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RESEARCH NEWS

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1 Cashless parking

Vacant parking spaces in town are thin on the ground. Finding one is just as tiresome as making sure you have the right change for the parking machine. An adhesive microchip on the windshield will make things much easier by unlocking the door to cashless parking.

2 Data are traveling by light

Regular LEDs can be turned into optical WLAN with only a few additional components thanks to visible light communication (in short, VLC). The lights are then not just lighting up, they also transfer data. They send films in HD quality to your iPhone or laptop, with no loss in quality, quickly and safely.

3 Solar power does not have a long shelf life

Storing power is complicated and expensive, but very often, especially far away from the regular power grids, there is no way around large batteries for grid-independent electricity consumers. It would make more sense to use the electricity when it is generated. This becomes possible with the help of a smart energy management system.

4 Making runways safer

Airplanes undergo significant stresses during take-off and landing, and parts often become detached, putting subsequent runway users at risk. Until now, airport staff have had to monitor runways without technical assistance – an activity that is prone to errors. A new radar system is set to increase safety at airports.

5 Spotting weaknesses in solid wood

Is there a hairline crack in the oak table? Was the window frame glued badly? Ultrasound thermography can reliably identify material defects during the production of wooden items. This allows rejects to be caught quickly and eliminated, and faulty goods to be repaired in good time.

6 Special software helps to save species

With the aim of better protecting endangered species, game wardens are studying the behavior of surviving great apes in the wild. This is often painstaking work because it is difficult to distinguish between different individuals. A new software system will make things easier by analyzing the animals' faces for individual identification.

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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Cashless parking

The car moves slowly towards the car park exit, the barriers open automatically – without the driver having to wind down the window and insert a ticket. This is thanks to a small RFID chip on the inside of the windshield. Devices on the ceiling above the car park entrance and exit read the adhesive foil transponder measuring just 1.5 x 10 centimeters and register the parking time. The fees are charged by a direct debit from an online account. VIATAG is the name of the RFID system which the research scientists at the Fraunhofer Institute for Material Flow and Logistics IML in Dortmund have developed for Munich-based company motionID technologies. "Waiting at the parking machine, searching for change, losing your ticket – all that is a thing of the past. The car driver saves time and enjoys a more convenient service," states project manager Arnd Ciprina from the IML, listing the advantages of the system. And the car-park operators benefit too. The cost of recording and billing the parking time is reduced, but they can continue to use their existing systems in parallel to the new solution.

VIATAG is a passive RFID solution, which means that the microchip does not need a battery. It draws its energy from the electromagnetic field of the reader device. The radio data are transmitted in the ultra-high frequency (UHF) range and the distance between the transponder and reader can be up to eight meters. Each chip has its own twelve-digit code, enabling every car to be identified when passing through the entrance and exit. The fees are charged in the background online. A database application running on a central server controls the payment transactions. The customer can maintain an overview of the amounts debited at all times on a web application, like online banking. A list of the parking time and charges can be printed out as a partial or complete account. The total amount owed is paid at the end of the month by direct debit.

Data security is not a problem either. Ciprina: "No personal data is stored on the chip. The twelve-digit code is encrypted so that third parties cannot connect the identification number with a user." Nor is it worth stealing the foil transponder. If the sticker is removed from the windshield it self-destructs and cannot be used again.

VIATAG successfully passed the initial practical tests, which lasted several weeks. The system has already been installed in public car parks in Essen, Duisburg and Munich. The research scientists at the IML and motionID technologies now hope that a lot more car-park operators will support the solution. Other sectors should also find the

contactless and cashless payment system interesting. Automatic billing would be suitable for highway service plazas, gas stations, drive-in cinemas and eateries, car washes and car hire firms, adds Ciprina.

The RFID chip is affixed on the inside of the windshield. It measures just 1.5 x 10 centimeters. (© motionID technologies)

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Data are traveling by light

Just imagine the following scenario: four people are comfortably ensconced in a room. Each one of them can watch a film from the Internet on his or her laptop, in HD quality. This is made possible thanks to optical WLAN. Light from the LEDs in the overhead lights serves as the transfer medium. For a long time, this was just a vision for the future. However, since scientists from the Fraunhofer Institute for Telecommunications, Heinrich Hertz Institute HHI in Berlin, Germany, have developed a new transfer technology for video data within the scope of the OMEGA project of the EU, its implementation in real life is getting markedly closer. At the end of May, the scientists were able to present the results of the project in Rennes, France. They were able to transfer data at a rate of 100 megabits per second (Mbit/s) without any losses, using LEDs in the ceiling that light up more than ten square meters (90 square feet). The receiver can be placed anywhere within this radius, which is currently the maximum range. "This means that we transferred four videos in HD quality to four different laptops at the same time," says Dr. Anagnostis Paraskevopoulos from the HHI.

