public under the motto "Logistics Makes It Possible". Visitors to the Fraunhofer IFF heard an interesting presentation, which was part of the Logistics Guest Lecture Series, delivered by Georg Wögerer, Head of Intrest OG's Transport Emissions Calculation and Reduction Division, in which he discussed innovative intelligent resource management systems.

April 19 – 24, 2010, Hannover
Hannover Messe
Organizer: Deutsche Messe AG
Exhibits: Condition-based maintenance strategy for vehicles; worker assistance and quality inspection for manual assembly operations; inertial sensors: automatic timekeeping for manual assembly jobs; artificial skin; dynamic safe zone monitoring; visual navigation; image processing for inspection jobs
Contributors: Dr. Norbert Elkmann, Dr. Dirk Berndt, Dr. Frank Ryll, Tobias Lietz, Sven-Uwe Hofmeister, Frank Mewes, Steffen Sauer and Martin Woitag

At this year's Hannover Messe, the Fraunhofer IFF displayed its latest high-tech developments in the fields of logistics, virtual reality and image processing. Among other things, the Fraunhofer IFF's engineers presented an augmented reality (AR) system for assembly operations, which guarantees high process

reliability by automatically inspecting quality. The Fraunhofer IFF's designers presented virtual development environments for design reviews of complex plants and factories on their mobile multi-touch table for advanced factory planning. It enables factory planners to experience factory buildings and their operations before they have even been built. In addition, they presented solutions for efficient warehouse management based on GPS.

In the special Mobile Robots and Autonomous Systems exhibition area, the Fraunhofer IFF's robotics experts presented their latest developments that dynamically monitor safe zones and a novel contact sensor in the form of an artificial skin for robots, equipment and plant components.

Energy concepts of the future were the focus at the Fraunhofer Energy Alliance's joint booth. The Fraunhofer IFF's process and plant engineers presented models of a compact fluidized bed unit that recovers heat from renewable solid fuels and an entrained flow gasifier that recovers energy from industrial residues.

1 Logistics Day traditionally coincides with the Fraunhofer IFF's annual Logistics Guest Lecture Series. The presentations are extremely popular, especially among students majoring in logistics at Otto von Guericke University Magdeburg.
Photo: Viktoria Kühne
2 The Fraunhofer IFF organized the conference "Fit through Knowledge" hosted by the Federal Ministry of Economics and Technology on May 27, 2010.
Photo: Dirk Mahler

April 23, 2010, Magdeburg
9th IFF Research Colloquium
Organizer: Fraunhofer IFF
Presentations: Inertial sensor-based timekeeping of manu-
facturing operations at assembly workplaces; calculation and
simulation of the automation of a flexible manipulator that
uses mobile robots to open and close doors aided by MATLAB/
Simulink; automatic identification of metal plated based on
character recognition; automated 3-D model generation from
biomedical volume data; sensor head and attention control
for a mobile robot's interaction with people; logistics event
management; cross-model configuration and evaluation of
distributed material flow simulations
Contributors: Prof. Michael Schenk, Martin Woitag, Roland
Behrens, Hagen Borstell, Felix Bollenbeck, Maik Poggendorf,
Annegret Brandau, Michael Raab and Steffen Masik

April 27 – 28, 2010, Halle
1st European Conference JOIN-TRANS 2010
Organizer: Schweisstechnische Lehr- und Versuchsanstalt Halle
GmbH
Presentation: Automatic in-process wheelset and wheel profile
measurement: technology and practical experience
Contributors: Dr. Dirk Berndt, Erik Trostmann, Silvio Sperling
and Michael Schiller

May 4 – 7, 2010, Stuttgart
Control (trade fair)
Organizer: Schall GmbH & Co. KG
Joint Fraunhofer Vision Alliance Booth
Exhibit: In-process optical 3-D measurement systems for qual-
ity inspection
Contributors: Dr. Dirk Berndt, Ralf Warnemünde and Dr. Chris-
tian Teutsch

May 27, 2010, Berlin
Fit through Knowledge: Solutions for SMEs (conference)
Organizer: Federal Ministry of Economics and Technology
BMWi
Organizer: Fraunhofer IFF
Presentation: Fit for the Future with the ProWis Approach:
Processes. Knowledge. Management.
Contributors: Stefan Voigt

May 28, 2010, Kharkiv, Ukraine
**Award of an Honorary Professorship to Dr. Gerhard Mül-
ler, Deputy Director of the Fraunhofer IFF**
by Prof. Volodymyr Kriftsov, President of "Kharkiv Aviation
Institute" National Aerospace University, Kharkiv, Ukraine

June 5, 2010, Magdeburg
**Long Night of Science 2010:
The Future of Energy**
Organizer: Capital City of Magdeburg, Wissenschaft im Dialog
Exhibition at the Fraunhofer IFF with informational booths,
exhibits and demonstrations of "The Future of Energy"
Contributors: Approximately eighty members of the Fraun-
hofer IFF's staff

