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RESEARCH NEWS

03 | 2015 ||

1 CeBIT: Panoramas for your tablet

Most people are familiar with the fictional world of "Star Trek," in which the characters can use a holodeck to create and interact with virtual worlds. It is possible to recreate a similar effect in the real world using 360-degree panoramic images. Researchers are bringing them now to our tablets – including individual camera work and editing.

2 Protecting nerve tissue during bowel surgery

After bowel surgery, more than half of the patients suffer from irreparable nerve damage. Now scientists have developed an assistance system that warns surgeons about the risk of inflicting possible injury during operations in the pelvic area. The experts are currently working on a solution for minimally invasive surgery.

3 Power vest

Each year millions of people within the EU injure themselves in the course of their work due to picking up heavy loads or from one-sided movements – ending up with serious health issues. Together with the industry, Fraunhofer researchers are developing a vest designed to take the burden off caregivers and others with physically demanding jobs.

4 Predicting pesticide loads more accurately

The EU wants to further improve the authorization process for plant protection products. The different national procedures for this are supposed to be further harmonized. Fraunhofer researchers have developed a software for estimating the transfer of pesticides into surface water initially in Germany.

5 Virtual vehicle testing – modeling tires realistically

Manufacturers conduct virtual tests on vehicle designs long before the first car rolls off the assembly line. Simulation of the tires has remained a challenge, however. The software tool "CDTire/3D" from Fraunhofer researchers now models the wheels realistically. The software takes into account the heat that is generated during driving and how the properties of the tires change.

6 High-precision radar for the steel industry

Steel is the most important material in vehicle and machinery construction. Large quantities of offcuts and scraps are left over from rolling and milling crude steel into strip steel. New radar from Fraunhofer researchers measures the width of the strip during fabrication to an accuracy of micrometers and helps to minimize scrap.

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 66 Fraunhofer Institutes and research units at over 40 different locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of around 24,000, who work with an annual research budget totaling 2 billion euros. About 70 percent of this sum is generated through contract research on behalf of industry and publicly funded research projects. Branches in the Americas and Asia serve to promote international cooperation.

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CeBIT: Panoramas for your tablet

Panoramic video thrusts viewers right into the middle of the action. "Even a 180-degree panorama leaves you really feeling part of the action," says an enthusiastic Christian Weissig from the Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut HHI in Berlin. While the technology has existed for a number of years now, when Germany's first IMAX cinema in Munich closed in 2010, 3D technology took over in drawing viewers into the action, and it seemed as if panoramic technology had already passed its peak. "Too expensive, not commercially viable" – that was the brutal verdict on the technology that acts as the inspiration for the "Star Trek" holodeck. Thanks to the research done by Weissig and his team, the panorama could soon pop up where we might least expect it: on the screens of smart TVs, smartphones and tablets. "Ultra-HD-Zoom" is a prototype that allows users to select and navigate around high-resolution segments of panoramic images. The researchers will be showcasing their tablet app at the CeBIT computer expo in Hanover, March 16-20 (Hall 8, booth E40).

Video panoramas are created by combining the images recorded by a series of high-resolution cameras. Fraunhofer HHI's OmniCam system, for instance, uses 10 HD cameras. This leaves the technology capable of creating 360-degree panoramic images in real-time – making it a fascinating proposition for covering live events. Last year for instance, Fraunhofer researchers recorded the soccer World Cup final between Germany and Argentina in Rio de Janeiro. They have also recorded the concert given by the Berlin Philharmonic on the occasion of the 25th anniversary of the fall of the Berlin Wall. The recordings have a resolution of 2000 x 10,000 pixels. "Sadly, none of us have a panoramic cinema at home, and the devices in our living rooms and in our pockets are simply not capable of processing this amount of data," explains Weissig.

