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Research News

No. 12 – 2009

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1 Traditional craft industry with a bright future

Mary and Joseph, the angels, the manger – at Christmas time, lots of people still decorate their homes with high-quality wooden figures depicting the nativity scene. Now, the wood carvers of South Tyrol are moving over to high-tech production methods.

2 Safe journey for works of art

Valuable paintings travel long distances when they are shipped from one place to another. To minimize damage, they are packed in special picture cases. In future, these will be equipped with sensors to detect the buildup of pollutant gases, emanating from adhesives for example.

3 Intelligent blood bags

Have the blood supplies got too warm? Do they match the patient's blood group? In the future, these kinds of questions will be answered by intelligent radio nodes attached to blood bags. These radio units will also greatly facilitate device management in hospitals.

4 A virtual physician's conference

Telemedicine facilitates communication between family physicians, hospitals and nursing services – yet current solutions lack flexibility and are consequently very expensive. A new software program is now available that can be tailored to a range of applications.

5 Milling and drilling in cyberspace

Machinists, NC programmers or mechatronics engineers – trainees in engineering jobs often have to master complex equipment. In the future, trainees will practice and learn milling, turning, drilling and programming routines son a virtual model.

6 Electromagnetic fields as cutting tools

The bodywork on motor vehicles must be sufficiently stable, but processing the high-strength steels involved – for example punching holes in them – can prove something of a challenge. A new steel-cutting process will save time, energy and money in the future.

7 Digital avalanche rescue dog

A novel geolocation system makes use of signals from Galileo, the future European satellite navigation system, to locate avalanche victims carrying an avalanche transceiver or a cellphone, to the precision of a few centimeters.

Woodcarvers are turning high-tech.

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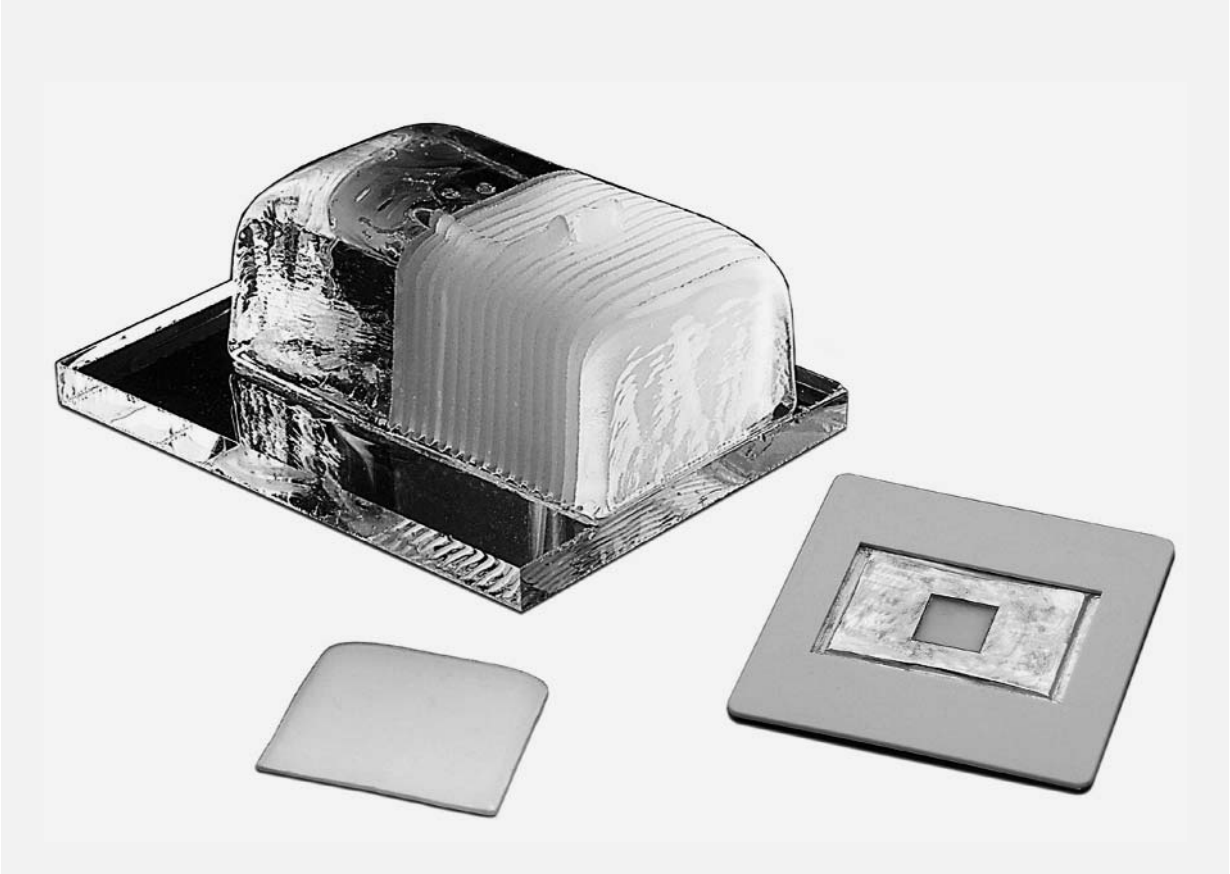
Traditional craft industry with a bright future