*3 Dr. Gerhard Müller, Deputy
Director of the Fraunhofer
IFF, receiving his honorary
professorship from the Na-
tional Aerospace University
Kharkiv on May 28, 2010.
Photo: Wolfgang Glöckner
4 Fascinated visitors in the
Elbe Dom at the Fraunhofer
IFF's Virtual Development
and Training Centre during
the Long Night of Science on
June 5, 2010.
Photo: Dirk Mahler*

June 5 – 11, 2010, Magdeburg
2010 Science Summer
Organizer: Wissenschaft im Dialog

Tent exhibition
Exhibits: Energy efficient logistics: playfully presented with a slot car race track; javelin with onboard electronics; e-mobility with electric car
Presentation: City planning in cyberspace

MS Wissenschaft 2010 – The Energy Ship
Exhibition "Planet Energy"
Exhibit: Fluidized bed model

Contributors: Dr. Matthias Gohla, Dr. Przemyslaw Komarnicki, Sergii Kolomiichuk, Andreas Höpfner, Frank Mewes, Dr. Frank Ryll, Tobias Lietz, Martin Woitag, Dr. Thoralf Winkler, Christoph Wenge, Kamil Lipiec, Bartlomiej Arendarski and Marcus Kögler

This year, research organizations all over the city opened their doors to the interested public on the Long Night of Science under the motto "The Future of Energy". The Long Night of Science launched the week-long 2010 Science Summer. Over 50,000 people took advantage of the opportunity to acquire insights into local research organizations' research on energy. In keeping with the 2010 Science Year, "The Future of Energy" was the theme of this major science festival. This time, the series of events, hosted by the research network Wissenschaft im Dialog in a different German city every year, made a stop in Magdeburg.

In the tent exhibition downtown, residents of Magdeburg were able to perform experiments themselves and discuss current research issues with researchers. One highlight was Wissenschaft im Dialog's exhibition ship MS Wissenschaft, which anchored in Magdeburg with many interesting thought provoking and hands-on experiments and exhibits below deck. Among other things, the Fraunhofer IFF displayed a demonstration model of a fluidized bed. Upon its conclusion, Minister President Wolfgang Böhmer looked back on the Science Summer and observed, "I'm certain that the Science Summer was a hit among many young people and research institutes and institutions of higher education profited from this hands-on research."

June 7 – 12, 2010, Leipzig
Interschutz (trade fair)
Organizer: Deutsche Messe AG
Joint MAVO GALILEO project booth
Themes: Ad hoc road network generation; navigation for first response teams
Contributor: Tobias Kutzler

June 8 – 11, 2010, Munich
AUTOMATICA 2010 (trade fair)
Organizer: Messe München GmbH
Fraunhofer IPA's joint Service Robotic Innovation Platform booth
Exhibits: Artificial skin; Visual navigation
Contributors: Dr. Norbert Elkmann and Katja Ziepel

1 *Science Summer in Magdeburg from June 5 to 11, 2010. How to best explain how to make logistics more efficient? With a slot car track, for instance, on which even children can learn about complex relationships by playing. Photo: Anna-Kristina Wassilew*

June 15 – 17, 2010, Magdeburg
13th IFF Science Days
Organizer: Fraunhofer IFF
Technical director: Prof. Michael Schenk

Program:
June 15, 2010
Workshop "Wheel and Tire: Measurement and Inspection Technologies"
Presentation: In-line geometry scanning of wheels and wheelsets in the automotive industry and railroad engineering

June 15 – 17, 2010
7th Conference on "Digital Engineering and Virtual Technologies for the Planning, Testing and Operation of Technical Systems"
Patron: Dr. Reiner Haseloff, Saxony-Anhalt Minister of Economics and Labor
Sessions: Automotive; VE in Product Development; VR/AR Applications; VR for Assembly Applications; Acoustics in VR Software and Tools; Medical Technology; Digital Technologies for Manufacturing

June 16, 2010
13th Cooperation in Plant Engineering Working Group "Knowledge-based Plant Planning and Operation"
Presentations: Documented Quality in Manufacturing and Operation as the Basis for a Company's Efficiency: A Solution Based on Aveva Net Portal; Knowledge Management in Plant Manufacturing

June 16, 2010
Workshop "Acceptance Inspection and Monitoring of Application-specific Dimensional Measuring Instruments with Optical Range Finders"
Presentations: Specifics of Dimensional Measuring Instruments Modified for In-line Geometric Quality Inspection; A measurement System that Inspects Profile Straightness and Train Wheelset Geometry as an Example of Acceptance Inspection

June 16 – 17, 2010
15th Magdeburg Logistics Conference "Efficient and Reliable Logistics"
Patron: Dr. Karl-Heinz Daehre, Saxony-Anhalt Minister of State Development and Transportation
Sessions: Efficient Infrastructures and Intelligent Logistics