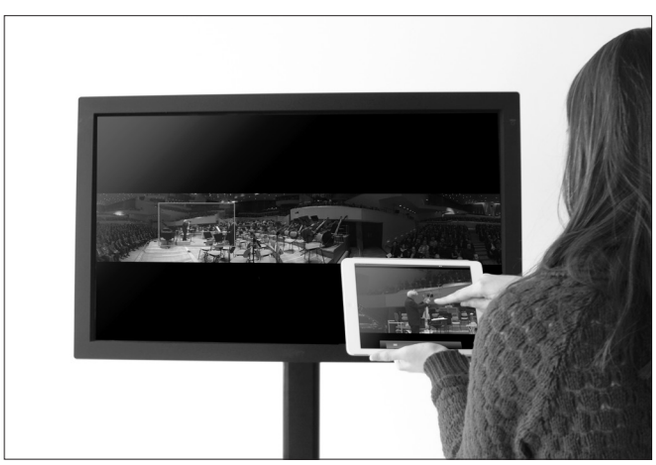
The cameraman-spectator

What is possible, though, using currently available LTE networks, is to transmit individual segments of the panorama. "What we've done is split the panorama into a set number of segments. These segments are made available to each user concurrently, with the app selecting the segments needed to display the desired section of the panorama," says Weissig. This approach makes it technically feasible for a very large group of people to use a panoramic image at the same time. Of course, they won't get the panorama at its full resolution, just the individual segments they choose rendered at the resolution of their device. "It's another step towards personalized television: users taking advantage of the 'second screen' to become their own cameraman and take over the footage, maybe by zooming in to a specific point within their chosen segment. Until now, the apps on the market have been able to offer only a selection of static camera angles, or else transmit a full panorama in HD definition," says Weissig.

Content providers and TV broadcasters also stand to profit, potentially offering the new capabilities as a service of their own. "We are already collaborating with partners who want to implement the technology themselves, for instance to improve the marketing of live concerts," says Weissig. The investment needed to produce panoramic recordings remains high – but now that cost can be spread across a large number of users via the pricing of the app, which still remains reasonable for each individual user. The technology should be commercially available within the year. "In the meantime, we'll be polishing the product to improve transfer speeds," says Weissig.

But isn't there still a shortage of content? And aren't panoramic recordings still far too expensive? "The trend is clearly one towards extremely high resolutions – just look at the new 4K TVs or the Japanese broadcasting corporation NHK's drive towards 8K resolution. Panorama technology is advancing too. In the future, there will be more content and more devices capable of displaying it. The Ultra-HD-Zoom app is a first application that we can expect to be available soon. As such, it's a pointer as to where panorama technology might go in the future," says Weissig.

At their CeBIT trade fair booth, the researchers have set up the whole scenario: Visitors can use the app to select a specific camera angle based on live footage. These are displayed as overview images on the right of the screen. If the visitor selects one of the OmniCam cameras, they are free to navigate the content themselves.



At CeBIT, Fraunhofer HHI is showcasing an app that allows users to navigate panoramas using their tablets. (© Fraunhofer HHI) | Picture in color and printing quality: www.fraunhofer.de/press

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Protecting nerve tissue during bowel surgery

According to the German Federal Statistical Office, bowel surgery is one of the most common surgeries in Germany. Complications are frequent, however, with more than half of the patients struggling with incontinence or sexual dysfunction following intervention in the pelvic area due to nerve tissue damage. The nerves controlling bladder, anus and sexual functions surround the intestine in a wafer-thin web. "In terms of color and structure, it's very difficult to distinguish this nerve network from other tissue and smaller blood vessels, which frequently leads to injury," explains Prof. Klaus-Peter Hoffmann from the Fraunhofer Institute for Biomedical Engineering IBMT in St. Ingbert. What makes it all the trickier is that often the surgeon doesn't notice the injury during the surgery, and problems only become evident a few weeks after the operation.

Warning surgeons before they inflict nerve damage

In the IKONA project (Continuous intraoperative neuromonitoring as a microtechnological navigation instrument), Fraunhofer IBMT coordinated a joint effort with several partners to develop an assistance system for intraoperative neuromonitoring. This involves placing flexible, wafer-thin electrodes directly onto nerve fibers and stimulating them by means of electric impulses. Software from IBMT partner inomed evaluates whether the surgical intervention is affecting the autonomous nerve network: if the surgeon gets too close to a nerve, or pushes or distends it, nerve function is affected. The surgeon is given a visual and acoustic warning if there is a danger of injury. The system is already undergoing clinical testing.

