Fraunhofer
IGD

FRAUNHOFER INSTITUTE FOR COMPUTER GRAPHICS RESEARCH IGD

New opportunities in the virtual space

OUR YEAR 2019

RESEARCH IN ACTION

Dear friends and partners,

In 2019, we remained firmly committed to collaborating closely with business and politics, and to embedding our projects within society as a whole, and vice versa: Real-world needs are at the root of the questions for which we seek solutions. In the face of climate change, new concepts must be adopted for built environments and infrastructure, for instance—and quickly. It has long been common practice for private citizens to voice their opinions via internet forums. However, the corresponding government agencies must cope with a veritable flood of posts and emails—including criticism or proposals that are simply not feasible as they do not comply with legislation. This can delay project implementation. In addition, the difficulty of bringing together all partners and experts hinders planning, slows down the agreement process, and delays important decision-making.

A realistic view of the future

We tackle and resolve these issues at their core—because visual computing makes things easier to understand and imagine. Furthermore, our solutions help to secure the involvement of all stakeholders, simply and digitally. Our applications harness high-fidelity visualization, and combine this with specialist knowledge, to explain and communicate complex ideas at the planning stage.

EDITORIAL

We offer both professional experts and lay citizens an interactive 3D web application that puts proposed development projects in an easy-to-comprehend and realistic context, and ensures markedly greater acceptance of the outcomes.

The city of Hamburg is already putting this into action. Citizens are able to recommend places to plant trees. They immediately receive a response on whether their suggestion complies with applicable rules and regulations—and, where this is the case, the city's planning software can suggest alternative locations. Transparent, rapid feedback of this kind encourages residents to take a proactive and productive part in urban planning processes.

The same approach can be applied to other areas, e.g., broadband infrastructure, traffic management, renewable energy, and much more. Everyone is able to contribute to the discussion, at any time, from anywhere. All have access to the same comprehensive information, and can exchange views via a virtual platform.

Learning in a virtual space

Fraunhofer IGD has also opened up new possibilities in education and training, enabling more cost-effective, eco-friendly, and efficient skills transfer. Learning across multiple channels, i.e., both verbally and via images, improves knowledge retention. So, since 2019, volunteers at the German Red Cross have participated in virtual training sessions—practicing emergency situations involving the deployment of ambulances, even when the actual vehicles are not available. Or consider this: How do apprentices at Heidelberg learn to understand, maintain, and repair the company's sophisticated printing systems? By halting production, taking the equipment apart, and putting it back together? Virtual training is much more efficient, allowing the new recruits to learn by "seeing" and understanding the printers' inner workings, without downtime. Moreover, our virtual experimentation environments do not require programming skills. And they support genuine learning, as they enable interaction between the student and the software. The user can try out things, explore, and add their own comments, notes, and more—visually, in a way that transcends language and geographical barriers.

Visual computing, including virtual reality (VR) and augmented reality (AR), is and will remain an exciting field, and not just in research. VR and AR have huge potential, as highlighted in a study by PricewaterhouseCoopers. By 2030, 400,000 people in Germany alone are expected to use these technologies in their work, compared to 15,000 today. These tools are designed to strengthen teamwork and collaboration—and that is what we aim for in our research: in the shape of a shared, communicative and participative process. In this annual report, we provide you with information and insights into our current projects in a spirit of cooperation and partnership. We look forward to our shared journey,

Dieter W. Fellner, Professor

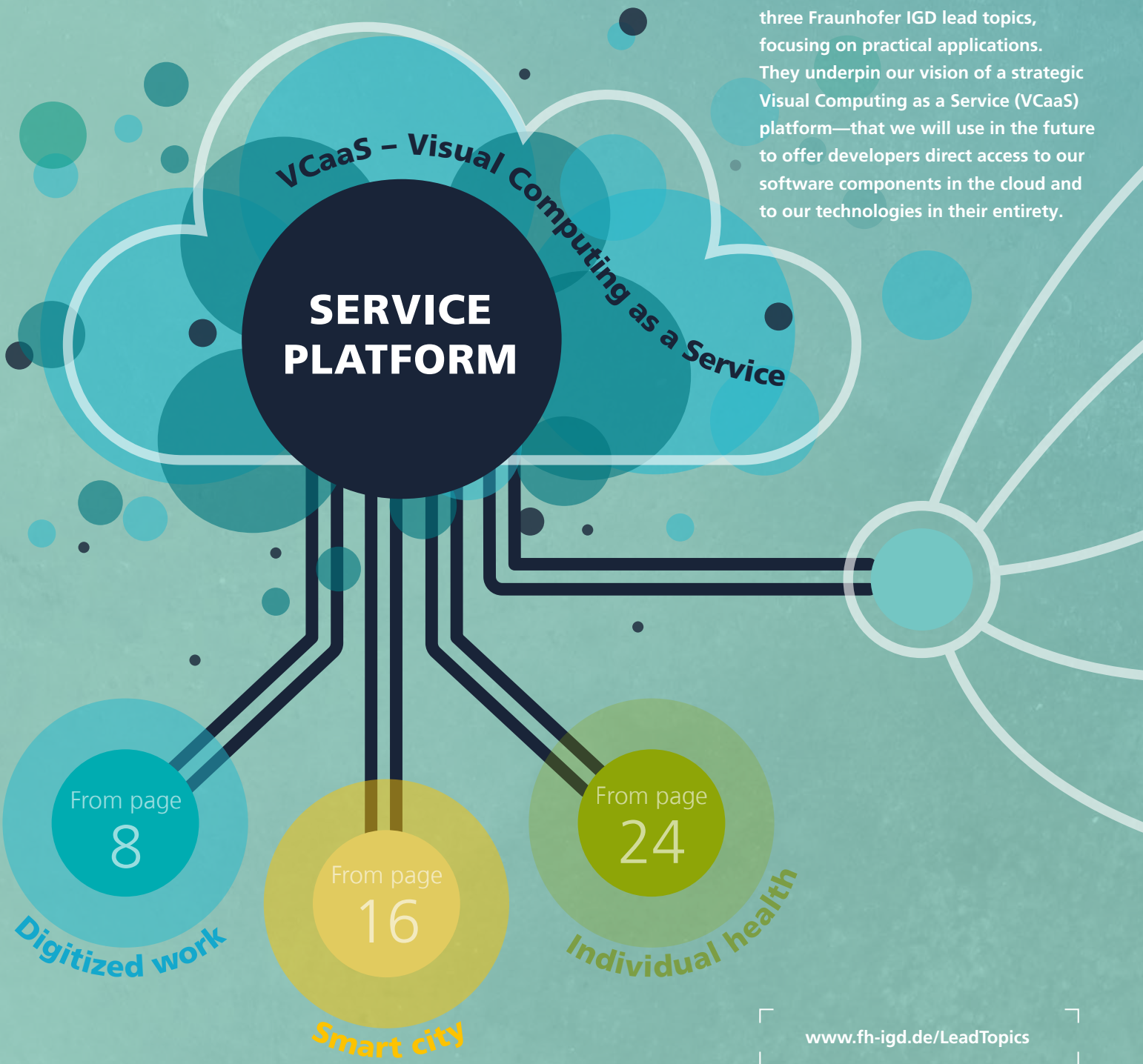
Dr. Matthias Unbescheiden

You can also read this annual report online:
www.fh-igd.de/JB19-en

OUR EXPERTISE: VISUAL COMPUTING

Our goal is to perform applied research in visual computing that has a substantial and lasting impact. We put people center stage, and leverage interactive visualization to make complex processes easier to understand, with the aim of aiding and improving decision-making.

Our research revolves around our three Fraunhofer IGD lead topics, focusing on practical applications. They underpin our vision of a strategic Visual Computing as a Service (VCaaS) platform—that we will use in the future to offer developers direct access to our software components in the cloud and to our technologies in their entirety.



www.fh-igd.de/LeadTopics

RESEARCH AT FRAUNHOFER IGD IS DIVIDED INTO FIVE STRATEGIC LINES:

CG

COMPUTER GRAPHICS

Image-synthesis technologies and methods create virtual representations of information, i.e., by generating images. We create virtual worlds for diverse scenarios. Our efficient, flexible processes keep pace with current trends: e.g., shared usage of resources, real-time capabilities, and mobility.

CV

COMPUTER VISION

The visual representation of real, physical objects forms the basis for advanced automation and engineering processes. A variety of sensors ensure high reliability for augmented reality, material acquisition, and 3D reconstruction. Our technologies capture, track, and reproduce objects, their position, and their texture at high speed and with high fidelity.

HCI

HUMAN-COMPUTER INTERACTION

We develop technologies that enable humans and machines to collaborate effectively on the basis of ever-growing data volumes. New interaction modalities, intelligent environments, and visualization methods enhance human-computer interaction in complex, data-intensive applications where robust security is critical.

SIM

(INTERACTIVE) SIMULATION

Computer graphics supports and accelerates simulation, i.e., the virtual replication of the behavior of physical objects and phenomena. We develop simulation processes that feature integrated modeling and visualization to speed up design work and enable users to directly interact with and modify the simulation.

MOD

MODELING

Models provide an abstract view of selected aspects of reality within an information processing system. We research 2D and 3D, as well as more complex, higher-dimension models for use in real-world scenarios. Supplementary information is added to make models suitable for new applications and connected solutions.

www.fh-igd.de/ResearchLines

DIGITIZED WORK

PEOPLE IN INDUSTRY 4.0

Our mission is to harness the full potential of digitization and find ways to best empower people in their daily work tasks. We unite the virtual and real worlds, and offer visual-computing solutions that assist activities ranging from planning, to manufacturing, to service and support.


DEV 3

LEARNING WITH THE HELP OF VIRTUAL REALITY

Virtual training environments from Fraunhofer IGD will soon be helping paramedics develop their skills. The Machine@Hand assistance system has been licensed to a regional branch of the German Red Cross, where it is demonstrating how digital transformation opens up new possibilities in knowledge transfer.

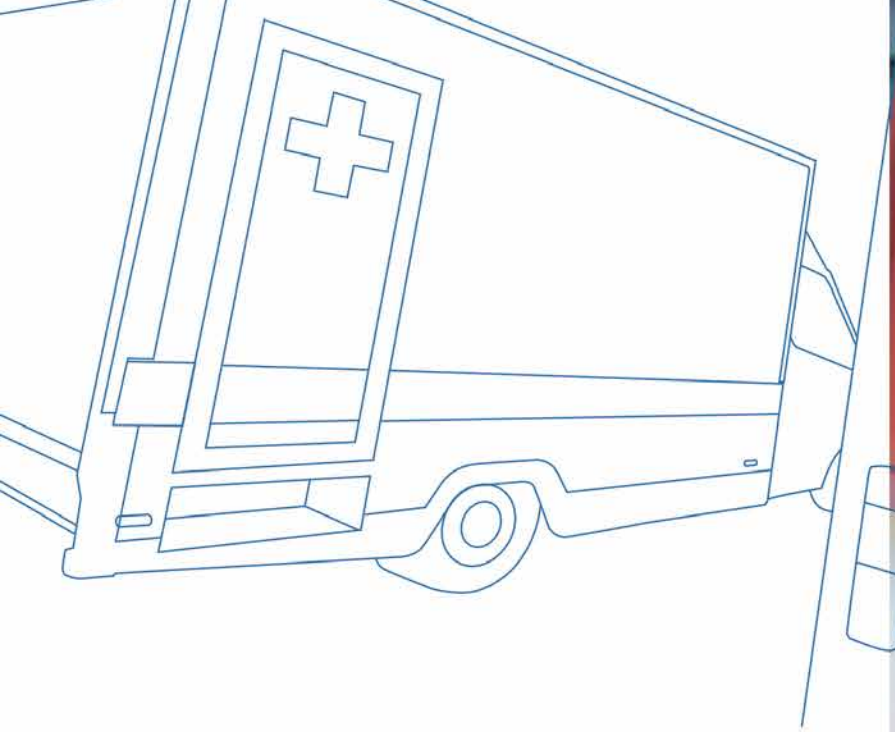
The training program for first-responder paramedics entails some 800 hours of tuition. For example, it is essential to know every last feature of an ambulance in order to find and retrieve equipment immediately in an emergency. The only way to acquire this knowledge is to practice, practice, and practice again. That takes time and, of course, access to an ambulance. And that can prove difficult, as the extremely well-equipped vehicles are required for real-life incidents—and those have priority. The Red Cross in Herford has therefore turned to virtual reality and has already gained positive experience with virtual accident scenarios and 360-degree depictions of various use cases. Now, the organization has acquired a license for Machine@Hand, a virtual tool from Fraunhofer IGD, for training its voluntary first responders. In a similar way to pilot training on a flight simulator, the plan is for each trainee at the Red Cross to complete a certain number of hours of practice in the virtual ambulance until they know by heart which drawer has to be opened in which situation. This should ensure the paramedic can act confidently in a genuine emergency, and reduces the time spent on the program, as there is no need to physically travel to a central training facility.