Logistics Workshop Series
Topics: Dense Networks – Short Distances!? Logistics in the Context of European Integration; Total Resource Management for SMEs: Save Resources and Cut Energy Costs; Interactive Outdoor Workshop: Intelligent Logistics (opening of Saxony-Anhalt Galileo Test Bed's Logistics Platform); Flex Pro: Innovatively Managing Flexible Production Facilities; Regional Maintenance Roundtable

Contributors: Prof. Michael Schenk, Prof. Ulrich Schmucker, Dr. Eberhard Blümel, Holger Seidel, Prof. Klaus Richter, Dr. Dirk Berndt, Dr. Rüdiger Mecke, Dr. Frank Ryll, Andrea Urbansky, Dr. Daniel Reh, Florian Skirl, Ralf Warnemünde, Tino Müller, Erik Trostmann, Stefan Voigt, Katrin Reschwamm, Thomas Dengler, Jörg von Garrel, Simon Adler,. Corinna Kunert, Dr. Katja Barfus and Marion Preuss

2 *Prof. Michael Schenk, Director of the Fraunhofer IFF, at the opening of the 13th IFF Science Days on June 15,2010. This year's event centered on the conferences "Digital Engineering" and "Logistics". Photo: Dirk Mahler*
3 *Saxony-Anhalt Galileo Test Bed's new logistics platform in the Hanse Terminal in Magdeburg Port was opened during the 2010 IFF Science Days. Photo: Viktoria Kühne*

Magdeburg's Fraunhofer Institute's major annual conference focused on the future topics of "Digital Engineering" and "Logistics". Over 500 experts from industry, research and government gathered at the research institute for the 13th IFF Science Days from June 15 to 17, 2010 and learned about results of current research in over eighty presentations and workshops and from numerous exhibitors, discussed innovative methods and applications in their fields and established new contacts with companies and research partners.

At the conference "Digital Engineering and Virtual Technologies for the Planning, Testing and Operation of Technical Systems", experts discussed the central issue of better integrating virtual technologies long-term in the entire product development process.

At the same time, results of current logistics research and projects were presented at the 15th Magdeburg Logistics Conference on June 16, 2010. The first day oriented toward research was followed by the a workshop series oriented toward practice on June 17, 2010.

According to Prof. Michael Schenk, Director of the Fraunhofer IFF, "The highlight of the 13th IFF Days is clearly the opening of the Saxony-Anhalt Galileo Test Bed's new logistics platform. With the logistics platform in Magdeburger Hafen GmbH's Hanse Terminal, we, that is Otto von Guericke University Magdeburg, the Fraunhofer IFF and the partners involved, are establishing ourselves as Germany's leading center of expertise in innovative transportation and logistics systems."

Other events in this year's Science Days' program were the 13th Cooperation in Plant Engineering Industry Working Group and a workshop on 3-D optical measurement systems.

June 17, 2010, Magdeburg
Signing of the Cooperation Agreement between DP DHL and the Fraunhofer IFF
Signatories: Dr. Keith Ulrich, Head of Technology and Innovation Management Deutsche Post AG and Prof. Michael Schenk, Director of the Fraunhofer Institute for Factory Operation and Automation IFF

June 25, 2010, Miskolc, Hungary
Award of an Honorary Doctorate to Prof. Michael Schenk, Director of the Fraunhofer IFF
by Prof. Dr. György Kocziszky, Dean of the Business School, Miskolc University, Hungary

July 12, 2010, Kuala Lumpur, Malaysia
Training Tools for the Future (Workshop)
Organizer: Fraunhofer IFF and Kumpulan IKRAM SDN. BHD. & KLI-UC
Presentations: Efficient Use of Virtual Reality Technologies in Industry (Best Practice)
Contributors: Ralf Opierzynski, Dr. Eberhard Blümel, Helge Fredrich and Andreas Höpfner

1 *Prof. Michael Schenk, Director of the Fraunhofer IFF, and Dr. Keith Ulrich, Head of Deutsche Post AG DHL Innovation Center, signed the cooperation agreement between both organizations on June 17, 2010. The Fraunhofer IFF and Deutsche Post DHL agreed to collaborate closely on the development of new sustainable technologies for reliable and efficient logistics. Photo: Viktoria Kühne*
2 *On June 25, 2010, the University of Miskolc awarded Prof. Michael Schenk, Director of the Fraunhofer IFF, an honorary doctorate for his contributions to the development of long-standing and successful collaboration between Otto von Guericke University Magdeburg and the Hungarian University of Miskolc. Photo: Fraunhofer IFF*

July 13, 2010, Magdeburg

Five Year Anniversary of the Center of Expertise in Energy Systems and Renewable Energies

Organizer: Fraunhofer IFF; Otto von Guericke University Magdeburg

July 14 – 18, 2010, Munich

Interforst (trade fair)

Organizer: Messe München GmbH

Booth: Intelligent Wood: RFID in Timber Logistics

Contributors: Dr. Ina Ehrhardt and Mike Wäsche

July 15 – 16, 2010, Bangkok, Thailand

Mega-Trends in Human Capital and Labour Productivity (conference)