"The fundamentals of visible light communication (VLC) were developed together with the industry partners Siemens and France Telecom Orange Labs," said the expert. At HHI, the team of project manager Klaus-Dieter Langer is now further developing the new technology. "For VLC the sources of light – in this case, white-light LEDs – provide lighting for the room at the same time they transfer information. With the aid of a special component, the modulator, we turn the LEDs off and on in very rapid succession and transfer the information as ones and zeros. The modulation of the light is imperceptible to the human eye. A simple photo diode on the laptop acts as a receiver. As Klaus-Dieter Langer explains, "The diode catches the light, electronics decode the information and translate it into electrical impulses, meaning the language of the computer." One advantage is that it takes only a few components to prepare the LEDs so that they function as transfer media. One disadvantage is that as soon as something gets between the light and the photo diode (for example, when someone holds his hand over the diode) the transfer is impaired. Laptops, Palm devices or mobile telephones are all potential end devices.

The scientists emphasize that VLC is not intended to replace regular WLAN, Power-LAN or UMTS. It is best suited as an additional option for data transfer where radio transmission networks are not desired or not possible – without needing new cables or equipment in the house. Combinations are also possible, such as optical WLAN in

one direction and PowerLAN for the return channel. Films can be transferred to the PC like this and also played there, or they can be sent on to another computer.

The new transmission technology is suitable for hospitals, for example, because radio transmissions are not allowed there. Despite this fact, high data rates must be transmitted without losses and unzipped, according to the experts. If part of the communication occurs via the light in the surgical room, this would make it possible to control wireless surgical robots or transmit x-ray images. In airplanes, each passenger could view his own entertainment program on a display, saving aircraft manufacturers miles of cables. Another possible venue for the application of this technology are production facilities, where radio transmissions very often interfere with the processes.

Currently the scientists are developing their systems toward higher bit rates. "Using red-blue-green-white light LEDs, we were able to transmit 800 Mbit/s in the lab," said Klaus-Dieter Langer. "That is a world record for the VLC method." The HHI scientists will showcase how videos are transmitted by light in Hall 11.1, Booth 8 at the International Telecommunications Fair IFA (Internationale Funkausstellung IFA) in Berlin from September 2-7, 2011.

In the future data will be transferred to laptops with the help of LEDs. (© Fraunhofer HHI)

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Solar power does not have a long shelf life

For fruits, cereals and leguminous plants such as oranges, wheat, beans and olives to grow in hot and dry climates, they must be irrigated regularly. And very often the water used comes from deep wells. In Egypt, many farmers currently use diesel generators to water their fields. A model project in Upper Egypt, in Wadi El Natrun, shows that other methods are possible. Here, a photovoltaic stand-alone system takes care of irrigating a wheat field. Concentrator photovoltaic system (CPV) modules – which, due to their higher degree of effectiveness and their particular construction, require far less space than traditional PV modules – supply the energy, while Fresnel lenses concentrate the rays of the sun onto pinhead-sized multi-junction solar cells. With the aid of a tracking motor, the CPV cells, which are attached to a pillar, follow the sun precisely to achieve an optimized yield of solar light. They supply the energy for a submersible pump that pumps the water up from a well that is 105 feet deep and for a small desalination unit that satisfies farmers' potable water requirements. The CPV cells also supply the energy for PV-module trackers, the monitoring and control system and an air-conditioning unit that cools the utility room of the facility.

In order to make the complete system as inexpensive as possible, the developers largely did without expensive batteries for the intermediate storage of the energy gained from the solar cells. "Where there is no public power grid, the PV systems currently operate cost-effectively, due to their low operating costs. The only problems are posed by the high initial costs of the investment, in which the batteries play a substantial role," explained Jakob Wachtel from the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg, Germany. "By immediately using the largest share of the energy that is generated we can save on expensive storage media capacities," adds his colleague, Alexander Schies. A sophisticated energy management system monitors the generation of energy and ensures that it immediately goes where it is needed at the moment, such as the submersible pump to fill up the water reservoir, the irrigation pump when it is time to irrigate the field or the desalination unit. Developers only store some of the solar energy in a relatively small battery to operate the CPV tracker and the measuring system. "We need this reserve, in particular, to align the CPV modules in the morning to their morning position," explained Jakob Wachtel. Unlike traditional solar modules made of silicon, the concentrating photovoltaic systems provide energy only if they are precisely aligned to the sun.