Training with VR means learning by doing

Machine@Hand was conceived as a visual assistance system for the manufacturing industry, where operational and maintenance tasks are becoming increasingly complex. The virtual training environment, which can be operated via a VR headset, a tablet, or a smartphone, is employed to visualize three-dimensional work instructions with high positional precision, creating a highly realistic impression. As a result, new tasks can be learned by doing, and with far greater speed than would be possible through purely theoretical tuition. Moreover, the tasks can be repeated far more often in the virtual world than in physical reality. The disassembly and reassembly of large items of equipment merely for educational purposes is not just cost- and time-intensive, it is often a logistical impossibility. As a result, printer manufacturer Heidelberg now deploys Machine@Hand to develop the skills of its service engineers. Currently, Fraunhofer researchers are working on a further development of the software. The aim is to make the new version even more versatile, allowing its use in more industries, with a broad choice of background scenarios and the ability to visualize multiple machines concurrently. Moreover, it will be able to run on a greater variety of devices. The goal is to develop this latest version into a licensable product.

New possibilities in healthcare

In engineering, design data are already available for the creation of 3D visualization, but in other sectors it is not as simple. In the case of the Red Cross, it was necessary to first create a highly detailed model by means of a 3D scanner. But it was a hurdle that Thomas Pilz, the digital transformation officer at Herford Red Cross and a self-described VR nerd, was determined to overcome. "We are motivated by a vision: Training people in a way that is aligned with our modern way of living. By making use of advanced technologies, we want to not just create a more flexible training program, but also make voluntary work more appealing." His vision is to take the principles learned in the pilot project and apply them to the Red Cross organization at regional and federal level. Dr. Mario Aehnelt, Head of the Visual Assistance Technologies Competence Center at Fraunhofer IGD, is convinced that the virtual training solutions developed by his team have widespread potential in



many other areas. "In principle, Machine@Hand can be applied to any type of machine or technical unit; for instance, medical professionals could learn how to operate new dialysis equipment. And if the 3D models are not already available, we can advise and assist with their creation, and leverage our broad network of partners. So, nobody should be put off taking the first step toward virtual training."

Intuitive and interactive

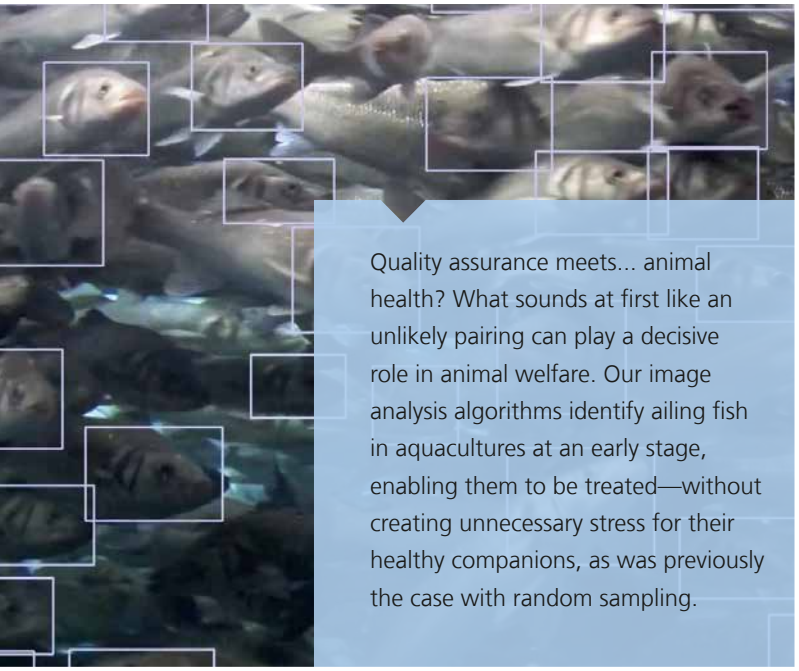
Once the data are in place, setting up the training application is highly intuitive. A variety of scenarios can be created on a PC, tablet, or directly in the virtual environment, and can be edited at a later point. The modular 3D models allow the simple and intuitive presentation of training content. Elements within defined scenarios can be highlighted with color, animated, made visible or hidden, and combined with text, images and videos. The trainees are not simply consumers of this information; they can include their own comments. The operating instructions, be it a cylinder printing press or an ambulance, are dynamic and interactive in nature—the user can add their own notes, videos or markings, and can share their ideas with others. This collaborative approach also helps to promote effective teamwork—what more could you want? ■

www.fh-igd.de/Virtual-Learning

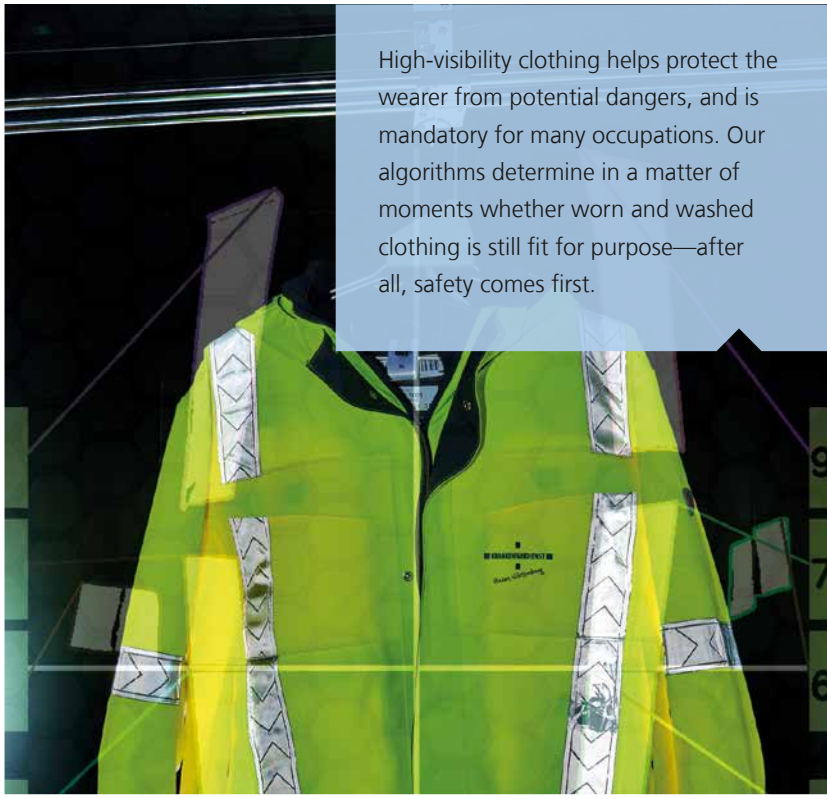
EVERYTHING OK? QUALITY CONTROL WITH VISUAL COMPUTING

Visual computing and its subdisciplines help to verify compliance with minimum requirements and to conduct quality assurance in a broad range of industries. Here, we present selected research activities in this space.

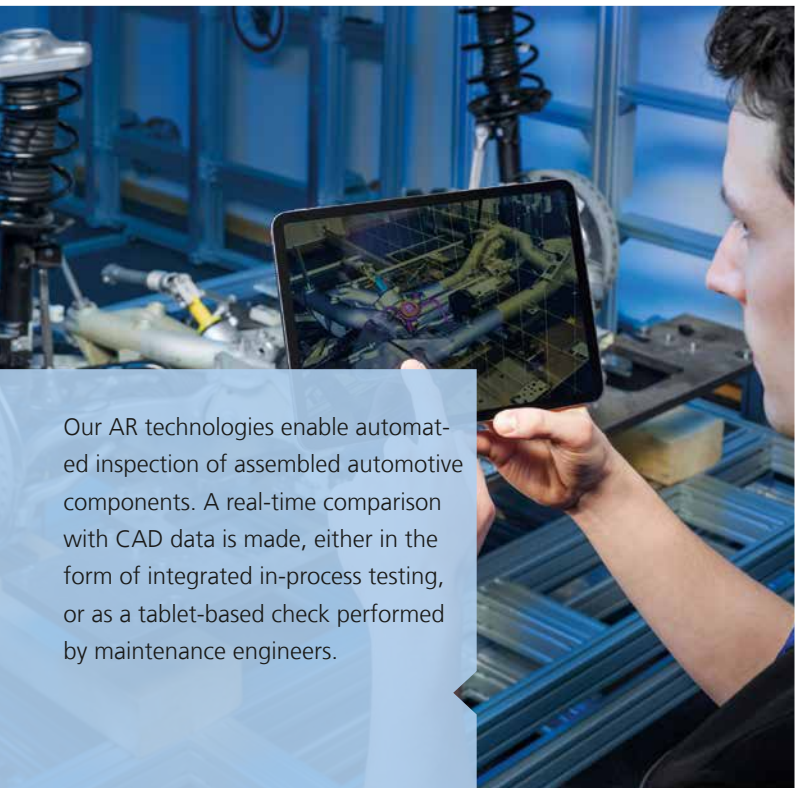
www.fh-igd.de/QualityAssurance



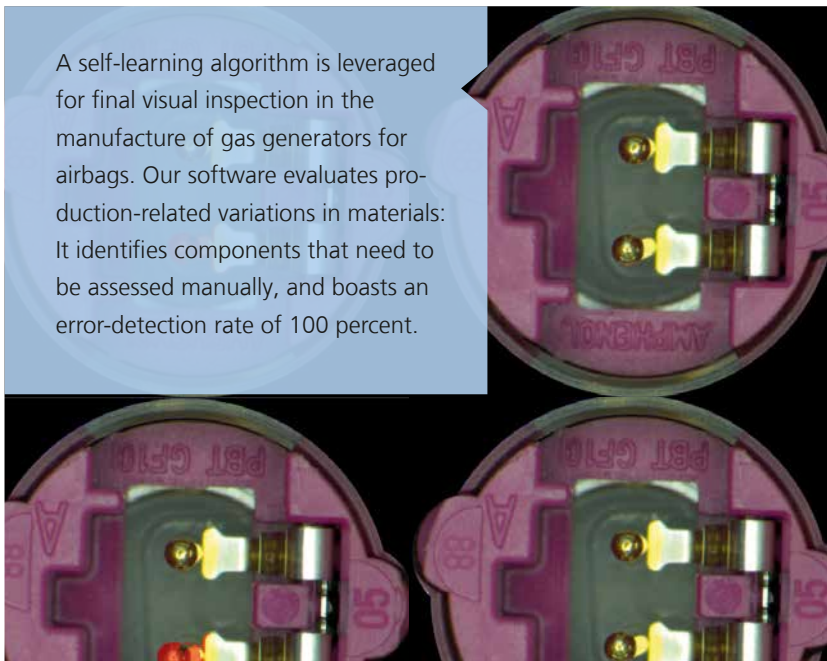
Quality assurance meets... animal health? What sounds at first like an unlikely pairing can play a decisive role in animal welfare. Our image analysis algorithms identify ailing fish in aquacultures at an early stage, enabling them to be treated—without creating unnecessary stress for their healthy companions, as was previously the case with random sampling.