Organizer: Ministry of Labour, Department of Skills Development, Thailand

Session: Digital Engineering

Contributors: Ralf Opierzynski, Dr. Eberhard Blümel, Helge Fredrich and Andreas Höpfner

August 26 – 27, 2010, Jena

NEMO SpectroNet Collaboration Forum

Organizer: SpectroNet Expertise Cluster

Presentation: Measurement and test engineering for food industry

Contributors: Dr. Dirk Berndt and Prof. Udo Seiffert

August 30 – 31, 2010, Leipzig

2nd Central German Logistics Forum "Value Added through Integration"

Organizer: German Logistics Association BVL, Netzwerk Logistik Leipzig-Halle, Automotive Cluster Ostdeutschland nad Chemical Logistics Cooperation in Central and Eastern Europe

Informational booth: KASSETS

Contributors: Holger Seidel and Corinna Kunert

September 6, 2010, Magdeburg

Start of the Harz Electric Vehicle Network Field Tests (opening event)

Organizer: Harz.EE-Mobility Consortium

Contributors: Dr. Przemyslaw Komarnicki, Kathleen Hänsch, Christoph Wenge, Bartlomiej Arendarski, Dr. Thoralf Winkler and Tobias Kutzler

The field tests of the Harz electric vehicle network commenced in Magdeburg's Port of Science on September 6, 2010. The concept was developed in the project Harz.EE-Mobility and is one of the most widely integrated and advanced electric vehicle networks in Germany. The Fraunhofer IFF in Magdeburg is working together with fourteen other partners on a system that controls the logistics of an electric vehicle concept, which will primarily use energy from renewable sources. In the project, the consortium is developing new digital electric vehicle network control centers and intelligent charging stations, which will guarantee vehicles have a stable supply of energy. At the same time, vehicles equipped with batteries that recover energy will be mobile elements of a distributed electricity storage system. Harz.EE-Mobility is being funded by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and supported by the Saxony-Anhalt Ministry of Economics and Labor.

3 Dr. Eberhard Blümel (l.) and Ralf Opierzynski (r.) welcome Thailand's Premier Minister Abhisit Vejjajiva (center) on behalf of the Fraunhofer IFF at the institute's information booth at the conference "Mega-Trends in Human Capital and Labour Productivity" in Bangkok on July 15, 2010. Photo: Fraunhofer IFF

4 Start of the field tests of the Harz electric vehicle network at Magdeburg's Port of Science. Photo: Viktoria Kühne

September 9 – 11, 2010, Swiebodzin, Poland
Eko-las (trade fair)
Organizer: Poznan International Fair
Joint INNOHOLZ booth
Exhibits/presentations: Best4VarioUse; off-road navigation;
Intelligent Wood: RFID in Timber Logistics
Contributors: Dr. Ina Ehrhardt and Steve Schneider

September 14, 2010, Kaiserslautern
**Effective Order Processing in Plant Manufacturing
(company workshop)**
Organizer: Fraunhofer IESE and Fraunhofer IFF
Presentation: Plant Engineering Demonstrator Platform: What
Can SMEs Expect?
Contributor: Thomas Schulze

September 14 – 17, 2010, New Delhi, India
Transport Flagship Mission (company excursion)
Organizer: European Business and Technology Centre (EBTC)
and the Fraunhofer IFF
Contributors: Kay Matzner and Corinna Kunert

September 21 – 24, 2010, Berlin
InnoTrans 2010 (trade fair)
Organizer: Messe Berlin GmbH
Joint booth: Fraunhofer Traffic and Transportation Alliance
Exhibit: OptoInspect 3D: Optical measurement system for
automatic wheelset inspection
Contributors: Dr. Dirk Berndt, Ralf Warnemünde and Erik
Trostmann

September 27 – 29, 2010, Brussels, Belgium
ICT 2010: Digitally Driven (trade fair)
Organizer: European Commission Information Society
Informational booth: EURASIAPAC project
Organization of the networking session on ICT R&D opportu-
nities with Japan and Korea
Contributor: Christian Blobner

September 28 – October 2, 2010, Stuttgart
**AMB – Internationale Ausstellung für Metallbearbeitung
(trade fair)**
Organizer: Landesmesse Stuttgart GmbH
Booth: Co-exhibitor with ANDREAS MAIER GmbH & Co. KG
Exhibit: Worker assistance and quality inspection for manual
assembly operations
Contributors: Dr.. Dirk Berndt, Ralf Warnemünde, Steffen
Sauer and Dr. Thomas Dunker

1 *Intelligent organization and
control of transport operations in
timber and biomass logistics are
steadily growing in importance.
For years, the Fraunhofer IFF's
logistics experts have been work-
ing intensively on new methods
and technologies that make these
operations more cost effective, for
instance, wooden RFID chips for
timber production, which sim-
plify the control timber transport
logistics and keep metal out of
later processing. Fraunhofer experts
presented these and other solutions
at the 1st International Biomass
Logistics Conference on October 12
to 13, 2010. Photo: Viktoria Kühne*