Currently, Hoffmann and his team are working on the successor project, autoPIN (Assistance system for the stimulation of autonomous pelvic nerves with the aim of intraoperative neuromonitoring in laparoscopy). In the autoPIN project, the Fraunhofer researchers are working with partners to facilitate this sort of neuromonitoring during operations, even for minimally invasive surgery. This differs from standard surgery in that electrodes have to be placed on the body externally. The problem is that the sacrum lies between the electrodes and the nerve network – and that obstructs the electrical field. "The challenge is placing the electrodes so that they are still able to stimulate the nerve network," explains Hoffmann. To achieve this, scientists from the Department of General, Visceral and Transplantation Surgery at Mainz University attach an electrode array to the body to form a grid-like field. "Then we activate individual electrodes, allowing us to identify those that will permit us to optimize the geometry of the electric field in such a way that we can effect a neuromodulation," says Hoffmann, describing Fraunhofer IBMT's role. Partner inomed has developed a smart algorithm that evaluates the raw signals from the neuromodulation and processes them in such a way that the surgeon can tell at a glance whether there's any risk of injury. "Our aim is to assure that surgery on the pelvic organs is of a guaranteed quality and protects the

nerves. It's all about preserving quality of post-op life," says the senior doctor on the team, Prof. Dr. Werner Kneist.

Since surgery in the pelvic area can often last several hours, the assistance system draws on the dry silicone electrodes developed at Fraunhofer IBMT in the course of the IKONA project, with nanoparticles within the silicone guaranteeing the necessary conductivity. In contrast to conventional electrodes, these silicone electrodes can provide a stable and reliable interface over an extended period of time. The new assistance system for minimally invasive surgery is currently undergoing preclinical trials.

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Power vest

In Germany, back pain is a national complaint, with nearly ten percent of all lost working days attributable to lower back problems, according to the 2014 Health Report published by the Techniker Krankenkasse. The study found that occupation had a significant impact on the duration and frequency of time taken off due to poor health. Caregivers are particularly affected, because working in a hospital or nursing home requires physical strength. There are patients to move, mobilize and help up – and all that puts the musculoskeletal system under stress. Now, modern technology offers caregivers' backs extra support. In the "CareJack" project, researchers from the Fraunhofer Institute for Production Systems and Design Technology IPK and the Fraunhofer Institute for Reliability and Microintegration IZM, both in Berlin, are working together with industry partners to develop an active vest designed for these kinds of workers. Cleverly, this non-bulky orthosis (a short form of orthopedic prosthesis) is light, soft and comfortable to wear. That means it can be worn over regular clothes like a coat. Experts call it soft robotics.

"Until now, there haven't been any efficient support systems to help caregivers with the heavy work they encounter in their extremely varied day-to-day work," says IPK expert Henning Schmidt, who heads up the project. Anyone working in hospitals, nursing homes or outpatient care needs a strong back. But how can you provide the spine with support without limiting its abundant range of motion? Schmidt and his team have joined forces with company partners to strike out on a new path. Rather than relying on the hard shells often used in orthoses, they've instead opted for a material that is flexible and comfortable to wear. All the electronics are incorporated into the material.

The energy required comes from the wearers themselves, through their movements. When a caregiver bends down to lift a patient up, the smart medical aid stores the kinetic energy and can release it again when required.

Orthosis helps avoid incorrect movements

Above all, the orthosis ensures that caregivers perform movements correctly. Lots of orthopedic problems are a result of improper movements: the classic example is lifting something heavy with a rounded back instead of squatting down to lift the object with a straight back. The smart vest features a myriad of sensors that continuously monitor the way the wearer is moving. A processor compares these data against the optimum movement pattern. As soon as it detects any irregularity, a warning lamp is activated. Not only that, but innovative synthetic actuators with adjustable rigidity help avoid incorrect movements and support correct ones. "The wearer can decide themselves what level of support they want," says Schmidt.

Functions of this sophistication call for a large amount of electronic equipment. "Still, nobody wants to haul around a backpack full of electronics," says IZM expert Erik Jung. In the CareJack project, he and his team collaborated with company partners to develop miniaturized components, flexible circuit boards and all the necessary sensors. A prototype of the vest should appear in 2015, and Schmidt estimates it will be in series production in one to two years. The demand, he points out, is extremely high. It's not just caregivers who could make use of this sort of active support, but anyone performing heavy physical work – construction workers, roofers, garbage collectors, brick layers and many more.