A South Tyrolean craftsman wearing ear protection carefully guides a tool arm over a master figure, producing forty or more mini-copies of the original at the cutting machine next to him. This kind of pantograph machine has long been the traditional means of manufacturing wooden figures in many of South Tyrol's valleys. "Pantographs are often given away in children's magazines and comics. Kids love them. With just a pencil and paper, they can reproduce their favorite characters on whatever scale they like, and then hang the posters on their wall. The same principle applies here, too – only in this case, we're talking about producing high-quality wooden carvings," explains group manager Jürgen Goetz of the Fraunhofer Institute for Manufacturing Engineering and Automation IPA. "First, an artist produces Mary or Joseph by hand, perhaps cast in bronze or brass. Then a colleague at the pantograph traces the figure and the carving machine produces copies." This traditional way of working has its disadvantages: It's loud, dusty, and the unenclosed machines are a hazard to workers. Additionally, it often takes several months before even a small production batch is ready for dispatch. The artist must first produce a design, then create a master figure; only after that can manufacturing begin.

On behalf of the company 3D Wood, Goetz' s team of scientists have now developed a new workflow for this traditional branch of woodworking. First, a 3D scanner traces the original, or else data is input from a CAD program. Then a software package processes up to 50,000 scanner data sets of the design model, producing the basis for a CNC program which controls the milling machine. Goetz reels off the technical details: "The 3 meter by 3 meter by 8 meter machine is fully automated, has five simultaneous axes, operates at up to 40,000 revolutions per minute, automatically swops tools, and stops immediately if any malfunction occurs. It produces 42 extremely high-quality copies simultaneously, and their size can vary anywhere between 10 and 600 millimeters." Using this automated process, figures can be turned out in less than half the previous time – and their quality is better too.

This new way of working cuts the time between design of the master and manufacture of the end product from several months to just a few weeks. The artist can even make the master out of soft wood or wax, which is in turn much quicker than casting a figure in bronze and enables work to begin sooner on new contracts. And let's not forget another happy side-effect: workers no longer need to be exposed to high levels of noise and dust.



The glass dosimeter detects the buildup of pollutant gases in picture cases.

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Safe journey for works of art

After being exhibited in New York, the priceless oil paintings move on to a gallery in Paris and then to a museum in Berlin. To protect the works of art from the effects of the environment during transport and storage, they are packed in special cases made of plastic, wood and glass. The microclimate inside these cases keeps the polluted outside atmosphere at bay. But the works of art are still exposed to a certain amount of risk, because the wood, plastics and adhesives used to make the transport containers can also emit damaging substances such as acetic acid. These substances react with the oil paint, causing it to gradually degrade. The painting itself can also emit pollutant gases that build up inside the case. Similar problems can be encountered when paintings are stored in the vaults of a museum or put on display in an enclosed, climate-controlled showcase.

