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RESEARCH NEWS

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1 Cell cultures from a machine

Cell cultures form the basis of day-to-day research work in applications that range from the development of drugs and vaccines to the decoding of functions of individual genes. Up until now, cell cultures have been sown, tended, observed and transferred to vessels – all by hand. A new device automates these worksteps completely.

2 The green look for EV charging stations

The network of electric-vehicle (EV) charging stations in Germany is still relatively sparse, but their number is growing rapidly. The majority of roadside charging points take the form of steel-clad pillars. A group of researchers has set out to develop an alternative design based on environmentally compatible materials.

3 Software to prevent abuse at the click of a mouse

Teaming up with investigators from the State Office of Criminal Investigation in Berlin, Fraunhofer researchers have come up with an automated assistance system for image and video evaluation that can detect child-pornographic images from among even large volumes of data. Soon, it will make prosecutors' work easier.

4 A living factory

The time it takes for new products to come to market is getting ever shorter. As a consequence, goods are being produced using manufacturing facilities and IT systems that were designed with completely different models in mind. Fraunhofer developers want to make factories smarter so they can react to changes of their own accord.

5 Microlenses for 3-D endoscopes

Modern endoscopic techniques enable doctors to perform surgery without major incisions. Certain interventions require instruments with special 3-D optics. Researchers have developed an image sensor that transmits perfect 3-D images from inside the human body thanks to the use of microlenses.

6 Clean soot particle filters

The soot particle filters found on diesel vehicles are designed to ensure that no harmful particles make their way through the exhaust pipe. Often, though, the exhaust from newer-model engines is not hot enough to free the filters from soot particles on a regular basis. A new method removes impurities even at low exhaust temperatures.

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 60 Fraunhofer Institutes at over 40 different locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of around 18,000, who work with an annual research budget totaling 1,66 billion euros. Roughly two thirds of this sum is generated through contract research on behalf of industry and publicly funded research projects. Branches in the USA and Asia serve to promote international cooperation.

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Cell cultures from a machine

Research News
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The human genome has been decoded. Of all the puzzles it contains, though, many remain unsolved. We know that the genome provides the blueprint for various proteins, the building blocks of each and every cell. But what role do they play? Which proteins control cell division in a healthy body, for instance? And what takes place in tumor tissue in which cells incessantly subdivide and control over proteins gets out of hand?

To get to the bottom of the functioning of various proteins, researchers start by cultivating cell cultures. They add a few cells to a petri dish, add nutrient and regularly check for resulting cell growth. Once suitable colonies of cells have taken hold, the researcher uses a pipette to transfer these to a new vessel where investigation of the cells can continue. To date, for the most part researchers have had to carry out these steps by hand – in time-consuming routine work. Researchers at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart, at the Fraunhofer Institute for Physical Measurement Techniques IPM in Freiburg and at the Fraunhofer Institute for Applied Information Technology FIT in Sankt Augustin have now teamed up with colleagues at the Max Planck Institute of Molecular Cell Biology and Genetics in Dresden to create a system that completely automates the process of cultivating cells.

The device consists of an array of modules: One of these is a robot that transports the vessels containing the cell cultures, known as multititer plates, from one place to the next. Dr. Albrecht Brandenburg, group manager at IPM describes another module: "A microscope regularly inspects the cells to assess the status and growth of the cultures. It transfers the s.o. plates to the microscope stage, focuses, switches lenses and activates the light sources it needs. The entire optical system is designed to withstand and operate in the high-humidity conditions the cells require. The results of microscopic analysis are fed into the system control, a capability never seen in automated cell cultivation before."

An example: A computer program assesses the microscope images and checks to determine how densely the surface of the vessel is already covered in cells. If suitable cell colonies have formed, another module, a hollow needle, picks cells ranging between 100 and 200 micrometers in size and transfers them to a new container. System users can train the software responsible for this pattern recognition – and thus for identifying the cells themselves as such: in the case of new cell types, they can define sample areas as foregrounds and backgrounds. In subsequent worksteps, the system then identifies the cell type automatically.

Large enough to fill a small lab, the device was recently set up at the Max Planck Institute. There, it will help researchers decode the functions of various proteins. Scientists inject cells with the segment of the human genome that delivers the blueprint for the proteins under investigation. The location in the cell at which the proteins are later found gives clues as to the proteins' respective functions. The system achieves a throughput of 500 cell cultures each month. The cell factory can be adapted for use in other applications as well: For instance, it can help test the effectiveness of various drugs. Because the system is modular, researchers in science and industry can also opt to automate just certain of the steps involved.