2

October 12 – 13, 2010, Hohenerxleben

1st International Biomass Logistics Conferenc
"Success through Cooperation: Combining Forces.
Exploiting Potentials. Sharing Know-how"
Organizer: Fraunhofer IFF
Poster presentations: Intelligent wood: RFID in Timber Logistics; WoodValue: Value Creation in Wood Supply Chains;
Best4VarioUse
Contributor: Steve Schneider

October 14 – 16, 2010, Timisoara, Romania

IADIS International Conference of Applied Computing
2010
Organizer: Politehnica University of Timisoara
Presentation: Adaptive preprocessing of large point clouds
from optical 3-D scanners
Contributors: Dr. Dirk Berndt, Dr. Christian Teutsch and Erik
Trostmann

October 19 – 21, 2010, Munich

eCarTec (trade fair)
Organizer: MunichExpo Veranstaltungs GmbH
Joint Federal Ministry of Economics and Technology booth
Representation of the joint Harz.EE-Mobility project
Exhibit: Electric vehicle network control center; electric vehicle
with telematic and navigation system
Contributors: Dr. Przemyslaw Komarnicki, Bartlomiej Arendarski, Kathleen Hänsch, Tobias Kutzler and Frank Mewes

October 20 – 22, 2010, Berlin

27th International Supply Chain Conference
Organizer: German Logistics Association BVL
Booth: Self-contained and secure transport chains with RFID
and telematics
Contributors: Prof. Michael Schenk, Prof. Gerhard Müller,
Prof. Klaus Richter, Holger Seidel;, Erik Dietzel, Helmut Röben,
Tobias Reggelin, Annegret Brandau and Jacqueline Görke

At the 27th International Supply Chain Conference in Berlin,
the Fraunhofer IFF's demonstrated new highly efficient technologies that organize entire shipments more efficiently and
securely. The presentation focused on the latest RFID and
telematic technologies. In addition, the institute presented a
development that optically determines the position of autonomous mobile transport systems.

October 22, 2010, Potsdam

4th Conservation Science Colloquium
"Methods of Nondestructive Surface Testing: State-of-
the-Art, Limits and Prospects"«
Organizer: Forschungsinstitut für Denkmalpflege und
Archäometrie e.V, Brandenburgisches Landesamt für Denkmalpflege und Archäologisches Landesmuseum, Fachhochschule Potsdam, Stiftung Preussischer Schlösser und Gärten
Berlin-Brandenburg and Rathgenforschungslabor der Staatlichen Museen zu Berlin
Presentation: Case studies of the Application of 3-D measurement systems and active thermography in historic preservation
Contributors: Michael Schiller

2 "Virtual Environments in
the Process Plant Life Cycle
in the Chemical Industry was
one topic at the guest lecture
series on "Virtual Reality: Hu-
mans and Machines in Inter-
active Dialog" from October
27 to December 1, 2010.
Photo: Dirk Mahler

FORSCHUNGS-
KOLLOQUIUM AM
FRAUNHOFER IFF
IN MAGDEBURG

1

October 27 – December 1, 2010, Magdeburg

"Virtual Reality: Humans and Machines in Interactive Dialog" Guest Lecture Series

Organizer: Fraunhofer IFF

Patron: Dr. Reiner Haseloff, Saxony-Anhalt Minister of Economics and Labor

Contributors: Prof. Michael Schenk and Marc Winter

The Fraunhofer Institute in Magdeburg held its "Virtual Reality: Humans and Machines in Interactive Dialog" Guest Lecture Series from October 27 to December 1, 2010. The institute offered interested experts and non-experts a fascinating excursion through different current applications of virtual technologies in industry and research. Top speakers explained projects and case studies and were available for discussion with attendees afterward. A brief demonstration of the Elbe Dom awaited attendees at the end of every presentation. A look at these unique virtual environments gave attendees a good idea of the wide-ranging potentials of digital simulation.

November 4, 2010, Arneburg

14th Cooperation in Plant Engineering Industry Working Group

Organizer: Fraunhofer IFF

Contributor: Andrea Urbansky

Efforts to cut energy consumption in the phase of plant operation by innovative process engineering and automation have been increasing for some time. Therefore, industry decision makers met this´year to discuss their experiences with and innovative ideas about "Energy Efficiency in Plant Engineering" and collectively seek potential solutions. Zellstoff Stendal GmbH, Central Europe's most advanced and largest manufacturer northern bleached softwood kraft pulp, hosted the 14th Industry Working Group.