All of the irrigation system components have micro-controllers that transmit their status data to the energy management system that controls them. The Universal Ener-

gy Supply Protocol (UESP) developed at the ISE was designed especially for this type of energy and load management and is the form of the communication of choice. Currently, the UESP is being integrated into the CANopen protocol CiA454 of the CiA (CAN in Automation) organization as an application profile for grid-independent energy supply systems. CANopen is rather prevalent in automation technology and has established itself as the standard for the control of electrical devices. "All systems that work with these kinds of protocols can be expanded at any time with devices that 'understand' CANopen or UESP – completely independent of the manufacturer. This is practical if a defective component has to be replaced," emphasized Alexander Schies. This, too, contributes to the savings. At the same time it simplifies the maintenance and further development of the stand-alone CPV system.

The concentrating photovoltaic modules in Egypt are precisely aligned to the sun. They supply power to irrigate wheat fields. (© Fraunhofer ISE)

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Making runways safer

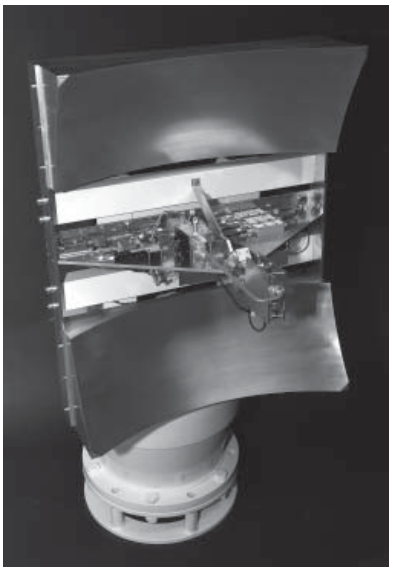
It might have happened over ten years ago now, but most people can still recall the Concorde crash: the TV images showing the supersonic jet with flames streaming from its tail were unforgettable. It was a piece of metal lying on the runway during take-off that caused the accident. The aircraft's tire burst as it rolled over the metal, sending chunks of rubber flying into the fuel tank, which then exploded – with the loss of 113 lives. To avoid accidents such as this, airport staff drive up and down runways at six-hour intervals looking for any pieces of debris. But to monitor the huge areas in question without any kind of technical assistance is time-consuming and error-prone work – especially in bad weather, for instance when fog is obscuring the view. And the intervals between checks are also too long.

A new weatherproof safety system will in future monitor runways continuously for debris and warn of any dangers. Research scientists at the Fraunhofer Institutes for High Frequency Physics and Radar Techniques FHR and for Communication, Information Processing and Ergonomics FKIE are developing the system in conjunction with the University of Siegen, PMD Technologies GmbH and Wilhelm Winter GmbH in a project dubbed LaotSe – short for "Airport runway monitoring through multimodal networked sensor systems". "Our technology would have prevented the Concorde tragedy from happening," says Dr. Helmut Essen, who heads the Millimeter-Wave Radar and High Frequency Sensors department at the FHR in Wachtberg. "Devices installed all along the runway continuously scan the surface. They can detect even the smallest of items, such as screws, but the system will only issue a warning if an object remains on the runway for a longer period of time. A windblown plastic bag or a bird resting briefly will not set off the alarm."

The system comprises an infrared camera, optical 2D and 3D cameras and networked radar sensors. These sensors were developed by researchers at the FHR. The three different types of equipment complement each other: Radar functions around the clock and whatever the weather. It can detect objects but not identify them. The cameras are better suited to classifying objects, but they are affected by the weather and the time of day. Whenever a radar sensor detects something, it instructs the cameras to take a closer look. All the sensor data are then amalgamated using software developed at the FKIE to produce a situational overview. The FKIE experts call this 'sensor data fusion'. If the overview shows an abnormal situation, air traffic control is informed in the tower. They can take a look at their screens to judge whether there is a real danger and, if so, halt air traffic. "Our solution is merely an assistance system.

The final decision on how to proceed lies with airport staff," stresses Dr. Wolfgang Koch, head of department at the FKIE.

While similar radar systems have been developed, these are only capable of detecting metal objects, and they often give rise to false alarms. What is more, because they are mounted high up on masts they can easily be damaged in the event of an airplane accident. Dr. Essen outlines some of the new system's advantages: "Our radar sensor transmits at a frequency of 200 GHz, so it can detect objects that are just one or two centimeters across. And using three different kinds of sensor means false alarms are almost out of the question. The device is miniaturized and scans up to 700 meters in all directions." Initial testing of a radar sensor and camera will begin at Cologne-Bonn airport this fall, and plans are in place for further testing using several demonstrator systems before the project ends in April 2012.