Thanks to this device, the work of cultivating cells can be fully automated. The "cell factory" is large enough to fill a small laboratory. (© Fraunhofer IPM)

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The green look for EV charging stations

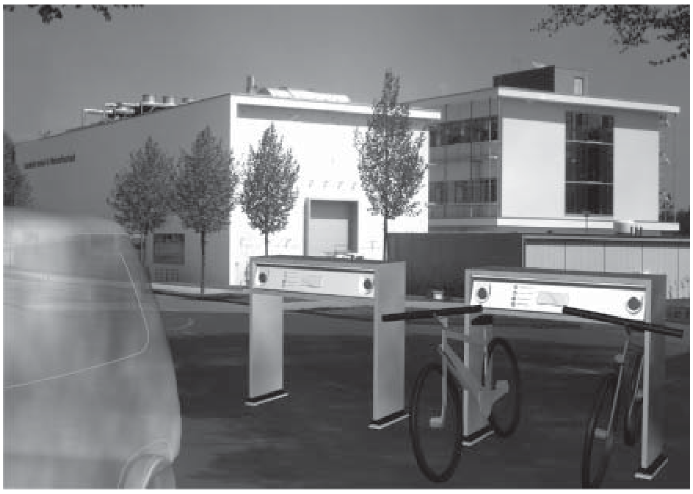
Our cityscapes will soon be dominated by a new feature: EV charging points. At present they usually feature a steel- or aluminum-clad housing. Researchers at the Fraunhofer Institute for Mechanics of Materials IWM in Halle want to improve their green credentials. In collaboration with industrial partner Bosecker Verteilerbau Sachsen GmbH, they are developing an alternative solution based on eco-friendly materials. Their idea is to replace the steel cladding that protects cables, power outlets and electronic switchgear with honeycomb panels made of a wood-plastic composite (WPC). At present, the main application for this type of reconstituted wood product is weather-resistant decking for patios.

WPC is a natural fiber composite made up of 70 parts of cellulosic wood fiber derived from sustainable resources to 30 parts of thermoplastic polypropylene. Its advantages, apart from the high proportion of sustainable raw materials, are that it is 100% recyclable and contains no tropical timber. Wood-plastic composites can be repeatedly recycled into new products and have a neutral carbon footprint. As Sven Wüstenhagen, one of the IWM researchers in Halle, explains: "Trees extract huge quantities of carbon dioxide from the atmosphere as they grow, and sequester carbon in their ligneous fibers. It is therefore probable that the use of WPC in this new application will result in lower CO_2 emissions compared with the use of steel."

Another advantage of the composite material, according to Wüstenhagen, is that its production is more energy-efficient than that of steel or other metal cladding materials. WPC is produced using an extrusion process that involves melting a mixture of wood fibers and thermoplastic resin under high pressure and at high temperature and feeding the resulting viscous product into a continuous mold. With modern processing technologies, the fibers can be added to the mixture in their natural state, without first being transformed into granulate, thus eliminating an energy-intensive intermediate stage and preserving the quality of the fibers. Because wood has a high thermal sensitivity, it has to be processed at temperatures below 200 degrees Celsius.

The housings are manufactured in the form of modular components that can be clipped together as required to create a wide variety of different designs, thus allowing them to blend in with the surrounding architecture. Their modular structure also enables the composite panels to be removed easily during repairs. Industrial design expert Wüstenhagen is already thinking about other possible new applications for the WPC components: "They could be used, for instance, to construct street furniture such as park benches or bus shelters. That's one of our next objectives. Another of our ideas is to integrate functional elements such as cable holders and cable management systems in the components for EV charging stations. This is a viable proposition because WPC can be formed into almost any shape, unlike the metal sheeting used in currently available housings."

Nonetheless, the WPC cladding has to live up to some very demanding requirements. It must be shatterproof and sufficiently elastic to withstand impact without damage, and it must be capable of resisting wide variations in temperature, high levels of humidity and prolonged UV exposure. The researchers are therefore testing samples of the material in a climate chamber to assess its resistance to extreme temperature conditions and determine which additives or types of coating provide the best weather protection. The IWM experts have almost completed their first prototype of the new WPC housing and are about to start outdoor testing. Sven Wüstenhagen and his team are confident that it won't be long before the first "all-green" EV charging stations appear on our streets.