November 9 – 11, 2010, Stuttgart

VISION 2010 International Trade Fair for Machine Vision

Organizer: Landesmesse Stuttgart GmbH

Joint Fraunhofer Vision Alliance booth

Exhibit: OptoInspect 3D: Optical Measurement System for Industrial Quality Testing

Contributors: Dr.. Dirk Berndt, Ralf Warnemünde and Dr. Christian Teutsch

November 10, 2010, Lemgo

1st Annual Colloquium on Image Processing in Automation

Organizer: Department of Industrial Information Systems, Ostwestfalen-Lippe University of Applied Sciences,

Presentation: Worker Assistance and Quality Inspection for Manual Assembly Jobs: A Virtual Technology for Manufacturing Contributors: Dr. Dirk Berndt and Steffen Sauer

November 11, 2010, Magdeburg

1st Laser Scanning and Virtual Reality in Plant Engineering Industry Working Group

Organizer: Fraunhofer IFF

Presentations: The aims and concept of the Laser Scanning and Virtual Reality in Plant Engineering Working Group; overview of the potentials of virtual reality

Contributors: Prof. Michael Schenk, Andrea Urbansky, Steffen Masik and Sabine Szyler

The first Laser Scanning and Virtual Reality in Plant Engineering Working Group was launched in collaboration with BASF SE and Scantec 3D at the Fraunhofer IFF's Virtual Development and Training Centre (VDTC) on November 11, 2010. the working groups intends to discuss presentations from research and industry and, building upon this, to initiate research and industry projects geared toward the commercialization of laser scanning in the plant life cycle.

November 16 – 19, 2010, Hannover
BioEnergy Decentral (trade fair)
Organizer: Deutsche Landwirtschafts-Gesellschaft DLG
Joint booth of the INNOHOLZ Timber Logistics Innovation
Network
Exhibit: Best4VarioUse; off-road-navigation; Intelligent Wood:
RFID in Timber Logistics
Contributors: Dr. Ina Ehrhardt, Steve Schneider and Mike
Wäsche

November 19, 2010, Magdeburg
10th IFF Research Colloquium
Presentations: Markerless Tracking for Augmented Reality
Applications in Product Marketing; Near-real Time Analysis of
Numbers of People in Public Spaces; Data Fusion and Visual-
ization for Monitoring Structural Surfaces in Historic Preserva-
tion; Electric Vehicles and Charging Stations: Communication
and Data Exchange
Contributors: Prof. Michael Schenk, Michael Schiller, Christoph
Wenge, Thomas Seidl, Daniel Anderson,Alexa Kernchen and
Matthias Kempe

November 23 – 24, 2010, Weinheim
Quality Indicators in Production (conference)
Organizer: Carl Hanser Verlag GmbH & Co. KG
Presentation: Optical 3-D manufacturing systems of tomorrow
Contributors: Dr. Dirk Berndt

November 30 – December 2, 2010, Toulouse, France
Aeromat (trade fair)
Organizer: BCI Aerospace
Joint Fraunhofer-Gesellschaft booth
Topics: Optical assembly inspection and guidance system; in-
process optical 3-D measurement
Contributors: Dr. Dirk Berndt and Steffen Sauer

December 9, 2010, Aalen
2010 Barbara Colloquium
Organizer: Aalen University
Presentation: 3-D Measurement Systems in Foundries
Contributors: Dr. Dirk Berndt; and. Ralf Warnemünde

1 | 2 *At this year's research
colloquium at the Fraunhofer
IFF, ten young researchers
from the Fraunhofer Institute
and Otto von Guericke
University Magdeburg
presented their ambitious
research. Their work ranged
widely from new concepts for
electric vehicle networks and
three-dimensional product
presentations to simulation
models for optimized logistics
operations.
Photos: Daniela Martin*

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Institute on Transport and Logistics, Bologna, Italy

Instytut Spawalnictwa, Polish Welding Centre of Excellence, Krakow, Poland

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Kuala Lumpur Infrastructure University College, Kajang, Malaysia

Kuka AG, Augsburg

Kumpulan IKRAM Sdn Bhd, Kajang, Selangor, Malaysia

La Sapienza University of Rome, Italy

Laboratory of Design, Production and Management, University of Twente, Netherlands

Laiwu Vocational and Technical College, Laiwu, China

LanXESS Deutschland GmbH, Leverkusen

LASAG AG, Thun, Switzerland

Laserscanning Europe GmbH, Magdeburg

Latvian Intelligent Systems, Riga, Latvia

LDT Laser Display Technology GmbH, Jena

Leibniz Institute for Neurobiology (IfN), Magdeburg

Leibniz Institute of Plant Biochemistry (IPB), Halle (Saale)

Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Gatersleben

Leica Geosystems GmbH, Munich

Lenze Automation GmbH, Aerzen

Lithuanian Innovation Centre (LIC), Vilnius, Lithuania

Liverpool John Moores University Higher Education Corporation, United Kingdom

Logitrans Consult Ltd., Tallinn, Estonia

Kharkiv Aviation Institute, Kharkiv, Ukraine

Maastricht University, Netherlands

MAN Nutzfahrzeuge Österreich AG, Steyr, Austria

Mannstaedt GmbH, Troisdorf

MEA Engineering GmbH, Leipzig

Molecular Machines and Industries GmbH, Eching

MRB Automation GmbH, Ilmenau

National Agency for New Technologies, Energy and Environment (ENEA), Bologna, Italy