The radar sensor can detect objects just centimeters across on runways. (© Fraunhofer FHR)

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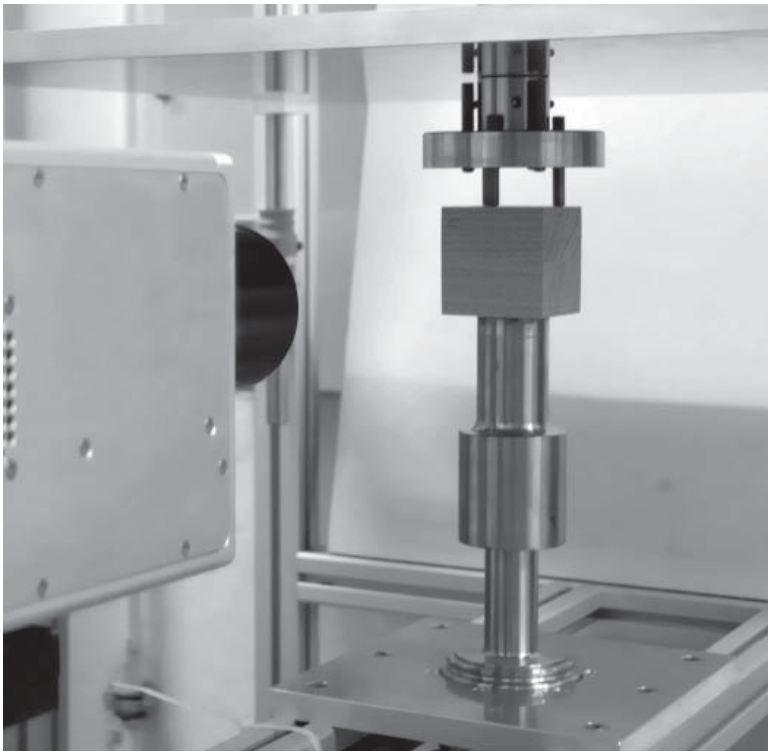
Spotting weaknesses in solid wood

People who buy an expensive solid wooden table or wardrobe want to be certain that their new piece of furniture is absolutely faultless. Pianos – whether upright or grand – can only produce an opulent tone if their soundboard, bridge and keyboard are made of high-quality materials. And wood that is free of imperfections is also essential in house building and window construction: load-bearing wooden beams need to be of the highest quality, as even the smallest crack can cause them to fail.

Research scientists from the Fraunhofer Institute for Wood Research, Wilhelm-Klauditz-Institut, WKI in Braunschweig are able to pinpoint defects in wood that cannot be seen with the naked eye. Using high-power ultrasound thermography they can detect longitudinal and transverse cracks, gluing errors, delaminations and black knots. To do this they vibrate the wooden item using a sonotrode, or ultrasound agitator, at a frequency of 20 kHz – in other words, 20,000 times a second. Where there are defects, the different parts of the material rub against each other and produce heat. This heat at the defect's extremities is picked up by a thermal imaging camera connected to a monitor; in the case of hairline cracks, frictional heat can be seen along the length of the crack as well. High-power ultrasound thermography even allows the researchers to probe beneath the surface to uncover dowels that have not been glued and defects hidden under coatings – something that today's much less reliable testing methods, such as mechanical materials testing or electrical measuring, are simply not able to do.

"We can spot the imperfections in raw timber. That is crucial for rejecting defective wood before time and money have been invested in processing it," says physicist Peter Meinlschmidt at the WKI. Whether the wood in question is oak, walnut or beech is not important, and neither is the condition of the wood ; defects in damp parts show up on the thermal imaging camera too. The depth to which the wood can be analyzed depends on its thermal conductivity, but up to 20 millimeters are possible. "Our process is especially suited for finding defects in high-quality solid wooden parts and window frame squares and to detect badly glued joints. It's a non-destructive testing method. Applying the ultrasound agitator does leave small pressure marks though – but these aren't an issue when you're dealing with raw timber," explains Meinlschmidt. The researchers have even managed to use high-energy ultrasound thermography to detect cracks in ceramics and glass. In laboratory tests, they were able to pinpoint defects in ceramic floor tiles and in glass mouthwash bottles. "In ceramics and glass we can spot defects that are up to 30 centimeters away from the

sonotrode," says the research scientist. A demonstrator of the ultrasound generator with thermal imaging camera has already been built.