The CareJack vest supports the back without restricting freedom of movement. (© Fraunhofer IPK/IZM) | Picture in color and printing quality: www.fraunhofer.de/press

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Predicting pesticide loads more accurately

Researchers of the Fraunhofer Institute for Molecular Biology and Applied Ecology IME have developed software for Germany that calculates the concentration of pesticides/plant protection products in surface waters like ditches or streams. The new process can be employed as a component of pesticide authorization procedures. The software developed by the scientists at the Schmallenberg location works more accurately and delivers faster results than current procedures in Germany and the EU. The concentrations of pesticides are used to assess the risk for the populations of aquatic organisms – these include fish, aquatic plants, and insects. The research partners are the Institute of Landscape Ecology and Resources Management of the Justus Liebig University Giessen, the RLP AgroScience - Institute of Agroecology, the RWTH Aachen University, and the French IT company FOOTWAYS S.A.S. The German Federal Environment Agency (Umweltbundesamt, UBA) sponsored the research.

A blueprint for other EU member states?

The software builds on existing computer models for authorizing active substances in pesticides within the EU. It might therefore serve as a blueprint for other EU member states to further harmonize the assessment procedures between EU countries for plant protection products. The prototype, named GERDA – short for "German Run-off, Erosion, and Drainage Risk Assessment" – has already been tested successfully by the researchers. "We are hopeful that the software will be introduced before the beginning of next year," says Dr. Michael Klein from the Department of Ecological Chemistry in Schmallenberg, "but the final decision on that will be made by the German approval authorities."

The researchers have optimized GERDA at many points in comparison to existing EU methods. The method now incorporates a comprehensive data base of scenarios for environmental conditions specific to Germany. These are based upon weather data over the last 30 years and detailed soil maps of Germany. The researchers have relied here on data from the Germany's National Meteorological Service (Deutscher Wetterdienst/DWD) and the German Federal Institute for Geosciences and Natural Resources (BGR). The software processes information about the active substances in the pesticides, their application area and their usage according to quantity and point in time. From the pool of data, GERDA calculates the particular pesticide concentration that represents a realistic worst case for the waters under conditions of good agricultural practice. "The final objective is that the populations are not impaired," explains Klein. Users of the program can set various environmental conditions to observe how the alterations affect the calculated environmental concentrations, such as how the concentrations in the waters decline if larger distances to surface waters are maintained for the particular agricultural area where the plant protection products are applied. "This information is then placed on the product packaging of the pesticide and repre-

sents a condition of authorization and use of the pesticide," says Klein. The models the researchers use to calculate the pesticide concentrations are complex. Nevertheless, they work faster than existing procedures. "We wrote simpler code for several of the calculations," Klein explains. The scientists developed a convenient user interface so that the software can also be operated by those who have a different technical background. "For users, it is as easy as filling out an input screen for a normal PC spreadsheet application program," according to Klein.

In order for the software to be able to process all the necessary data the researchers first transferred the heterogeneous pool of information comprising meteorological, geographical, and chemical data into a format that the predictive model can process. Klein's colleague Udo Hommen from the Department of Ecotoxicology contributed knowledge of when an ecosystem becomes damaged. "There is a difference, for example, between short-term and long-term exposure. If organisms are harmed by even very brief exposure, then it does not make sense to implement daily average values as relevant for the aquatic concentrations. In contrast, for other substances short-term exposure may have no effect," Hommen explains. The predictive model facilitates this differentiation.

The function of plant protection products is to protect crops against plant or animal pests or against fungi. To avoid negative effects of these chemicals on humans and on the environment, there is a two-level authorization system in the EU. First, the active substances in the pesticide are checked at the EU level. Then the pesticides are evaluated and authorized at a national level. In Germany, the Federal Office of Consumer Protection and Food Safety (Bundesamt für Verbraucherschutz und Lebensmittelsicherheit/BVL), the Julius Kühn Institute (JKI), the Federal Institute for Risk Assessment (Bundesinstitut für Risikobewertung/BfR) and the Federal Environment Agency (Umweltbundesamt/UBA) are responsible for this.

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Fraunhofer

Virtual vehicle testing – modeling tires realistically

The vehicle races along uneven streets, rumbles over stones, crashes across potholes, and slides over icy roads. But of course, only virtually, for it is still far from being produced yet. With the cars as well as the bumpy test roads, the simulations come first. How operationally stable is the vehicle? Does the design deliver what it promises? These kinds of virtual experiments offer many advantages: Different variations of a motor vehicle can be tried out at an early phase of development already, whether an automobile, truck, or tractor, and the design systematically optimized – without expensive prototypes.