In future, various types of environmental sensors will be available to measure the rising concentration of gases inside the case. They have been developed by researchers at the Fraunhofer Institute for Silicate Research ISC in Würzburg in collaboration with a number of European project partners. One of these sensors is a glass dosimeter, which is particularly sensitive to the presence of acids. As the head of the relevant ISC business unit Dr. Gerhard Schottner explains: "The acid attacks the surface of the glass and gradually erodes it. After a few days, a reaction layer starts to form. We quantitatively analyze this reaction layer using an infrared spectrometer. A few weeks later, crystalline products may also start to appear on the surface of the glass, enabling us to identify the type of acid involved." Atmospheric pollutants have a similar effect, producing nitrogen and sulfuric oxides. The new sensors detect such aggressive compounds in the air inside the showcase.

"The sensors help us to identify the pollutant gases and determine which were produced inside the showcase and which have penetrated it from outside. They enable us to build zero-emission showcases and substantially improve the microclimate surrounding the valuable artworks," says Schottner. The sensors are also useful when assessing claims for damages sustained by a painting during shipment, because they enable the display-case manufacturer to provide documented evidence of the origin of the harmful emissions. The research team has already conducted initial pilot tests.

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Blood bags that are not needed during an operation can only be reused if the cold chain has been maintained. In the future, a radio node attached to the blood bag will constantly monitor the temperature.

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Intelligent blood bags

In difficult operations, patients sometimes lose a lot of blood. Surgeons therefore keep blood supplies on hand for emergencies. If the blood bags are not needed, they can only be reused if the cold chain has been maintained. Up to now, monitoring this chain has been a tricky process, but, in the future, a radio node attached to the blood bag will constantly monitor the temperature to ensure that most of these blood supplies can be reused. The radio nodes should also help to improve safety. For example, using the wrong blood by mistake during a blood transfusion could have fatal consequences for the patient. Radio nodes attached to the blood bags and to a patient wristband can exchange information. If the donor blood does not match that of the patient, a warning signal sounds and a red light illuminates.

The intelligent radio nodes were developed by researchers at the Fraunhofer Institute for Integrated Circuits IIS and the Fraunhofer Working Group SCS in collaboration with their partners T-Systems, Vierling, delta T and the University of Erlangen-Nuremberg. The project is funded by the German federal ministry of economics and technology (BMWi). "In contrast to tags that use RFID – radio frequency identification – we do not expect intelligent radio nodes to interfere with hospital medical devices," explains Jürgen Hupp, department head at IIS. "While the transmit power required for RFID tag reading can be as much as two watts, radio nodes only transmit in the milliwatt range." This is because RFID tags only consist of a memory chip and antenna. To read an RFID tag, it must first be activated by the reader. In contrast, an intelligent radio node is an active radio system that is battery-powered and has its own processing unit. Radio nodes can continuously gather information and trigger actions.

The system is built upon a basic platform which the researchers can tailor to different applications. One example involves using radio nodes to optimize the management of medical devices in hospitals. Devices such as syringe pumps and cardiac monitors often move between departments and can be hard to track down when they are needed. This problem could soon be a thing of the past, since attaching radio nodes to the devices enables them to report their position automatically. "Hospitals can get by with fewer devices, eliminate unnecessary time-wasting and cut costs," states Dr. Alexander Pflaum, department head at SCS. A six-month test phase is set to begin at Erlangen University Hospital in January 2010, and the Opal Health system could be ready for use in around two years.

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A new software program for telemedicine facilitates coordination between physicians, specialists and nursing staff, helping them to identify the optimum course of treatment.