High-visibility clothing helps protect the wearer from potential dangers, and is mandatory for many occupations. Our algorithms determine in a matter of moments whether worn and washed clothing is still fit for purpose—after all, safety comes first.



Our AR technologies enable automated inspection of assembled automotive components. A real-time comparison with CAD data is made, either in the form of integrated in-process testing, or as a tablet-based check performed by maintenance engineers.



A self-learning algorithm is leveraged for final visual inspection in the manufacture of gas generators for airbags. Our software evaluates production-related variations in materials: It identifies components that need to be assessed manually, and boasts an error-detection rate of 100 percent.

HOW MACHINES LEARN THE FINE ART OF SELF-IMPROVEMENT

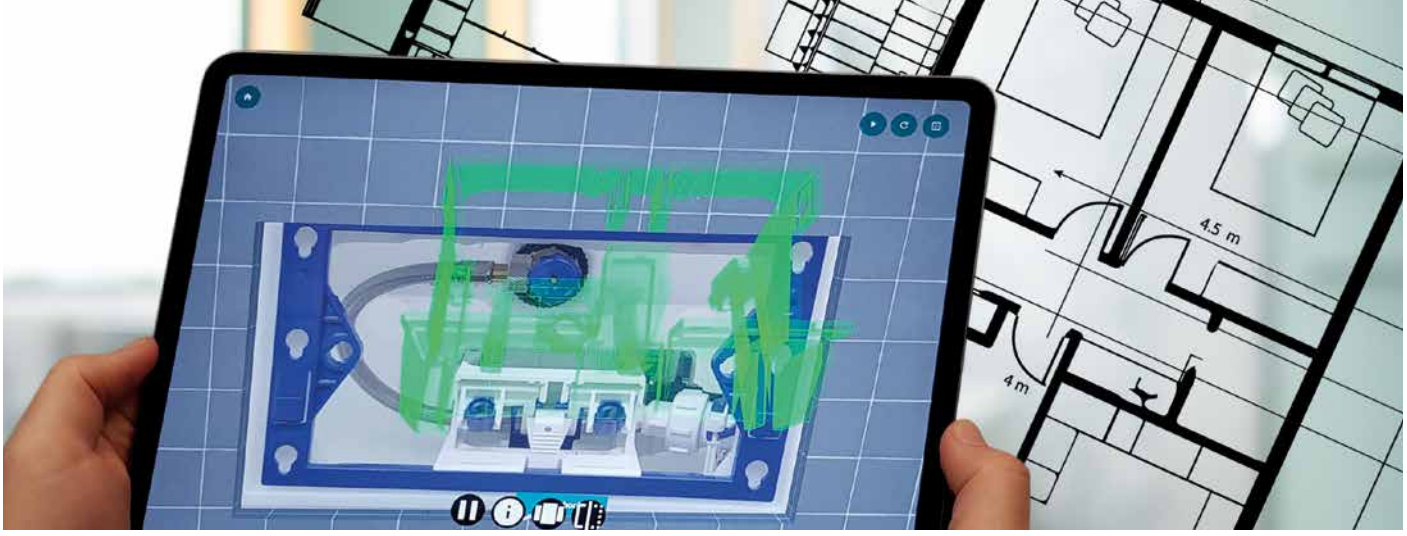
Self-improvement has an important role to play in education. From an early age, school children are encouraged to critically review their own work, to look for mistakes and correct them. What if machines could do much the same thing?

Imagine the following scenario: In every system it makes, a company installs a sensor unit that is able to analyze data and recognize anomalies. These systems are sold worldwide, and as soon as they are in operation they transmit data to a shared cloud. As a result, all systems are able to learn from each other. Any deviation from normal operation can be identified, even if the particular system in question has never encountered the corresponding pattern. Data@Hand, a new solution from Fraunhofer IGD, is designed specifically to enable this type of anomaly recognition. It empowers machines to monitor their own performance—and make targeted improvements.

Anomaly detection thanks to machine-learning algorithms

By harnessing artificial intelligence, Data@Hand's algorithms are able to detect deviations from the norm. "What's special about this technology is that we can deal with operating states never previously encountered, and we have a system that continuously evolves itself. It learns to recognize normal operation and corresponding deviations," states Dr. Mario Aehnelt, Head of the Visual Assistance Technologies Competence Center at Fraunhofer IGD in Rostock. He and his team were responsible for developing Data@Hand as an information tool. The goal is to optimize processes and to assist people with the analysis of large volumes of complex data. Importantly, however, the decision regarding how best to respond to any anomaly remains with the human expert. If there is a change in a machine parameter, such as an increase in the temperature of a compressor, the sensor unit detects it in real time and signals to the operator that they need to intervene. Data@Hand resides in the cloud and works in the background, upstream of existing interfaces or visualization systems such as Fraunhofer IGD's own Health@Hand or Plant@Hand. As a result, customers can simply continue to work in their familiar systems environment. The new Data@Hand technology can also add decisive value when it comes to analyzing health data, e.g., by alerting physicians in real time to significant changes in patient data. To achieve this goal, machine-learning solutions are trained to recognize the difference between healthy and unhealthy patient conditions. ■

www.fh-igd.de/DigitizedWork



MORE THAN JUST COWORKING – A SOFTWARE PLATFORM FOR AD HOC TEAMWORK IN THE CONSTRUCTION INDUSTRY

Coworking is one of the latest trends in the business world—people who are involved in diverse projects are located in the same place and are therefore able to benefit from creative exchange and discussion with others. And when it comes to the construction industry, coworking goes above and beyond networking over a coffee break. To plan and execute these projects effectively, freelance contractors and salaried employees working for diverse companies must cooperate—forming temporary teams with changing lineups for a variety of projects. At least, that would be the ideal scenario. In reality, things can be a bit different. Diverse software standards can make collaborating much more challenging. Ultimately, project teamwork is still often based on hardcopy drawings and verbal agreements—not exactly keeping with the times.

BIM: Great in theory, difficult in practice

The goal of BIM (building information modeling) is to make processes in the construction industry digital, and to plan, build, and manage real estate using software. Currently, many stand-alone services are being developed for specific tasks. Integrating these services and enabling data sharing across various software solutions is not easy, as there are only very few standard interfaces and open platforms. At the same time, there are ample IT solutions in place. Property developers and construction companies face the challenge of choosing the best software applications for their tasks. The key to end-to-end digital project management—from planning to construction to ongoing operation—is a virtual model of the building. And there's the rub: The CAD data needed to portray a building are huge in volume and very difficult to manage using market-typical software. And that means the various project stakeholders are not able to share the data they need for effective digital collaboration and communication.

A readily accessible planning model

Fraunhofer IGD has contributed its compression and visualization skills to the BIMSWARM software platform, in the form of a baseline service that runs in the background. BIMSWARM supports the creation of large data models, which can be subsequently viewed and edited on tablets and smartphones. This enables the CAD model to be compared to the physical building in real time for all types of construction work—forming the basis for a variety of applications. Property developers can monitor and document project progress, for instance, and service engineers can perform maintenance work with the help of guidance provided via augmented reality (AR).

Seamless availability of data

The BIMSWARM platform allows various applications, services, and content to be easily shared on the basis of open standards. All software tools on the platform are certified, compatible with each other, and in compliance with the latest technical and legislative requirements. Open and web-based interfaces ensure individual components can be integrated with existing systems or cloud solutions from various vendors. This is especially attractive for mid-sized companies who want to combine their current IT solutions with new products. The BIMSWARM project is funded as part of the Smart Service World II technology program, supported by the German Federal Ministry for Economic Affairs and Energy (BMWi). ■

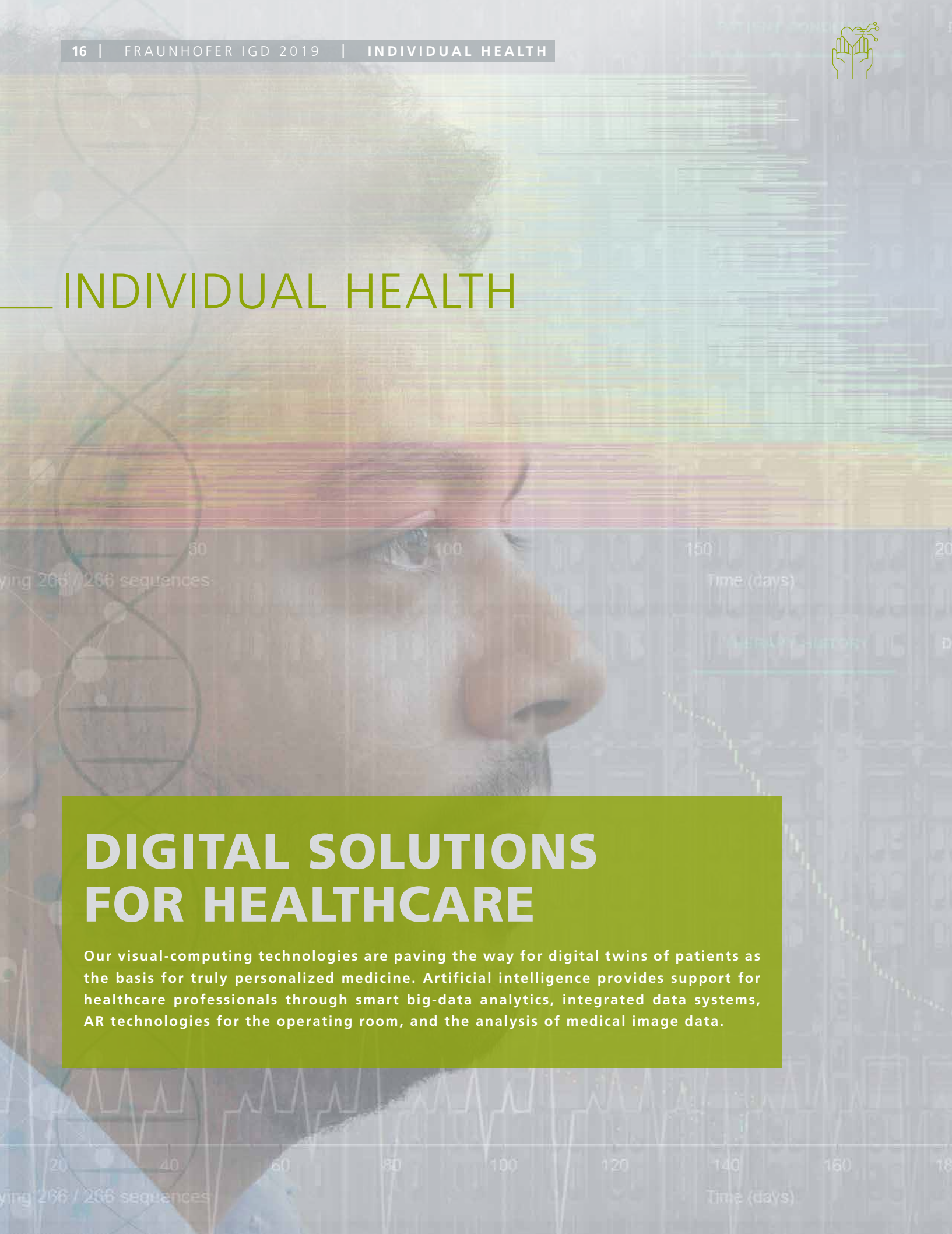
GROWING DEMAND FOR INDUSTRIAL 3D SCANNING

3D scanning is now key to diverse processes in manufacturing—for quality assurance, reverse engineering, placing products in online catalogs, and more. The Fraunhofer IGD-based CultLab3D laboratory has been active in this space for many years. Its fully automated scanning technology excels, in particular, in color calibration, light-surface interaction, and highly detailed resolution, down to 20 µm—all in conjunction with rapid data acquisition. The highest speeds are reached when CultLab3D is implemented as an end-to-end solution, i.e., as a scanning system complete with a conveyor. In this form, CultLab3D is able to digitize objects weighing up to 50 kilograms, and in just under 10 minutes per item on average. Because of its high throughput and the excellent fidelity—from all angles—of the virtual copy to the original, CultLab3D has immense potential for, e.g., product portfolios and online shops.