Realistic yet fast calculations

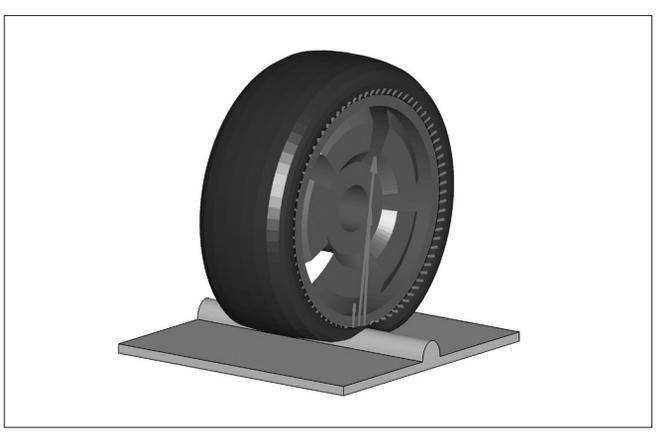
The simulation of the automobile itself is well-understood. However, the tires remain a challenge because they behave in a complex, non-linear manner. The calculation is either very drawn out, computationally intensive, and cannot be easily incorporated into the overall model, or it provides inexact results. Researchers at the Fraunhofer Institute for Industrial Mathematics ITWM in Kaiserslautern developed a simulation tool called "CDTire/3D" that overcomes this dilemma. "We have used technology to find a good balance between computation time and accuracy," says Dr. Manfred Bäcker, head of tire and vehicle simulation at ITWM. The simulation mirrors reality well and is fast at the same time. The researchers will be presenting the software at the Hanover Trade Show in the joint Fraunhofer "Simulation" booth located in Hall 7 from April 13-17, 2015.

The scientists map the properties of the tire to a structural shell model. "Instead of mapping it as a volumetric model, we represent the tire as a shell – and that saves a great deal of simulation time, yet still takes into account all of the properties," Bäcker explains. First, the researchers calculate individual shells for every functional ply of the real tire: one for every steel belt ply, one for the cap ply, and so on. They subsequently bring these together into a single shell. What is special: the model takes into account the sidewall as well. In usual simulations, the automobile manufacturers need to completely re-adjust the parameters as soon as the tire width changes in the simulation or the tire pressure varies. "We completely separated geometry from material properties so that you can alter the tire geometry without having to match the computer model to it." The automobile manufacturers value that as well. The simulation is already in use world-wide, including at Toyota and Daimler.

Additionally, the scientists now incorporate temperature into the simulation. This is important because the tire is dynamically deformed during driving and because the brakes give off heat. As a result, the tire warms up – and thus its properties change. The researchers first save the results from CDTire/3D in the temperature model. Then, with the help of these calculations, they simulate how the heat travels in the tires, and

finally couple the results back into the structural model. The Swiss Formula-1 Team Sauber wants to employ the temperature model in the future to make their race cars faster in the turns.

"Since the system is modularly constructed, we can couple the temperature model to any simulation tool you want," says the researcher. As a result, it can also be connected to the "CDTire/Realtime" tool. This software can also be employed for example during the design of an electronic control system like the Electronic Stability Program, or ESP for short. If a car starts to loose traction or slide, the ESP selectively applies the brakes of the individual wheels. CDTire/Realtime runs in real time – just like the temperature calculation tool does, though up to now only on larger computers in the lab. In future, CDTire/Realtime will be able to be deployed using microcontrollers installed in the car to increase the accuracy of the ESP while driving. Bäcker guesses it will still take about one to two years until then.



CDTire/3D tire simulation while rolling over an obstacle. (© Fraunhofer ITWM) | Picture in color and printing quality: www.fraunhofer.de/press

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Fraunhofer

High-precision radar for the steel industry

Measuring dimensions precisely is crucial for production engineering – for instance in the production of steel. Several tons of the material are processed in a steel mill every day. 20 centimeter white-hot ingots of cast steel are rolled out into thin sheet steel kilometers in length and subsequently wound into rolls. The plate steel roars through the rolls at speeds of up to 20 meters per second, But the strip often ends up too wide during this process. The excess edges need to be trimmed off afterwards – and that means a high material losses. New millimeter-wave radar of the Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR in Wachtberg provides assistance here. It measures the width of sheet steel during processing to an accuracy of micrometers. This permits the rolling facility to self-adjust so that less scrap is produced with considerable savings in costs.