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A virtual physician's conference

Wounds suffered by patients with diabetes tend to heal poorly. For treatment to work, the patient's physician must discuss the situation with specialists and nursing staff to decide on the best approach. However, e-mailing the files containing the diagnosis and discussing them on the telephone is a time-consuming process. Telemedicine could facilitate communication and provide a better means of overcoming physical distance, but the solutions offered to date have failed to establish a market presence. "Currently available software mostly comprises one-off solutions that are difficult to adapt to alternative application scenarios," explains Oliver Koch from the Fraunhofer Institute for Software and Systems Engineering ISST. The software therefore has to be re-programmed for each application, which is a costly, time-consuming business.

In collaboration with the Protestant Hospital in the town of Witten, researchers at the ISST have now developed a software program that makes coordination both simple and cost-effective. "Our software is designed to be modular – you start with the basic core services and simply add the specialist individual services you need in each case," Koch explains. For basic program functions such as barcode recognition, the scientists have chosen existing open-source solutions. To tailor these to a specific application, the programmer simply modifies certain parameters.

The software is used for a weekly "Wound Conference" in Witten, in which doctors present problematic wounds that are not healing properly and discuss possible courses of treatment. Doctors can click on a link to register and download the program, which includes an easy-to-use installation wizard. Once a doctor has obtained their patient's consent, they can enter the patient's data in an on-screen form, including a description of the wound and any laboratory findings. The doctor can then upload photos of the wound using a barcode that was photographed together with the wound. The barcode automatically assigns the images to the patient's file, and the doctor can add updated photos whenever required. To check how the healing process is going, conference participants simply click to display the photos in a series. In addition, the software automatically pulls in new information on how treatment is progressing. All the data is stored centrally on one of the hospital's servers. More than 300 cases have already been documented in the virtual network, and the researchers now intend to expand the pool of basic services and assess requirements for new services.

Trainees use a computer to operate this virtual handling system for biological compounds. They can transport Petri dishes with bacteria cultures over a conveyor, control grippers and take samples.

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Milling and drilling in cyberspace

A trainee carefully clamps a workpiece in a lathe. He must program the machine correctly before he can machine the part. This is a tricky task and the trainee will have to solve a similar problem for his final exam. Therefore, he is learning to handle such equipment at a vocational school. However, rather than standing in front of a real machine, he sits in front of a computer. The control panels and the lathe behind it appear on a monitor. A computer guides the trainee step by step.

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The Fraunhofer Institute for Factory Operation and Automation IFF, the Technologie- und Berufsbildungszentrum TBZ Magdeburg and the Schweisstechnische Lehr- und Versuchsanstalt SLV Halle have launched the ViReKon project, which is being coordinated by the Rationalisierungs- und Innovationszentrums RKW Sachsen-Anhalt. They intend to train engineers with the aid of virtual reality VR. Researchers at the Fraunhofer IFF are developing virtual models of different machines for this. "The TBZ presently uses a simple model of a real sorting system for hands-on training. It only allows trainees to practice a few tasks though," says André Winge, Group Manager at the Fraunhofer IFF. "However, budding mechatronics engineers, programmers or machinists can be taught quite specifically on virtual equipment and train a whole number of different tasks." To this end, the experts from the Fraunhofer IFF are developing special e-learning methods together with the vocational trainers. "A trainee ought to be able to operate more than just the machine and the control unit," says Winge. "An integrated didactic training concept explains the tasks to students. The system monitors their achievement and provides them feedback on the correctness of their performance of the individual tasks."

Another advantage: Vocational schools do not have to purchase any expensive equipment. Turning, drilling and milling are possible in cyberspace – on large as well as small machines. "We are able to design a virtual model of any system," says Winge. For instance, the researchers also created a VR model of a handling system for biological compounds. A conveyor transports Petri dishes with bacteria cultures. A gripper picks them up and transfers them to the sampling station where a pipetting unit takes a sample and processes it further. Trainees follow the procedure in the virtual system on a monitor, while the control unit they use is real. Specialists or maintenance engineers in companies could also be trained on such a VR system in the future.