CultLab3D was developed concurrently with the autonomous CultArm3D-P, a mobile, photogrammetry-based 3D scanning robot with a more compact form factor. CultArm3D-P is able to scan objects that vary in size, geometric complexity and surface material. It digitizes with true-to-life colors and in reproducible high quality. ■

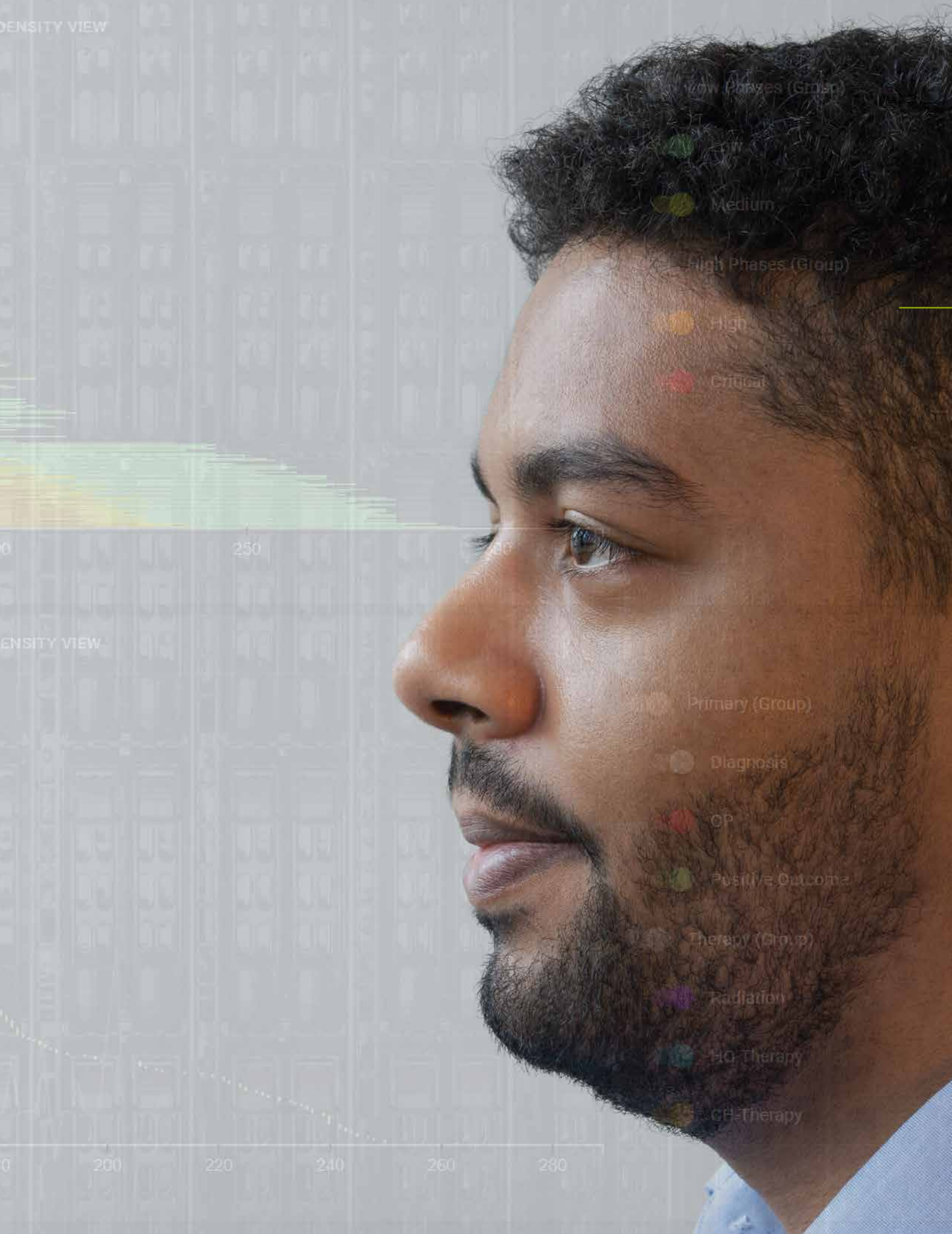
www.fh-igd.de/3Dscanning

INDIVIDUAL HEALTH



DIGITAL SOLUTIONS FOR HEALTHCARE

Our visual-computing technologies are paving the way for digital twins of patients as the basis for truly personalized medicine. Artificial intelligence provides support for healthcare professionals through smart big-data analytics, integrated data systems, AR technologies for the operating room, and the analysis of medical image data.


DENSITY VIEW
Low Phases (Group)
Low
Medium
High Phases (Group)
High
Critical
250
ENSITY VIEW
Primary (Group)
Diagnosis
OP
Positive Outcome
Therapy (Group)
Radiation
HO Therapy
CH Therapy
200
220
240
260
280

PERSONALIZED TREATMENT OF INFLAMMATORY BOWEL DISEASE

In Germany, 300,000 people suffer from inflammatory bowel disease. Yet it is frequently difficult to immediately identify the best medication. In the future, it is hoped a software tool will be able to automatically compare disease progression for large groups of patients, giving medical professionals actionable information for personalized, targeted treatment.

Let us take a look into the future, perhaps two or three years from now: A 23-year-old patient consults his general practitioner—he is struggling with diarrhea and severe lower abdominal pain. After an initial examination, he is referred to a specialized center for inflammatory bowel disease. A variety of activities ensue, including a stool sample, endoscopy, blood analysis, and an ultrasound. A software tool is used to capture all data, and to compare them with those for other patients. Where are there similarities, and what conclusions can be drawn with regard to treating the individual patient? The doctor at the center is presented with a choice of visualized treatment paths, together with an assessment of the probability of success and of treatment cost. The physician then uses this information to make a decision.

Following the first examination, the 23-year-old patient returns to the center at regular intervals for checkups. To be more precise, these are ultrasound scans, as these are patient-friendly, cost-efficient and an effective way of observing and judging any changes. In this context as well, the software offers valuable support. It compares the current scan with previous ones. How have the patient's intestines changed—for example, with regard to the thickness of the gastrointestinal wall, inflammation sites, or peristalsis? The software automatically categorizes the images and puts them in chronological order. Again, it makes a comparison with images for the relevant patient cohort. Does it make sense to continue with the prescribed medication, or is there a different product with greater potential benefit? As a result, the physician can tailor the treatment to the patient and the pattern of disease. The patient therefore does not need to take any medication that would bring little improvement to his condition, is not needlessly subjected to side effects, and receives a genuinely beneficial treatment at an earlier juncture. Additionally, by eliminating ineffective treatments, there are significant cost savings.

A joint effort for joint success: MED²ICIN lighthouse project

End-to-end approaches of this kind are made possible by research work on the part of the seven Fraunhofer institutes within the MED²ICIN lighthouse project—headed up by Fraunhofer IGD. The project focuses on inflammatory bowel disorders such as Crohn's disease. These are very widespread, with more than 300,000 sufferers in Germany alone. In particular, the project benefits from Fraunhofer IGD's expertise and resources in the automatic analysis of visual medical data. The institute has a long and successful track record in this field. The existing infrastructure is soon to be further expanded in order to accelerate development work and to further enhance the existing ultrasound skillset.

Automated comparison of disease progression

When treating a case of inflammatory bowel disease, the first question to be addressed is: What treatment will best help the individual patient? While one patient may respond to one particular treatment, another may experience no improvement at all. "To be able to make sound predications, we create a digital twin that consolidates all data relating to that patient—including examinations, previous illnesses and lifestyle," explains Professor Jörn Kohlhammer, Competence Center Head at Fraunhofer IGD. These data are then consolidated with data for cohorts of patients with

similar disease types and progression. As it would be extremely time-consuming to manually sift through these cohorts to identify significant similarities, the researchers let powerful technology perform this monotonous task. The result is graphic depictions of correlations that aid physicians' decision-making.

Disease progression

Understanding the development of a disease over time is also key to choosing the right treatment. Consequently, Fraunhofer IGD researchers conduct regular longitudinal analyses in association with clinical partners, such as Frankfurt University Hospital, with a focus on chronology. What are the differences between images captured at differing times? "Our software tool will be able to recognize anatomical structures in the ultrasound scans, and to automatically superimpose and compare the images," states Dr. Stefan Wesarg of Fraunhofer IGD.

Of vital importance to the development of medical technology of this kind is feedback from subsequent users, hospital physicians and general practitioners. To this end, the researchers are establishing a pool of medical professionals who provide advice "from the front line." The first step will be to recruit university hospital doctors, to be joined in a second step by general practitioners. ■

www.fh-igd.de/MED2ICIN-en

THE VIRTUAL PATIENT: DIGITAL TWINS HAVE A PLACE IN INDUSTRY. AND IN HEALTHCARE, TOO?

WHY DOES MEDICINE NEED DIGITAL TWINS?

The "one size fits all" philosophy is employed all too often. Many treatments and medications are prescribed without considering how their impact might vary from person to person. In contrast, a digital twin offers a detailed view of an individual's health. It combines underlying attributes—e.g., age, genetic history, and lifestyle—with recent findings, such as blood test results or biomarkers. A digital twin is therefore the vital basis for personalized and affordable medicine.

WHY IS PERSONALIZED MEDICINE SO IMPORTANT?

The aim of personalized medicine is to enable more precise diagnoses and targeted treatments. It focuses on specific individuals within a cohort of patients suffering from a particular disease or medical condition.

This approach is also applied to prevention. Using a digital twin, doctors can simulate the results of a particular treatment in advance. Consequently, they can adjust and improve the therapy, taking information such as gender, lifestyle, and even social and environmental factors into account. Patients are spared unnecessary procedures and discomfort, while insurance companies avoid unnecessary expenditure.

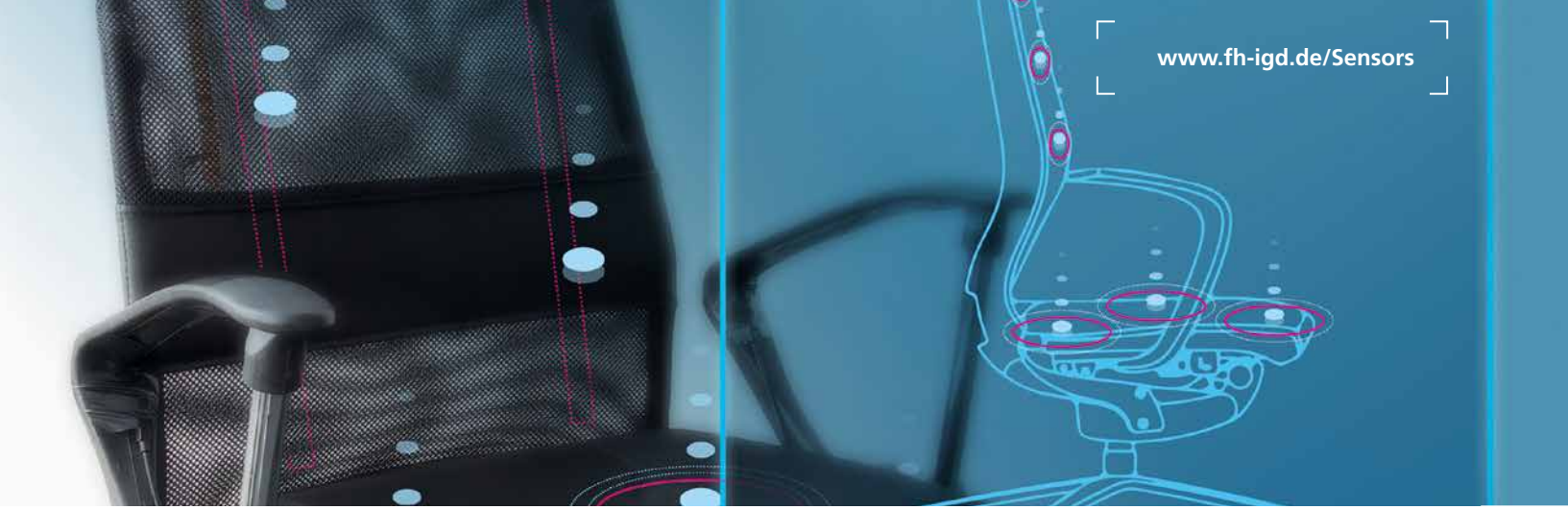
WHAT ADVANTAGES DO DIGITAL TWINS AND PERSONALIZED MEDICINE HAVE FOR ME, AS A PATIENT?