Two radar sensors mounted at the side of the rolls measure the distance to the edge of the steel. In principle, the system can be compared with echo-locating by bats. The ultrasound signals that bats emit are reflected back by mice, branches, wires, and mosquitoes like echoes. Bats listen to the echoes from things located in front of them and distinguish prey from obstacles.

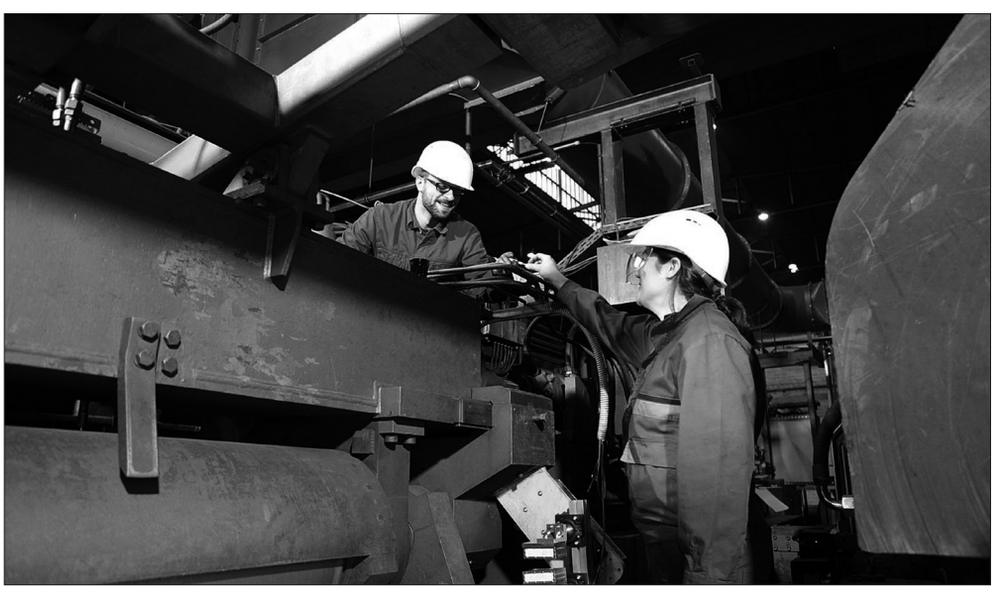
"Our radar sends out continuous electromagnetic signals that are reflected by the right and left edges of the strip. The transmitted and received signals are then compared to each other with the help of numeric algorithms. The width of the sheet can be calculated from this comparison," says Prof. Nils Pohl, scientist and head of department at FHR, in explaining the principle of how the system operates. The radar that determines distances of up to several meters with a precision of just a few micrometers, also measures very quickly – 5000 times a second. Silicon chips developed in-house make these values possible.

The system operates reliably in fog, dust, and smoke

An additional advantage: the system operates even under severe conditions of dust, heat, steam, and fog. "The hot strip steel has to be water-cooled during rolling. This forms dense steam, especially in winter. Lasers and cameras also measure very accurately, of course, but they are not suitable for deployment in environments with high humidity and varying lighting conditions. Radar signals by comparison penetrate dust and fog very well," says Pohl.

Due to its low transmitting power, which is less than that of a cell phone, the radar can be operated in any environment without having to meet additional safety requirements. Since the sensors are mounted to the sides of the rolls, the system can be integrated easily into existing plants. There are presently three steel mills in Germany testing its operation.

In future, the high-frequency radar, which operates with electromagnetic waves above 30 GHz, will be mass produced. This means that the applications are not restricted to just the steel industry. The plastics sector could also benefit from the precision tool – for instance to measure the thickness of pipes. The possibilities and mode of operation of the system will be presented by the researchers from Wachtberg at a workshop on the topic of millimeter-wave radar at Fraunhofer FHR on May 5-6, 2015.



Researchers of Fraunhofer FHR installing the radar at a strip mill in Eisenhüttenstadt. (© Fraunhofer FHR) | Picture in color and printing quality: www.fraunhofer.de/press

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