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Topic 6

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Electromagnetic fields as cutting tools

Squealing tires and the crunch of impact – when an accident occurs, the steel sheets that form a motor vehicle's bodywork must provide adequate impact protection and shield its passengers to the greatest extent possible. But the strength of the steels that are used throw up their own challenges, for example when automobile manufacturers have to punch holes in them for cable routing. Struggling to pierce the hard steel, mechanical cutting tools rapidly wear out. And because they also leave some unwanted material on the underside of the steel (burr, as the experts call it), additional time has to be spent on a finishing process. One possible alternative is to use lasers as cutters, but they require a great deal of energy, which makes the entire process time-consuming and costly.

Working together with a number of partners including Volkswagen, researchers at the Fraunhofer Institute for Machine Tools and Forming Technology IWU in Chemnitz have come up with another way to make holes in press-hardened steel bodywork. Dr. Verena Kräusel, head of department at the IWU, explains: "The new method is based on electromagnetic pulse technology (EMPT), which was previously used primarily to expand or neck aluminum tubes. We've modified it to cut even hard steels. Whereas a laser takes around 1.4 seconds to cut a hole, EMPT can do the job in approximately 200 milliseconds – our method is up to seven times faster." Another advantage is that it produces no burr, thus doing away with the need for a finishing process. Stamping presses become superfluous, and no costs arise from the need to replace worn-out parts.

The pulse generators comprise a coil, a capacitor battery, a charging device and high-current switches. When the switch closes, the capacitors discharge via the coil within a matter of microseconds, producing a high pulsed current. The coil converts the energy stored in the capacitors into magnetic energy. To be able to use this process to cut steel, the researchers simply had to modify the coil to ensure the resulting electromagnetic field is strong enough: the pressure with which the field hits the steel must be so high that it forcibly expels the material from the sheet. "The impact pressure on the steel is approximately 3,500 bar, which equates to the weight of three small cars on a single fingernail," says Kräusel. PSTproducts GmbH in Alzenau provided the original EMPT system. With regard to the customer demands the researchers develop now the coils for various cutting geometries.

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Topic 7

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Digital avalanche rescue dog

For many skiers and snowboarders, there is nothing quite like being the first to make tracks in the virgin snow, off the regular piste. But this can be a fateful decision, because the risk of avalanche is many times greater here. Once buried under a mass of snow, a person's only hope of survival is if their location can be pinpointed swiftly. If not rescued within half an hour, their chances of being found alive diminish rapidly. Victims stand the best chance of being saved if the uninjured members of their group start searching for them immediately – but for that the buried victim needs to be wearing an avalanche beacon.

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"In the experience of rescue teams not everyone actually carrys beacons," says Wolfgang Inninger of the Fraunhofer Institute for Material Flow and Logistics IML. "However, nearly everyone has a cellphone. This is why we decided to enhance our automatic geolocation system that works with Galileo, the future European satellite navigation system." To do so, two new components have been added to the 'avalanche rescue navigator' ARN: a cellphone location function and software that calculates the position of the buried victim on the basis of local measurements. Starting from the approximate place where the victim is thought to be lying under the snow, the rescuers measure the field strength of the signal transmitted by the cellphone or beacon at three to five reference points. The system then uses a highly precise calculation algorithm to pinpoint the source of the signal, indicating with high probability the location of the buried victim. In this kind of situation, the position relative to the rescue team's starting point is more important than the absolute position relative to global coordinates, which may be subject to measurement inaccuracies. This gives the rescuers immediate information on the direction and distance from their present location at which the victim can be found.

For their development work on the system, the researchers are using the GATE Galileo test and development environment in Berchtesgaden, where transmitter antennas installed on six mountain peaks simulate the Galileo signals. The researchers intend to combine these signals – and the real ones, after 2012 – with signals from existing satellite navigation systems such as the American GPS and the Russian Glonass, and to add signals for error estimation and correction. The project is being implemented by a consortium of regional companies, institutes and universities in collaboration with the Berchtesgaden mountain rescue service and the police, and is being sponsored by the German Aerospace Center DLR.

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