Diagnoses and treatments tailored to individuals prevent the use of medications that are only effective for certain patients—avoiding the administration of drugs to the people who would suffer side effects without receiving any benefit. Moreover, improved availability of data and the option of simulating therapies on a digital twin allow many operations to be avoided. For example, medical staff are already making decisions on breast cancer treatments based to a large extent on the genetic makeup of the cancer and the individual's predispositions.

In summary, prevention and treatment plans are tailored to each person, minimizing side effects from medications and maximizing successful outcomes.

WHAT DOES THIS MEAN FOR DOCTORS, HEALTH INSURERS, AND CO.?

Predispositions and diseases can be identified sooner—potentially allowing illnesses to be mitigated or even prevented. For care providers, health insurers, and hospitals, this can translate into significant savings. As a result, the healthcare system can be made more cost-effective, to the benefit of patients. To this end, however, medical data must first be combined and consolidated—in order to create a comprehensive picture of the individual patient. And this requires all stakeholders to work hand-in-hand.



IN CHARGE: HOW SENSORS CAN HARNESS OUR BODY'S ELECTRICAL CONDUCTIVITY TO MANAGE SMART FURNITURE

Just imagine your office chair would notice when your posture is less than ideal or would alert you, via an app, to the fact that it is time to stand up and stretch your legs a bit... sound like science fiction? It could soon be reality, thanks to sensor technology from Fraunhofer IGD.

Soon, your typical office chair may be able to recognize your position and movements—and be able to improve workplace health. The key is capacitive sensors. These use the presence of an electric charge and the conductivity of the human body, which largely consists of water that is ionized, and therefore has a slight electric charge. As a result, we humans are all surrounded by small electric fields where our bodies act as one terminal of a capacitor, and our immediate surroundings (for instance, the backrest of a chair) as the other. When we start to sit down, the pattern of charge distribution changes, and the electric field between our body and the chair backrest alters. This change in the weak electric charge, that we are unable to detect, can be measured by the capacitive sensors. Using these data, the algorithms devised by Fraunhofer IGD are able to recognize changes in our seating position, and to communicate recommendations to a smart watch, a smartphone, or a desktop PC. What's more, the sensors are contactless. Even if your back does not actually make contact with the chair rest, the system is able to track your body's position—it is therefore a better, more accurate technology than, say, the usual pressure sensors that require direct physical contact.

A smart chair that monitors health exercises

Body position detection in the workplace is not just a way to prevent back pain caused by extended periods spent sitting, or sitting in the wrong position. Following an operation, and especially in the field of orthopedics, patients are often given very specific exercises as part of their follow-up treatment. An app, connected to the sensors, can be used to remind them to keep to their post-operative regimen, and can provide feedback on whether the exercises are being correctly performed. To this end, the system applies machine learning to a huge variety of movements. The user then selects the prescribed exercises and the appropriate duration and frequency. In other words, the chair and the app act as personal health assistants, and help medical professionals capture important information for post-operative care.

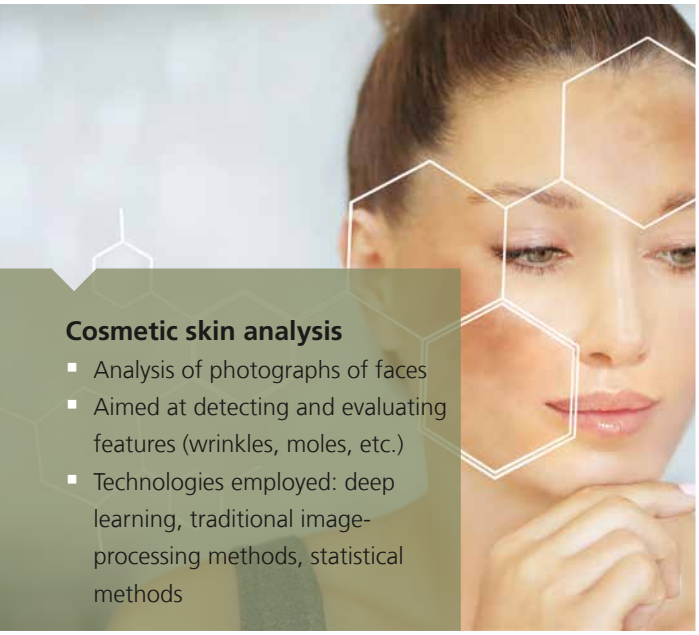
Potential for smart-living use cases

Because they are deployed separately from the electrode, the sensor components are easy to install and highly affordable. The capacitive sensors can be incorporated unobtrusively into everyday environments, concealed with fabric or integrated directly into items of furniture, either during or after production. As a result, they are ideal for state-of-the-art smart-living solutions. In fact, there are many and varied potential use cases—the intelligent office chair is just one example of how capacitive sensors can be put to good use in smart-home and healthcare scenarios. Fraunhofer IGD is actively seeking industrial partners for collaboration on further applied research in, for example, furniture manufacturing. ■

MEDICAL IMAGING
THE VALUE OF IMAGES IN HEALTHCARE

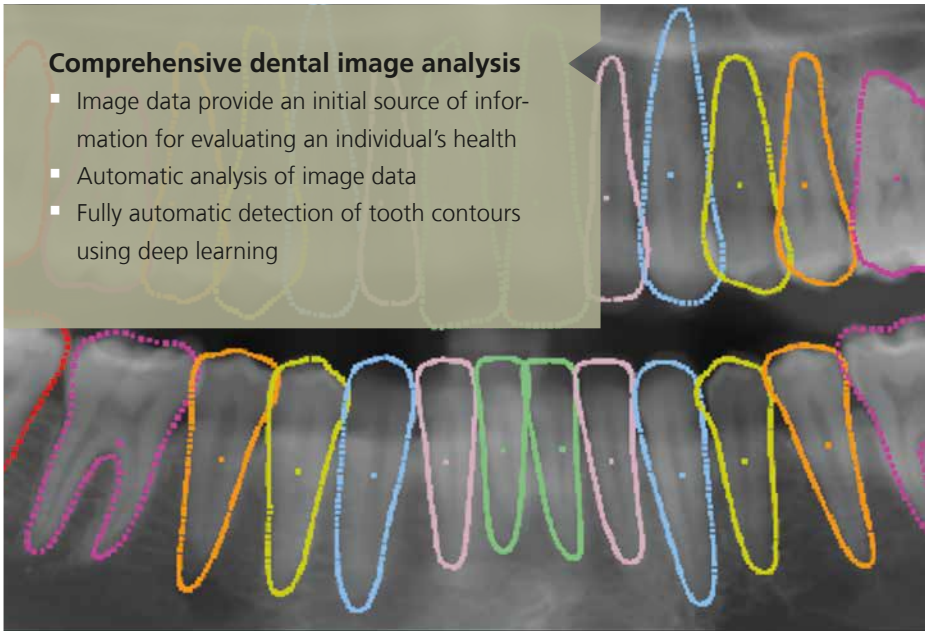
Medical imaging comprises techniques and processes for creating a visual representation of the interior of a body for medical intervention and analysis. This makes it possible to view anatomical structures and the functioning of organs and tissues that would otherwise be hidden by skin and bones. Medical conditions and diseases can therefore be diagnosed and treated faster—and, particularly when it comes to early detection of anomalies, speed can often be life-saving. Furthermore, imaging can be harnessed beyond diagnostics, and across the patient journey. Here are just a few examples—from preventing illness to providing treatment—of Fraunhofer IGD's research.

www.fh-igd.de/Medical-Imaging



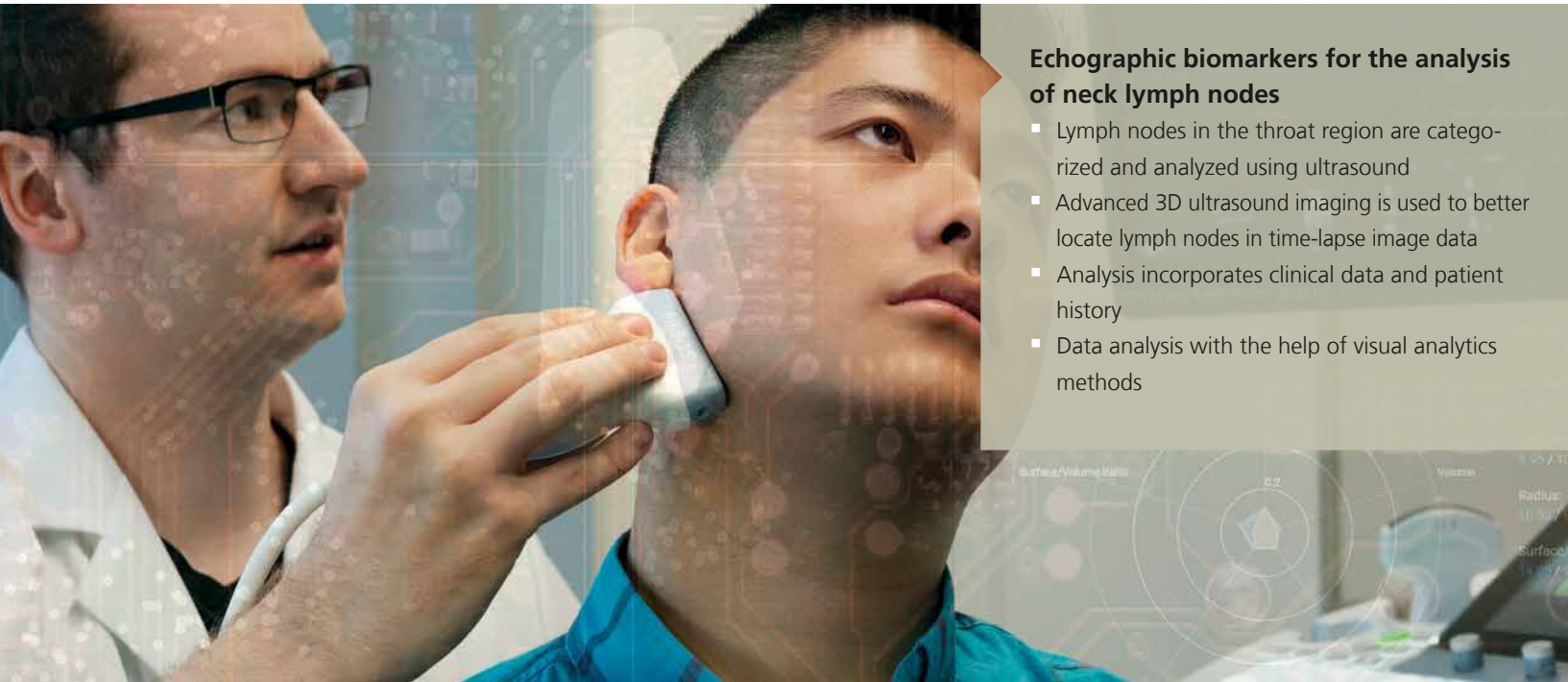
Cosmetic skin analysis

- Analysis of photographs of faces
- Aimed at detecting and evaluating features (wrinkles, moles, etc.)
- Technologies employed: deep learning, traditional image-processing methods, statistical methods