National Science and Technology Development Agency (NSTDA) , Pathumthani, Thailand

NDT Systems & Services AG, Stutensee

Department of Chemistry and Chemical Engineering, Niigata University, Japan

öko-control GmbH, Schönebeck

Otto von Guericke University Magdeburg

OWL Maschinenbau e. V., Bielefeld

Politecnico di Milano, Milan, Italien

Prämab GmbH & Co. KG, Burg

Precis Maschinen und Anlagen Service GmbH, Brandenburg (Havel)

Premium Aerotec GmbH, Bremen

Regional Development Agency Mura Ltd., Murska Sobota, Republic of Slovenia

Rehability Rehafachhandel, Weinheim

Research Designs & Standards Organisation, New Delhi, India

Rheinisch Westfälische Technische Hochschule Aachen, Institut für Arbeitswissenschaft (IAW), Aachen

Riga Technical University,Riga, Latvia

RKM GmbH, Munich

RKW Sachsen-Anhalt GmbH, Magdeburg

RWE Rhein-Ruhr Netzservice GmbH, Technik Center Primärtechnik, Wesel

RWTH Aachen, Lehrstuhl für Technologie- und Innovationsmanagement (TIM)

SCHIESS GmbH, Aschersleben

SchmitterGroup AG, Thüngen

School of Mathematics and Natural Sciences, University of Cologne

School of Vocational and Technical Education, Tianjin University, Tianjin, China

SCHUNK GmbH & Co. KG , Lauffen (Neckar)

Schweisstechnische Lehr- und Versuchsanstalt Halle GmbH, Halle

Scottish Crop Research Institute (SCRI), Dundee, United Kingdom

Semantic Systems, Derio, Spain

Sheffield Hallam University, United Kingdom

Siemens AG, Munich

SKL Engineering & Contracting GmbH, Magdeburg

SKL MOTOR GmbH, Magdeburg

SM Calvörde Sondermaschinenbau GmbH & Co. KG, Calvörde

Sondermaschinen und Anlagenbau GmbH, Magdeburg

Staffordshire University, United Kingdom

Steinbeis-Transferzentrum, Stuttgart, Halle (Saale)

Stiftung Dome und Schlösser Sachsen-Anhalt, Leitzkau

Strabag AG, Stuttgart

Taiyuan Heavy Industry Company Ltd., Shanxi, China

tbz Technologie- und Berufsbildungszentrum Magdeburg gGmbH, Magdeburg

Technical University of Crete, Chania, Greece

Technical University of Kosice, Slovak Republic

THALETEC GmbH, Thale

The University of Sheffield, Dept. Animal and Plant Sciences, United Kingdom

TRIMOS SYLVAC S.A. PTY LTD , Pretoria, South Africa

Trinity College Dublin, United Kingdom

TU Kaiserslautern

TÜV Rheinland Industrie Services GmbH, Cologne

Unison Engineering & Consultants GmbH, Berlin

Universidad Politecnica of Valencia (UPVLC), Valencia, Spain

University of Bielefeld, CITEC

University of Helsinki, Finland

University of Miskolc, Miskolc, Hungary

University of Modena and Reggio Emilia, Modena, Italy

University of Nottingham, United Kingdom

University of Porto, Porto, Portugal

University of South Australia, Adelaide, Australia

University of Tampere, Finland

VAKOMA GmbH, Magdeburg

VALCO Engineering, Magdeburg

VHS Bildungswerk Sachsen-Anhalt, Magdeburg

Virtual Reality Laboratory, University of Michigan, Ann Arbor, Michigan, USA

VTT Technical Research Centre of Finland, Espoo, Finland

Wacker Chemie AG, Nünchritz

warmX GmbH, Apolda

Warsaw University of Technology, Warsaw, Poland

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Patents (granted)

Warnemünde, R. ; Berndt, D.:
Method and device for determining the spatial geometry of a curved extruded profile.
Patent, issue date October 2, 2010, patent no. US 7,489,412

Patents (pending)

Behrens, R. ; Elkmann, N.:
Continuous or quasi-continuous kinematic chain with a sensor system.
Patent, filing date December 28, 2010, application no. 10 2010 056 607.1-15

Elkmann, N. ; Förster, T. ; Greve, G. ; Behrens, R. ; Fritzsche, M.:
Gear Mechanism.
Patent, filing date February 24, 2010, application no. 10 2010 009 447.1-12

Elkmann, N. ; Walter, C. ; Vogel, C.:
Device that monitors at least one three-dimensional safe zone.
Patent, filing date April 16, 2010, application no. 10 2010 015 765.1-26

Elkmann, N. ; Walter, C. ; Vogel, C.:
System that identifies a safe zone in workplaces shared by humans and machines and unit that monitors workplaces shared by humans and machines.
Patent, filing date April 16, 2010, application no. 10 2010 015 764.3-26