Tomorrow's EV charging stations will be clad in eco-friendly reconstituted wood products.
(© Fraunhofer IWM)

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Software to prevent abuse at the click of a mouse

Research News
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Investigators estimate that there are currently more than 15 million photographs of child abuse victims circulating on the Internet. By the time this material has been tracked down and deleted, pedophiles have long since downloaded it to their computers. Many are avid data collectors: when suspects' data media are confiscated, detectives must often click their way through hundreds of thousands of files to find the illegal images they seek. An extremely time-consuming process – until now. Because researchers working with Dr. Bertram Nickolay of the Fraunhofer Institute for Production Systems and Design Technology IPK in Berlin have come up with a program that tackles the job automatedly. The scientists call this tool "desCRY," a seldom-heard word in English meaning "to catch sight of, to discern." "With novel pattern-recognition processes, desCRY rummages through digital photos and videos in search of illegal content, no matter how well-hidden it may be," Nickolay explains. Photos slipped in between harmless snapshots from the beach, or hidden within the action-packed sequences of a Hollywood film. The researcher and his team partnered with investigators from the State Office of Criminal Investigation in Berlin to develop a system tailored to their requirements.

The heart of the software consists of intelligent pattern-recognition algorithms that automatically analyze and classify images and video sequences. "Technologies such as facial and skin-tone recognition are combined with contextual and scene analyses to identify suspicious content," project manager Raul Vicente-Garcia explains. The algorithms use up to several thousand characteristics that describe properties such as color, texture and contours in order to analyze whether an image depicts child abuse. If the system is run on a standard PC, it classifies up to ten images per second, drastically accelerating detectives' investigations.

The software searches all of the files in a computer, e-mail attachments and archives included. Another benefit: Among other features, files can be filtered according to size and type; this makes the work of analysis less time-consuming. What's more: desCRY offers a wide variety of search options. It can perform content-based data sorting and filtering, for instance. This way, investigators can sort files by person, object or location, for example.

The search result is displayed in an image viewer that can accommodate several hundred photos as tiny icons visible at a glance. Suspicious photos are singled out, for instance by displaying them at the top of the list of results. Investigators can enlarge the images with a click of the mouse; a second mouse click stores them as evidence. Still, the system does not make detectives redundant. At the end of the analysis process, an investigator must determine whether the photos classified as illegal really contain prohibited content.

Detectives of the criminal investigation department are currently reviewing the suitability of desCRY in realistic field tests. The system could become part of the Berlin investigators' everyday toolkit by October. And they are not the only ones expected to benefit. The software group SAP has agreed to serve as integration and marketing partner. The group from Walldorf, Germany, has already joined the Fraunhofer IPK in initial discussions with other pilot users internationally.

Criminal authorities in several countries have already shown an interest in the system. As Nickolay points out: "Experts in criminal investigations find our methodology for the identification of child pornography a particularly innovative and promising approach in an international comparison."

desCry is a program that automatically searches photos and videos for child-pornographic content. Suspicious images are displayed on an image viewer. (© Fraunhofer IPK)

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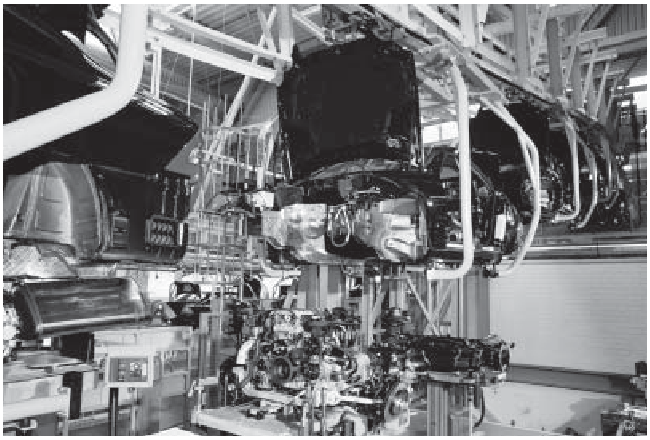
A living factory

As soon as DNA is mentioned, we automatically think of biology and living beings. It is the DNA molecule found inside each and every cell that holds the encoded blueprints for humans, animals or plants. But factories too have a master plan of this kind. All modern manufacturing facilities resemble living organisms in their complex structure. And, just as in biology, all their constituent parts are linked to one another and have to be painstakingly coordinated. Now, the Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB in Karlsruhe has taken up the challenge – together with Fraunhofer IPA in Stuttgart and Fraunhofer IPT in Aachen – of decoding "factory DNA".