Comprehensive dental image analysis

- Image data provide an initial source of information for evaluating an individual's health
- Automatic analysis of image data
- Fully automatic detection of tooth contours using deep learning



Echographic biomarkers for the analysis of neck lymph nodes

- Lymph nodes in the throat region are categorized and analyzed using ultrasound
- Advanced 3D ultrasound imaging is used to better locate lymph nodes in time-lapse image data
- Analysis incorporates clinical data and patient history
- Data analysis with the help of visual analytics methods

A SMART ROLLATOR WALKER FOR POST-OPERATIVE CARE

Patients often experience pain and side effects following a hip or knee operation. And that makes regaining mobility very soon after surgery especially important. The autonomous RoRo robot rollator walker is designed to help. It analyzes an individual's gait, (i.e., pattern of walking) in hospitals and care homes to help doctors determine the patient's degree of recovery, and to provide tailored physical-activity training. The movements that RoRo supports help strengthen muscles and counter the effects of improper posture. In addition, the electrically powered rollator lightens the workload on medical staff, by moving autonomously to the patient and assisting them to appointments, e.g., for an X-ray or physical therapy. To this end, the RoRo employs a camera-based indoor navigation system. The Central Innovation Programme for SMEs (ZIM, initiated by BMWi, the German Ministry for Economic Affairs) is providing funding for the project, which is active through May 2021. ■

SMART CITY

INNOVATIVE, DIGITAL, AND SUSTAINABLE LIVING

The cities of the future will be shaped by holistic development concepts—making them more efficient, more technologically advanced, greener, and more socially inclusive. These ideas, united under the Smart City banner, address all forms of human coexistence.

ACCELERATED ROLLOUT OF FIBER-OPTIC BROADBAND IN GERMANY

The introduction of broadband across Germany, especially in rural areas, is slow, with many households waiting impatiently for connectivity. One of the main obstacles is the extended planning stage.

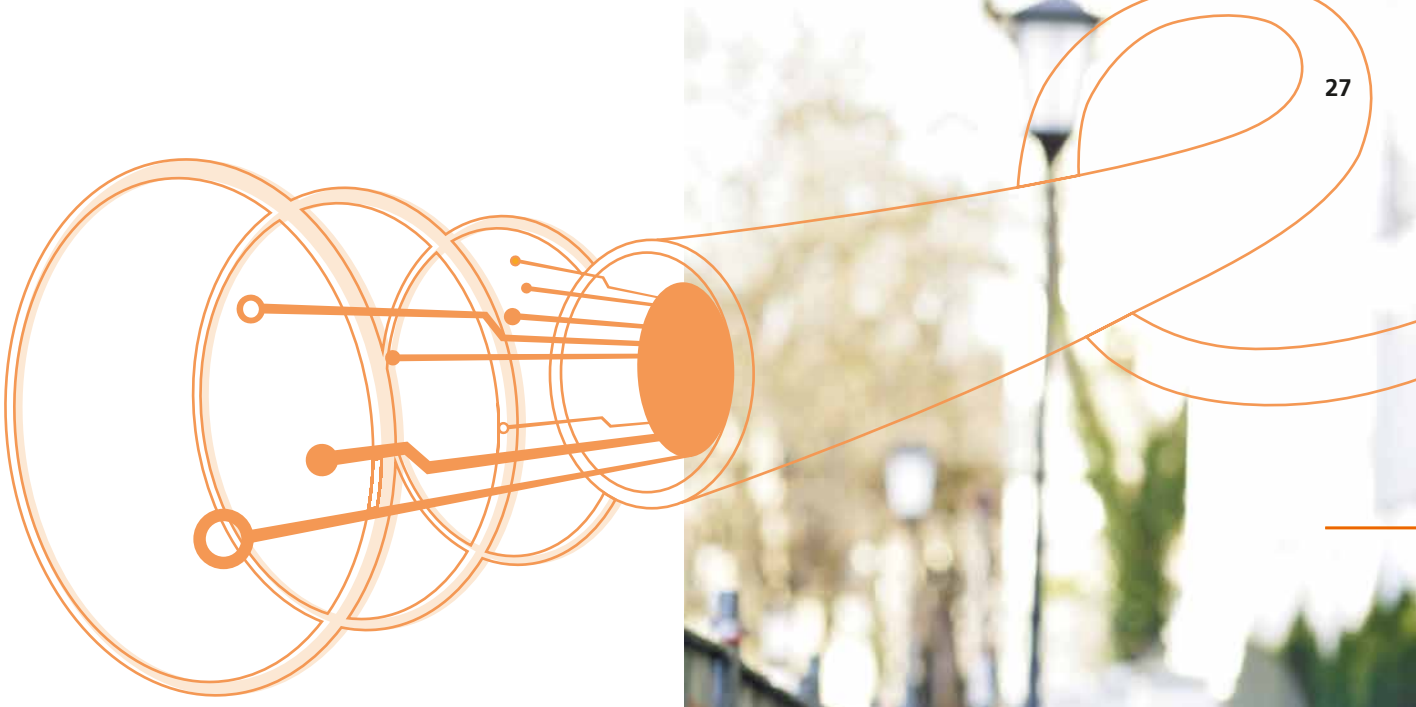
Laying fiber-optic cables is not that simple. But the widespread criticism is understandable. A slow internet connection makes it difficult to implement teleworking, to deploy state-of-the-art smart-home solutions, to attract new businesses—and it can even lead to existing digital-economy jobs being relocated elsewhere. Construction work itself is typically completed quickly and without significant impact on existing infrastructure. But there is a long lead time for planning and approval before a cable can be placed in the ground.

Deutsche Telekom is collaborating with Fraunhofer IGD to find a way of rendering the time-consuming visual inspections of proposed cabling routes unnecessary. The solution, dubbed Fibre3D, allows planning in a virtual environment. This eliminates the time and expense involved in making on-site visits, and requires no additional effort at Deutsche Telekom, as Fibre3D makes use of existing photographic images. Cameras and scanners mounted to vehicles capture 2D and 3D pictures of the roads where cables are to be laid, enabling the planner, or more accurately their avatar, to move around freely in, and view, a virtual environment.

Fiber-optic cables – detangling the process

As soon as a local town or county has received approval for a new fiber-optic broadband network, the first step is to install a distribution cabinet. This manages the individual connections to local buildings. And although the white box on the side of the street may seem fairly innocuous, choosing its precise location is no easy matter. The routes must be cost-effective but also meet the town/county's other requirements. Each street needs to be carefully analyzed to ensure no unexpected events will obstruct installation work and cause delays to the project. After all, for the initial laying of cables, the asphalt surface has to be ripped up to make room for the plastic ducts. These make it easy to install and later maintain the fiber-optic cables, which can be inserted with the help of compressed air and replaced just as easily.

But back to the distribution cabinet: Before the planner arrives on-site, a suitable position is found and marked on a 2D map. However, two dimensions are not always enough, lacking essential information on, for example, windows and driveways. This forces the on-site planner to make ad hoc decisions. And this is where Fibre3D offers a way forward. It makes use of visual information that, at least in theory, is readily available—360° photographs of the roads already exist. Machine learning solutions are capable of automatically recognizing trees, cars, and doors by means of vehicle-mounted 3D scanners that additionally generate a point cloud of the spatial environment. As a result, distances can be precisely measured. Fraunhofer IGD has now been tasked with developing a tool that consolidates and combines these huge quantities of data, and provides them to planners in a form that can be used easily and intuitively. To this end, the researchers harness the processing power of cloud computing, reduce the volume of data, and filter out the information required for 3D imagery. This is also the basis for real-time visualization with Fibre3D on the web.



Virtual on-site inspection saves time and money

The approval process between Deutsche Telekom and the local government agency commences as soon as the proposed cabling route has been determined. A key step is the creation of a before-and-after comparison of the local environment—showing exactly where the distribution box will be positioned in the future. And visualization not only makes it easier for planners to imagine the proposed work; it also makes it simpler for the corresponding authorities. This means fewer follow-up questions and misunderstandings. Going forward, the aim is to add rich communication functionality to Fibre3D, enabling all stakeholders to enjoy full visibility into the planning process. ■

www.fh-igd.de/SmartCity

MORE DATA FOR A BETTER HARVEST
ARTIFICIAL INTELLIGENCE IN AGRICULTURE

Huge fields and new satellite images every couple of days—that means vast volumes of data. Farmers need systems that enable them to analyze this information at high speed. And that was the aim of the EU project DataBio, which concluded in December 2019 after three years' work.

The goal was to leverage artificial intelligence to improve yields and sustainability in agriculture, fishing, and forestry. At Fraunhofer IGD in Darmstadt, the focus was on farming. "All three elements of the project combine multiple data sources," explains Ivo Senner from the Spatial Information Management Competence Center. In this way, it is possible to identify and make use of correlations. "Particularly with large expanses of land, it can be difficult to identify invasive species or environmental degradation," the IT expert states. "That makes it complicated, for instance, to assess loss of crops in order to calculate compensation." Ideally, the new systems will enable the effective evaluation of even very small areas. Moreover, it is hoped they will support EU-common agricultural policy processes designed to verify the veracity of applications for funding. The new technology will, for example, allow plausibility checks across significant territories instead of making spot checks, as is currently the practice. This is made possible by incorporating efficient processes drawn from artificial neural networks. "Artificial neural networks are computer systems that mimic the structure of the human brain. And just like human brains, these systems can learn. The more often they receive certain signals, the more precisely they are able to recognize images or patterns." Every one to two weeks, satellites provide new measurements and images—huge amounts of data that can be rapidly processed by artificial intelligence.

The DataBio project entails the participation of 48 partners from 17 countries, including researchers, farmers, and IT companies. Some of the findings are already being employed in practice; others are currently being studied further with regard to their real-world applicability, including, e.g., within the scope of a pilot project in Greece. Talks are being held on possible follow-up projects that will take a closer look at forestry. The methods already developed could then be leveraged to monitor the health of woodlands.

www.fh-igd.de/EnvironmentalMonitoring

www.fh-igd.de/DigitalCity

WHAT IF... VISUALIZATIONS COULD ENABLE MORE EFFICIENT URBAN PLANNING

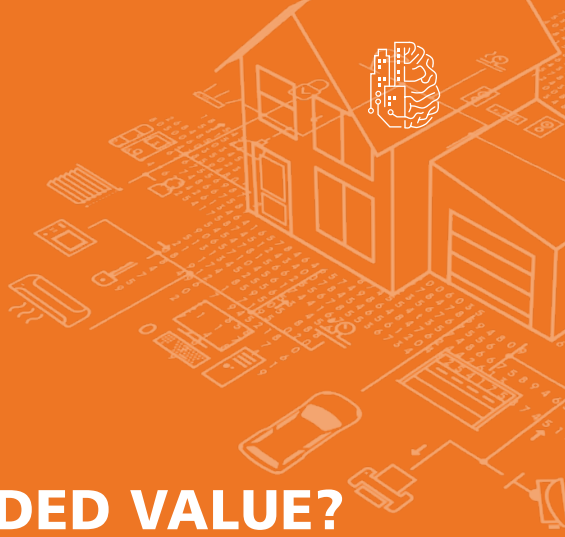
Urban planning in the era of smart cities is about process acceleration, digital visualization, and the involvement of all stakeholders. Participative planning is the name of this new game. The essential ingredient is a consistent, standardized pool of data and a common understanding of the aims and the prerequisites for implementation. Fraunhofer IGD develops systems for digital urban planning. After pilot phases and testing under real-world conditions, two of them are now ready for roll-out.