Fraunhofer-Gesellschaft e.V.
VDTC
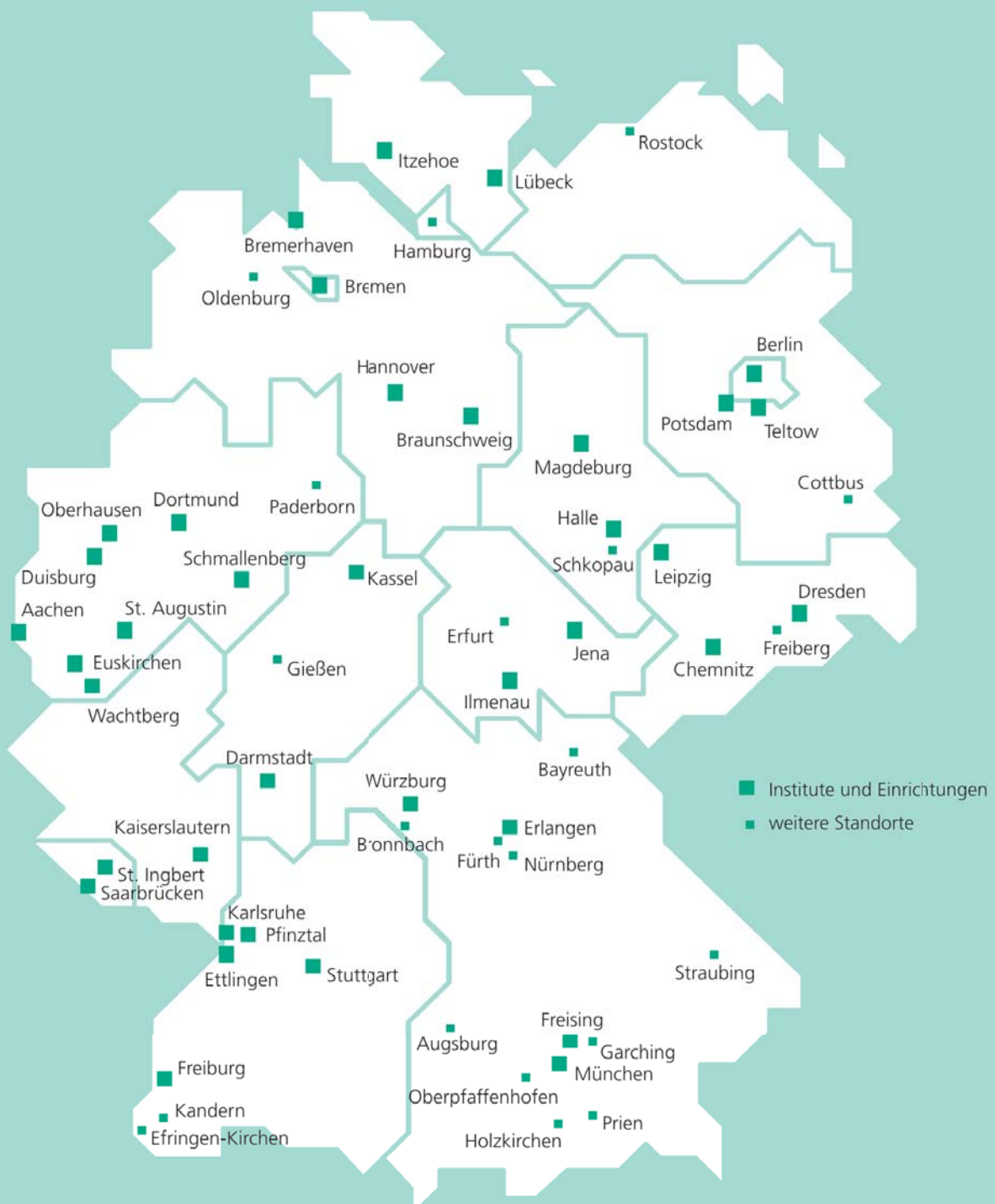Trademark, filing date September 15, 2010, application no. 30 2010 054 687.5/42

Richter, K. ; Hoffmann, H. ; Schulz, J.:
Load carrier system with an energy storage system.
Patent, filing date June 15, 2010, application no. 10 2010 024 382.5-24

Seiffert, U. ; Bollenbeck, F.:
Training method for an adaptive evaluation algorithm, a hyperspectral instrument, a unit to apply supplies.
Patent, filing date July 9, 2010, application no. 10 2010 027 144.6-53

Schlinkert, A. ; Thomas, S.:
Method for producing synthesis gas from biomass.
Patent, filing date February 5, 2010, application no. 10 2010 007 588.4-24

Walter, C. ; Saenz, J. ; Reimann, B. ; Schulenburg, E. ; Elkmann, N.:
System and robotic system for the inspection of the insides of tubular objects.
Patent, filing date June 2, 2010, application no. 10 2010 022 608.4-24

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■ Institute und Einrichtungen

■ weitere Standorte

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