It's a catchy concept, but one that is bound up with solid goals: The aim is to reduce the costs that arise whenever products or machines have to be changed. Up to now, the interplay between a factory's various systems has not been optimal. This problem is at its most obvious when production is being switched to a new item, such as a new model of car. The simple addition of a manipulator to a production line – or even just an operating system update – can cause havoc, since the slightest of changes has an impact on the entire operation. What is lacking is an intelligent link between components: the products being manufactured, the facilities doing the manufacturing, and the IT systems controlling things. This is where the experts from the IOSB are stepping in. They want to make the factory smarter by way of new interfaces that will enable it to react more or less autonomously to any changes. In this endeavor the researchers are benefiting from their years of experience of developing software solutions for factories. They are working first and foremost with Daimler AG: Their "ProVis.Agent" production management system manages around 2,000 machines in the plant where the C-Class Mercedes is made.

The key thing is to put in place intelligent links between the manufacturing facilities and the IT systems. Today, if a product is changed, the first step is to rearrange the production line. Only then is the IT system reconfigured. What's more, the details of each machine that belongs on the line have to be entered manually into a computer. This work is tedious and error-prone, involving as it does a multitude of cryptic alphanumeric combinations. "And the trouble is, you only notice any mistakes when the line is back up and running," says Dr. Olaf Sauer, division director at the IOSB. Thankfully, the research scientist and his team have managed to come up with a more elegant approach: Now employees can simply plug in a data cable and that's that. The magic words are "plug and work".

Home computing underwent a similar development. In the past, you had to install the appropriate driver before you could connect a peripheral device. Nowadays, all you need to do is plug in a USB cable. The new device uses this to communicate with the PC and to identify itself. This is effectively the approach that is set to be taken in modern factories, even if things there are a little more complex. For instance, a factory will often have many different kinds of machine built by many different companies. And the sector is nowhere near having standardized software – or even a standard software language. So the researchers have invented and patented a digital translator to take the various digital device descriptions and convert them into a standard machine language called Computer Aided Engineering Exchange (CAEX). This information is then sent to a special data storage system, which is also being patented by the Institute. “Together, these two components are enough to make a simple USB-type solution feasible,” says Sauer. “Once the data have started to flow, the computer can design a process control plan for the new production line unaided.” The IT specialists have proved that the procedure works by putting together a miniature model facility comprising four components: a conveyor belt, a turntable, a testing device, and a further conveyor belt. Work has already started on an initial real-world application.



Special software and data connectors will in future allow computers to produce graphical representations of new production lines automatically. Pictured: The production plant for the C-Class Mercedes in Bremen. (© Daimler AG)

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Microlenses for 3-D endoscopes

Research News
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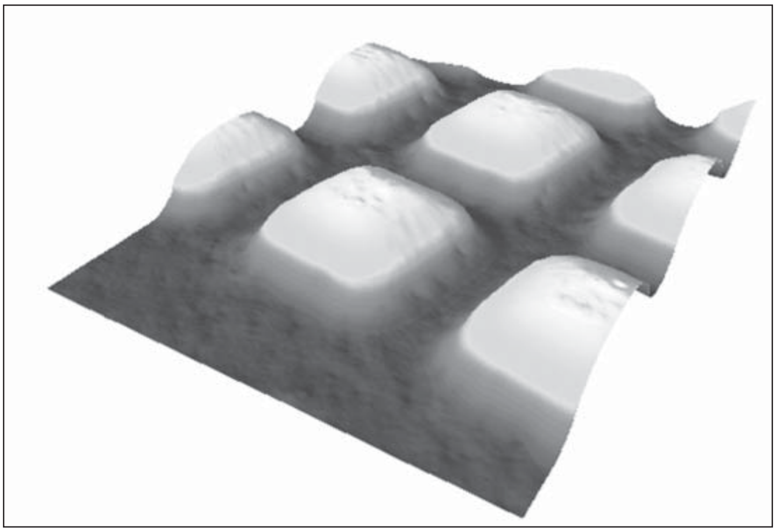
The surgeon carefully guides the endoscope through the patient's nasal cavity to the operation zone. It is a delicate procedure for which the surgeon has to prepare in detail before commencing the actual intervention. Where are the blood vessels that need to be avoided, what is the exact location of the cancerous tissue, and to what depth must the surgeon cut through the brain tissue to expose the area of interest? The camera integrated in the slender endoscope tube enables the surgeon to see every detail in sharp 3-D resolution – almost as if he were actually inside the patient's brain. The stereoscopic vision provided by a 3-D endoscope considerably simplifies the work of neurosurgeons and other specialists. They can navigate a safe path through the tissue without the risk of collateral damage, and the work can be accomplished faster.