Breathing new life into historical town centers

Particularly in more rural regions, the town centers are often decaying—through falling population numbers, demographic change, and the development of new homes and industrial parks on their periphery. To rejuvenate these historical downtown areas and to improve their infrastructure, urban planners must develop effective concepts. Within the scope of AktVis, a project funded by the Federal German Ministry of Education and Research, Fraunhofer IGD developed an interactive 3D web application that invites architects, politicians, property owners and residents to exchange and discuss ideas. The WebGIS application unifies the many and varying sources of geoinformation relevant to the local area, overcoming the problems associated with differing data formats and types, and eliminating the need for the laborious conversion that often plagues conventional systems. The coherent, standardized pool of data can be employed to create highly realistic views of buildings and streetscapes. All stakeholders then share a "single version of the truth." Integrated functions for checking economic efficiency and compliance with building regulations make it possible for the feasibility of ideas aired at workshops and stakeholder meetings to be immediately verified.

Overcoming misgivings about new technologies

Virtual reality and augmented reality can be put to good use to extend and enhance existing methods of stakeholder participation. To overcome potential misgivings or inhibitions associated with the new technologies, a group of researchers in Austria, with contributions from Fraunhofer Austria, have produced a new guide for local authorities. It offers practical advice on establishing the basis for the deployment of VR or AR applications and offers realistic estimates for the expense, supporting the implementation of innovative methods of participative planning. The guide was created as part of the VR Planning—We're Planning project, supported financially by the Austrian Federal Ministry for Transport, Innovation and Technology within the Mobility of the Future program. The VR Planning project developed simulation software for concrete planning activities. The fully working VR and AR application prototypes allow street and building proposals to be experienced intuitively by means of a VR headset or a tablet, allowing a better understanding of the 3D environment—which is the essential basis for successful participative planning. It is possible to conduct surveys within the application to gain direct user feedback on the virtual plans. ■



SMART HOMES: ALL BELLS AND WHISTLES, NO ADDED VALUE?

CAN I STILL USE MY SMART HOME WHEN THERE IS NO INTERNET CONNECTION?

A number of smart systems and assistants only work when they are connected to the internet. As a result, many technologies currently on the market could potentially lock you out of your own home.

The solutions typically need the processing power of servers in the cloud. But this comes at a price: Vendors are often interested in the corresponding user data. At Fraunhofer IGD, by contrast, we are developing systems that can operate independently, that protect privacy, and support local processing and storage of data.

CAN SMART-HOME TECHNOLOGIES BE EXPLOITED FOR SPYING AND SURVEILLANCE?

This is an ever-present danger, and as a user you should know how your smart devices work. For example, do you really need a cleaning robot that takes pictures of your home? Or could you make do with a system that navigates its surroundings by means of random routes? And does a cleaning robot even need to be online? ATHENE, the National Research Center for Applied Cybersecurity in Darmstadt, has been actively working on smart but secure home technologies since 2020. Until these systems are available, the best thing to do is to ensure your home network is secure and to keep confidential data safe.

DO SMART-HOME DEVICES CONSUME ELECTRICITY AROUND THE CLOCK—EVEN WHEN NOT IN ACTIVE USE?

Although stand-by technologies, such as those deployed on TVs, have come a long way in recent years, it is still worth taking a closer look at how much power is consumed by your domestic appliances. Even if most products are now far more energy-efficient, we have a growing number of them in our homes. The most power-hungry devices are often smart speakers with displays or, almost imperceptibly, remote-control power outlets: A wireless socket can easily incur electricity costs of up to seven euros annually. At Fraunhofer IGD, we are passionate about the responsible use of resources. Our field sensors, for example, passively measure the impact a human presence has on the surrounding electrical field.

ARE WE DENYING OLDER PEOPLE CONTROL OVER THEIR OWN LIVES?

Our assistance systems are designed to support older people yet never take away their right to self-determination. Smart-home residents have access to a switch that allows them to disable our systems, or at the very least deactivate their internet connectivity. This fact is very reassuring for many users; however, at the same time, in an emergency, help needs to be provided quickly—and this makes the provision of information unavoidable. Someone who is lying on the floor following a heart attack is less concerned with retaining control over their lives than with securing rapid medical assistance. An intelligent chain of alarms commences in the resident's own home, and the user can intervene to prevent alarms from being forwarded to an external organization.

A NEW APPROACH TO URBAN LIVING

The Zusammenleben 4.0 project in Halle-Neustadt will create an entire residential district based on the principles of smart living.

Most people want to live in environments that are attractive, affordable, and offer social interaction. But in major cities in particular, conditions are often less than ideal, and compromises have to be made. A home in an in-demand area with good public transportation comes with a corresponding price tag. Against this backdrop, Halle-Neustadt is looking to implement state-of-the-art smart-living solutions that improve quality of life for an entire district at low cost.

The choice of Halle-Neustadt is not pure chance: The federal state of Saxony-Anhalt, where the city is located, has the oldest population in Germany, with an average age of 47.5 in 2016. The first step was to equip a single model apartment with intelligent technologies. Now the aim is to roll out the concept for an entire district, led by Fraunhofer's Ambient Assisted Living Alliance in conjunction with the Halle-based Fraunhofer Institute for Microstructure of Materials and Systems IMWS. Named Zusammenleben 4.0 (Living Together 4.0), the undertaking is aligned, in particular, with the needs of older people, but is also designed to help individuals with physical disabilities lead independent lives. For instance, apartments will be able to detect dangerous situations, such as falls or anomalies in residents' vital signs. The telemedicine features can be activated or deactivated according to personal needs and preferences. Furthermore, these smart homes provide assistance that is unobtrusive in nature by, for example, automatically switching on lights or closing shutters.

But the new district is not only aimed at seniors and people in need of care. The target group for the approximately 4000 converted apartments includes families and young singles—who will likewise benefit from the convenient capabilities of an intelligent home environment. There are plans for a sports center, which will act as a hub for personal interaction. After all, the overarching vision of Zusammenleben 4.0 is to create smart communities: enabling shared journeys, improving logistics for long-term care, and encouraging activities, such as urban gardening, that bring old and young together. ■

www.fh-igd.de/SmartLiving-en

CYBERSECURITY

A NEW ERA OF CYBERSECURITY

CRISP becomes ATHENE: the National Research Center for Applied Cybersecurity ATHENE (the German name for the Greek goddess Athena).

Fraunhofer IGD is an active member of ATHENE. Within this role, it focuses on cybersecurity and privacy—based on skills and methodologies drawn from computer vision and visual analytics, such as biometrics and the visual analysis of data with relevance to cybersecurity. The institution is an acknowledged expert in this space, with a reputation second to none in Germany and Europe.

ATHENE is a unique and innovative cooperation model. It combines first-class university and non-university research to the benefit of business, society and government, and gives fresh impetus to scientific endeavor. The research center is agile and efficient, and is therefore able to respond rapidly to new challenges and evolving threats.

www.athene-center.de/en

PRIVACY ISSUES WITH BIG DATA AND VULNERABILITIES IN BIOMETRY

Opportunities and risks often go hand-in-hand in the digital age. Being online means being in danger. And the more complicated the infrastructure, the more vulnerable it is. Cybersecurity's mission is to minimize the risks in order to make better use of the opportunities of digital transformation. Against this backdrop, we wish to present two example projects.

Data privacy problems highlighted in the age of big data

Data that are used effectively can be extremely valuable to the world of business and society as a whole. Online players such as Facebook, Microsoft and Google already earn billions with their services. And more and more companies are jumping on the bandwagon, collecting, processing and selling data.

In addition to their high economic value for businesses, data also hold significant potential for society; for instance, when various individual records are aggregated and analyzed. But with these upsides come downsides. The privacy of the individual in each case is in significant peril. A recent scandal provides a prime example: A Facebook app shared large volumes of user data with UK-based Cambridge Analytica, compromising the confidentiality of sensitive information for millions of people.

ATHENE researchers seek to find the right balance between data-based value creation and privacy. They employ technologies that promote and enforce, or at least support, data protection in information and communication systems.

In this context, Fraunhofer IGD is working to visualize critical aspects of data analytics and data protection. ATHENE researchers help developers and users of data analytics software to identify weaknesses and highlight risks associated with the use of multiple combined data sources. And consumers benefit from visualization, as they can assess the impact on their privacy—and what counter-measures are possible.

More secure biometric ID photos

Many countries (including Germany, since November 1, 2010) now require the use of biometric images in e-passports and other ID documents, such as driver's licenses, to guarantee accurate identification.

But not all biometric samples are equally suitable for the automated recognition of an individual person. Low-quality photos frequently lead to errors—a weakness that criminals exploit through face morphing, i.e., when two faces are combined. ATHENE researchers at Fraunhofer IGD are therefore looking into methods of assessing the quality of facial images.

To date, the requirements specified for biometric ID photos are limited to how they are taken—i.e., the background, the facial expression, the pose, and permissible accessories. In the future, the goal is to expand specifications to include quality attributes: Metrics will be employed to identify images that are unsuitable for automatic facial recognition.

If methods of assessing the quality of facial images are successfully developed, they could be advantageous in a number of use cases—including automated border control systems, such as the proposed entry/exit system for the Schengen Area. ■

UNDERWATER TECHNOLOGIES

SUBSEA@FRAUNHOFER

When it comes to the development of advanced subsea technologies, a single research discipline alone is not sufficient. Consequently, 13 Fraunhofer institutes and Fraunhofer research institutions came together in 2016 to form the Subsea@Fraunhofer network of experts. Within this unique, Europe-wide subsea-tech research group, experts from IT, material sciences, engineering, electronics, sensors, energy technologies, robotics, aquaculture, and automation collaborate to create new solutions—working towards more sustainable approaches to ocean use. At the 2019 Digital Ocean Convention Rostock, the network presented the Smart Ocean Technologies—Solutions for the Sustainable Use of Ocean Resources position paper to political decision-makers. This document examines the potential of interdisciplinary subsea research for industry and scientific projects, and provides concrete recommendations for research funding and for the establishment of international standards.

www.subsea.fraunhofer.de/en

DIGITAL TECHNOLOGIES AS SUBMARINE EYES AND EARS

Fraunhofer IGD in Rostock has been developing pioneering digital technologies for underwater deployment for many years, contributing to the eco-friendlier, more sustainable exploitation of our oceans. Here are two examples.

Eyes have a vital role in discovering unknown worlds. Conventional cameras, however, have limitations when employed as an "artificial eye" underwater. Below the surface, stirred-up sediment and the scattering of light obstruct human vision. A smart camera helps by enhancing underwater images in real time, by canceling out turbidity, blurring, and light attenuation. This helps improve visibility for submersibles. Harnessing artificial intelligence, special algorithms automatically detect objects and immediately send the already optimized view, with additional information, to the operators of subsea robots. As a result, the images not only aid subsequent analysis, but actively provide assistance during dives—allowing more reliable ad hoc decision-making.

To survive and thrive in an unfamiliar environment, it helps to observe what the natives do. How do they navigate their world? For the Acoustic Eye project, Fraunhofer IGD researchers use dolphins as role models: The scientists deploy a system for acoustic 3D imaging and measurement that mimics the marine mammals' method of signal processing. For researchers or employees of various companies, that means if you are operating an underwater vehicle on the seafloor, you are able to visualize seabed features—to some extent, even below the visible surface—via a headset. This allows users to, for instance, rapidly identify shipwrecks, inspect buried cables and pipelines, or explore natural manganese deposits—all with a minimally invasive impact on the natural environment. ■

www.fh-igd.de/Underwater

UNDERWATER TECHNOLOGIES
WHY DO WE NEED THEM?

Fish, coral and other denizens of the sea need protection from the actions of people—but human intervention in, and use of, the oceans is an unavoidable necessity, and will increase in the future. Reconciling these sometimes contradictory imperatives will only be possible with the help of research and the development of new technologies.