The ultrasound agitator causes the wood to vibrate, which generates frictional heat wherever there are cracks. A thermal imaging camera shows these defects up. (© Fraunhofer WKI)

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Special software helps to save species

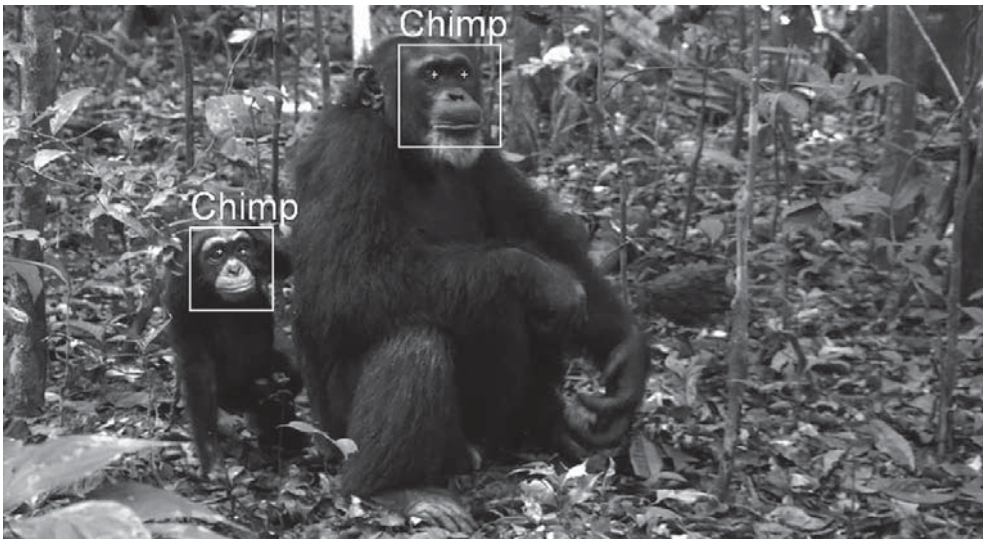
The pictures from the video trap are highly encouraging. A strong young male gorilla appears several times – in a tree, moving through the forest, at a feeding place. This is a good sign for the park ranger. It indicates that the population in the protected zone is recovering. What he does not know, however, is whether it's the same gorilla each time or various young adults. Knowledge of how many individuals are living in a particular area is vital if these extinction-threatened species are to be more effectively protected. The park rangers therefore spare no effort to obtain reliable figures about the population. They search the forests for feeding and gathering places, read tracks and try to match them to specific individuals. In addition, they spend hours analyzing pictures from video and photo traps – a painstaking and time-consuming job, which is also subjective and susceptible to error.

A new software system could soon make things easier for the park rangers by searching through the photos and videos for sequences in which the animals appear and assigning the images to individual gorillas. Scientists at the Fraunhofer Institutes for Integrated Circuits IIS and Digital Media Technology IDMT as well as at the Max Planck Institute for Evolutionary Anthropology are jointly developing the system in the SAISBECO project.

"The pictures are first filtered to find the ones on which the primates' faces can be seen," explains Alexander Loos from the IDMT in Ilmenau. This task is handled by a detection software program developed by research scientists at the IIS in Erlangen which detects faces on individual pictures as well as on video streams in real time. Loos and his colleagues are currently developing a module that will assign the faces to specific individuals. "Our software analyzes the primates' faces using special algorithms," states Loos. At the moment these face-recognition algorithms analyze the entire face. In a data pool of 24 chimpanzees at Leipzig Zoo the Max Planck research scientists achieved a recognition rate of 83 percent.

This good hit accuracy is due to the high quality of the photos. "The algorithms are strongly affected by external influences," explains Loos. "In poor light or if the faces are partially occluded the recognition rates quickly drop to below 60 percent." Because it is much more difficult to get good pictures in the wild, the Ilmenau-based research scientists intend to add further algorithms which will not analyze the entire face but specific biometric features – such as the eyes, nose and mouth.

The new software system also analyzes audio signals and assigns them to various noises made by the apes, for example chest drumming and threatening grunts like pant-hoots. This provides not only a basis for studying their social behavior but also enables specific individuals to be quickly identified, as the research scientists no longer have to listen to all of the recorded material. As a next step, the scientists intend to expand their data sets, because the software system learns as it performs the analysis, and the recognition rate improves as the number of pictures per individual in the data pool increases. A further module is also to be added to the system. This will automatically recognize what activity the ape is engaged in and provide valuable information in particular for studying their social behavior.



The new software system searches through photos and video sequences, analyzes the apes' faces and links them to individuals. (© Dr. Tobias Deschner - MPI EVA (2009), Taï Nationalpark)

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