The ability to see inside the patient's body in perfect 3-D is the result of work by researchers at the Fraunhofer Institute for Microelectronic Circuits and Systems IMS in Duisburg and the project partners in the EU project "Minisurg". The CCD sensors available in the past only provided low-resolution images. Thanks to the researchers' work, CMOS image sensors of the type commonly incorporated in single-lens-reflex (SLR) cameras can now be used in medical applications. "To make this possible, we developed special microlenses," explains IMS project manager Dr. Sascha Weyers. The secret lies in the optical design of the CMOS sensors, in which a cylindrical microlens is placed in front of every two vertical lines of sensors in the pixel configuration. A superimposed lens captures the light falling on the microlenses, which focus it on the pixels. The special feature of this arrangement is that the lens has two apertures, "rather like the right and left eye" says Weyers. In other words: two beams of light are captured by the lenses – that arriving from the left passes through the "left eye" to be focused on the right-hand vertical line of sensors, and vice versa. The two light rays cross underneath the lens arrangement. As a result, the CMOS sensor receives two sets of image data that are processed separately in the same way that the brain processes images coming from the left and right eye. A software program splits the incoming data and processes each set separately. Depending on the capabilities of the display system, the surgeon either sees the 3-D images directly on the screen or can see them when wearing polarized glasses.

It takes a special kind of microlens to ensure that the light rays are focused precisely on the sensor. In order to manufacture the lenses, the Fraunhofer engineers first had to calculate the optimum shape by means of simulations. To eliminate external factors, it had to be ensured that the lens was capable of clearly separating the right and left visual channels. In concrete terms this means ensuring that no more than five percent of the energy from one light ray is captured by the line of sensors serving the other channel – in signal transmission this is known as crosstalk.

The next task for the researchers was to adapt the conventional manufacturing process for microlenses to the requirements of the calculated lens shape. They also had to fulfill a number of requirements relating to the production of the miniature camera. They met the challenge, and the resulting chip is so small that it fits into a tube measuring no more than 7.5 millimeters in diameter. Together with the bundle of optical fibers that serves as the light source, the endoscope measures 10 millimeters in diameter – the perfect size for minimally invasive surgery.



Specially designed microlenses will one day help to transmit 3-D images from inside the human body. Their function is to precisely focus the light rays on the sensor. (© Fraunhofer IMS)

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Clean soot particle filters

Long gone are the days when trucks spewed black clouds of exhaust into the air: Nowadays, there are filters in place that capture the largest of these soot particles. After a time, if too much soot accumulates in the filter, the soot is burned off and the filter is regenerated. The problem: Soot particles only burn above temperatures of 500 to 600 degrees Celsius. Yet the temperature of truck exhaust is increasingly dropping as part of the effort to minimize emissions of nitric oxides harmful to the environment.

There exist two approaches to removing soot from the filter: the first involves an oxidation catalytic converter that converts nitrogen monoxide in the exhaust into nitrogen dioxide. If nitrogen dioxide is passed through the filter, the soot burns at lower temperatures. In some engine operating states – such as when the engine is still cold – this regeneration method does not suffice: In these cases, liquid fuel is added, that combusts with residual oxygen in the exhaust to heat the exhaust and filter. This cleansing method only works at exhaust temperatures in excess of 230 degrees Celsius, however. At lower temperatures, the fuel-exhaust mixture fails to ignite, damaging the catalytic converter. The problem: Exhaust from newer-model truck engines is only 160 to 180 degrees Celsius.

Researchers at the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg, Germany, have come up with a method that reliably regenerates filters even at exhaust temperatures as low as 140 degrees. "We add a synthesis gas consisting of carbon monoxide and hydrogen to the exhaust," explains Dr. Thomas Aicher, group manager at ISE. "We introduce this gas mixture at the oxidation catalytic converter – lowering the ignition temperature to 140 degrees Celsius and freeing the filter from soot even at these low exhaust temperatures."

But where does this synthesis gas come from? "We have two ways to generate this gas: One is to heat diesel fuel in the absence of air. This produces hydrogen and carbon. Then, the carbon is burned with the exhaust, creating carbon monoxide. Experts refer to this process as pyrolysis. The other way is to oxidize diesel with a very small amount of air so that the diesel combusts only partially. This is known as partial oxidation," explains Robert Szolak, a scientist at ISE. Researchers have already built and successfully tested prototypes for both approaches. The experts have now partnered with an industrial partner to investigate partial oxidation in greater detail.

A researcher checks whether the soot particle filter is freed from soot even at exhaust temperatures of 140 degrees Celsius. (© Fraunhofer ISE)

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