We know more about the dark side of the moon and the planet Mars than the depths of our oceans. Yet we rely on our seas in many ways. They are employed for the transportation of passengers and freight by ship, and are traversed by fiber optic cables that enable high-speed internet. They are a valuable source of food. And they are used industrially, for example, for a growing number of offshore wind parks, and for oil and gas platforms. Moreover, our use of ocean resources is expected to rise sharply—with growth on land stretched to its limits, humankind will require new ways of providing the world with food and energy. This raises the question: How can these resources be exploited efficiently and responsibly—while also safeguarding the integrity of marine environments? It will only be possible with in-depth knowledge, paired with the very latest technologies. Society, politics and the economy require insights that only underwater research can deliver.

Challenges below the surface

Conditions above and below the ocean surface are harsh. Winds and storms whip over the water, salt eats away at materials, greater depths mean greater pressure—and much more besides. The sea presents people and equipment with special challenges. Is a machine going to be submersed? Then the difficulties faced are substantially greater. For example, wireless communication underwater is limited. This and other issues mean testing new developments under real-world conditions is vital—allowing researchers to determine, for instance: Can robots on the seabed be reliably operated remotely? Can cameras and other sensors deliver actionable insights?

Up to now, there have been few possibilities to test complex subsea systems and how they function in actual use cases. In artificial environments, e.g., research pools and pressure tanks, it is only possible to replicate currents, salinity, visibility and other natural attributes of the open ocean to a certain degree. Consequently, to conduct tests under real-world conditions, scientists often have to join research trips, which can take considerable time, effort and funds. Against this background, a dedicated subsea test site is essential for testing new technologies and their reliability—for instance, to develop new control units or sensor systems for vehicles, to assess underwater image-enhancement algorithms, or to trial anti-fouling coatings for offshore infrastructure. ■

UNDERWATER TESTING FOR SUBSEA TECH

From 2020, the Digital Ocean Lab (DOL), an underwater test site in the Baltic Sea, aims to fill this need for realistic subsea research opportunities. Construction is underway on new testing areas adjacent to an artificial reef built 16 years ago for fishing research in Nienhagen, Germany. Soon, scientists and industrial customers under the direction of Fraunhofer IGD will be able to study a wide range of subsea technologies under real-world conditions—from sensors employed to locate buried cables, to underwater vehicles for maintaining offshore equipment, to systems that identify and recover unexploded ordnance. But that is not all. In the vicinity of the onshore operations center for the new underwater test site, an entire Ocean Technology Campus (OTC) is being constructed. Located at the Rostock Freight and Fishing Port (RFH), the OTC will be a rich and invigorating environment where advanced technologies can be developed and checked for seaworthiness—with industry players and researchers from a variety of disciplines working hand-in-hand. This close collaboration and physical proximity will promote technology transfer, accelerating and strengthening innovation.

The commencement of this unique and major Baltic coast project on 9 August 2019 coincided with the international Digital Ocean Convention Rostock. Professor Reimund Neugebauer, President of Fraunhofer-Gesellschaft, underscored: "The launch of the Ocean Technology Campus is a milestone on the path to more responsible, sustainable use of our seas—to the benefit of all." Over the last six years, Fraunhofer IGD has spearheaded the project, joining forces with multiple Fraunhofer Institutes within the scope of the Subsea@ Fraunhofer network of experts. In the first half of 2020, a new, interdisciplinary group of researchers will begin their work at the fishing port, with their number expected to rise to around 25. ■

www.igd-r.de/dol-en

2nd DIGITAL OCEAN CONVENTION ROSTOCK

4 – 5 November 2020 · HanseMesse Rostock
Digital underwater technologies:
The prerequisites, the opportunities,
and the potential use cases

- Keynote speeches and panel discussions
- Exhibition featuring the latest products and developments
- Presentations of start-ups and innovative new technologies
- Evening reception with networking opportunities

More information and registration: www.igd-r.de/doc-en

THE INSTITUTE

VISUAL COMPUTING IN ACTION

Fraunhofer IGD is the leading international institute for applied research in visual computing. This scientific discipline combines computer graphics and image processing. It involves both the extraction of information from images and videos, and the creation of images from computer-generated models.

221

employees

144	Darmstadt
42	Rostock / Kiel
9	Graz
26	Singapore

5

Institutes and research centers

Darmstadt
Rostock
Kiel
Graz
Singapore

€21 MN

Annual research funding

€15 MN

Contract research

43%

Federal/state government

57%

Industry and publicly funded research projects

FRAUNHOFER IGD

Fraunhofer IGD was formed in 1987 from a working group originally created by Fraunhofer-Gesellschaft. In 1992, a second site was established in Rostock—one of the first Fraunhofer locations in the former East Germany. Affiliated organizations followed in 2008, when Fraunhofer Austria set up its visual computing division, and in 2017 with the founding of Fraunhofer Singapore.

It is our mission to empower people in the digital age—to enable them to leverage increasingly complex computer systems and rising volumes of data.

To this end, we are continuously evolving and advancing our visual computing technologies for the benefit of people, society, and the economy. Visual computing has a wide range of potential uses, including for the digitized world of work, personalized medicine, and smart cities—Fraunhofer IGD's three lead topics that focus on practical application.

In the future, we will make our basic technologies available to customers via our cloud-based visual computing as a service (VCaaS) platform. ■

www.igd.fraunhofer.de/en

ADVISORY BOARD

The board not only provides expert advice to the corresponding Fraunhofer institute; it also has a supervisory role. Its members are renowned representatives of both the science and business worlds.

Chairman		
Dr. Kai Beckmann	Merck KGaA	Darmstadt
Members		
Michael Astor	Prognos AG	Basel
Prof. Edgar Dörsam	TU Darmstadt	Darmstadt
Prof. Reinhard Klein	University of Bonn	Bonn
Prof. Stefanie Lindstaedt	Know-Center GmbH	Graz
Petra Mahnke (Oceanographer)	German Association for Marine Technology	Hamburg
Minister Dr. Ulrike Mattig	Hessen State Ministry for Higher Education, Research and the Arts	Wiesbaden
Dr. Torsten Niederdränk	Siemens AG	Erlangen
Prof. Albert Remke	52° North GmbH	Münster
Prof. Bernt Schiele	Max Planck Institute for Informatics	Saarbrücken
Prof. Heidrun Schumann	University of Rostock	Rostock

SCIENTIFIC EXCELLENCE

The many publications by Fraunhofer IGD's scientists underscore the excellence of our institute's research. Each year, within the scope of a Computer Graphics Evening, an independent jury comprising external scientists awards the very best publications. The following highlights a small selection of these.

Doctorates

Jian Cui
"Mid-Air Hand Interaction with Optical Tracking for 3D Modelling"

Johannes Edelsbrunner
"Domain Specific Methods for Procedural Modeling of Historical Architecture"

Roman Getto
"Parametric Procedural Models for 3D Object Retrieval, Classification and Parameterization"

Ngoc Anh Huynh
"Frequency Analysis and Online Learning in Malware Detection"

Ma Jingting
"Self-Learning Shape Recognition in Medical Images"

Andreas Riffnaller-Schiefer
"A Subdivision Approach to Isogeometric Analysis – Analysis, Design and Simulation"

Ahmed Rabee Ahmed Sadik
"Worker-Robot Cooperation and Integration into the Manufacturing Workcell via the Holonic Control Architecture"

Martin Radolko
"Change Detection in Combination with Spatial Models and its Effectiveness on Underwater Scenarios"

Folker Wientapper
"Optimal Spatial Registration of SLAM for Augmented Reality"

Best Paper

Alan Brunton, Can Ates Arikan, Tejas Madan Tanksale, Philipp Urban
"3D Printing Spatially Varying Color and Translucency"

Simon Meister, Junhwa Hur, Stefan Roth
"UnFlow: Unsupervised Learning of Optical Flow with a Bidirectional Census Loss"

Naser Damer, Yaza Wainakh, Viola Boller, Sven von den Berken, Philipp Terhörst, Andreas Braun, Arjan Kuijper
"CrazyFaces: Unassisted Circumvention of Watchlist Face Identification"

Best Thesis

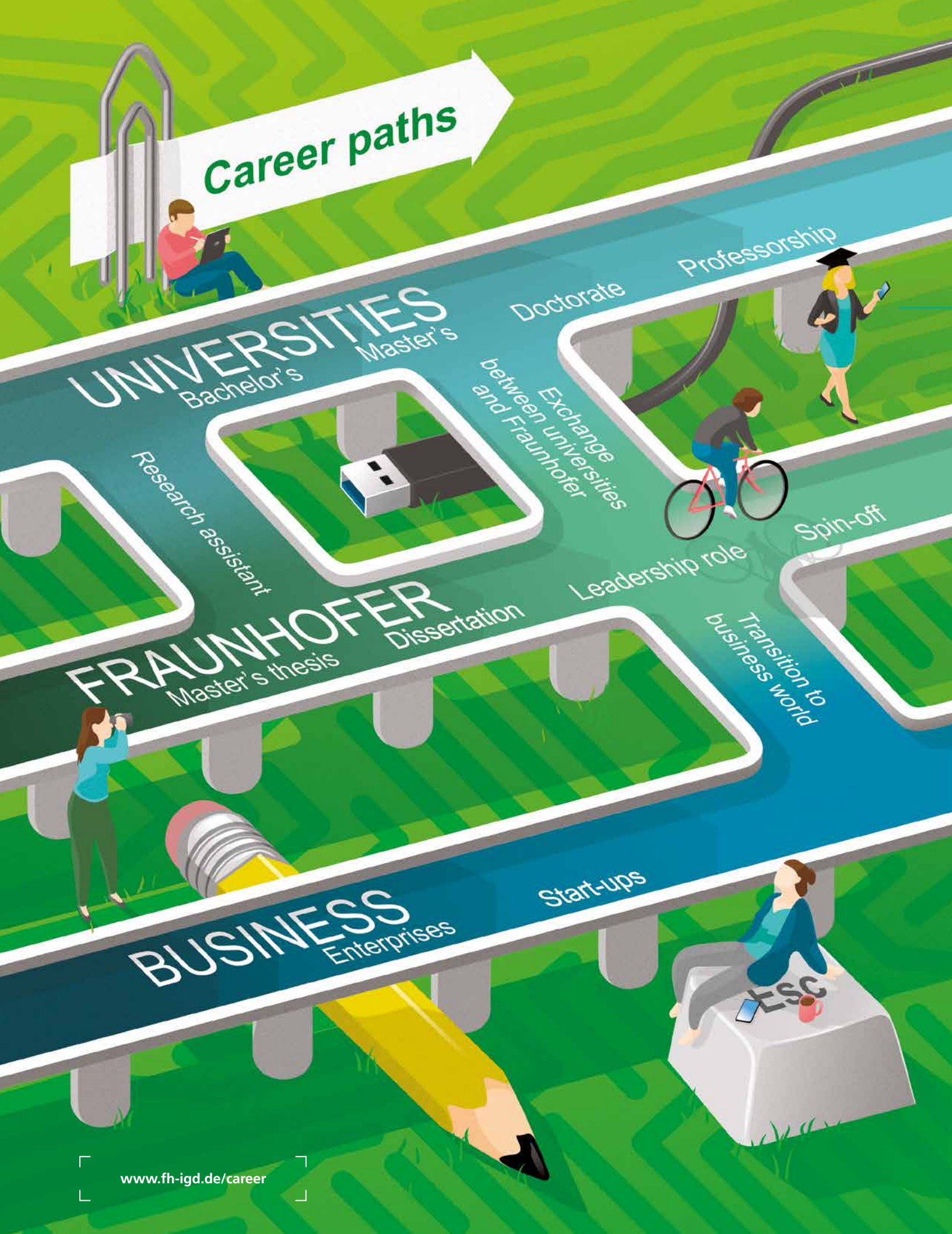
Award for bachelor's, master's, and doctorate theses in the visual-computing cluster

Daniel Ströter
"Tetrahedral Mesh Processing and Data Structures for Adaptive Volumetric Mesh Booleans on GPUs"

Yousif Hashisho
"Underwater Image Enhancement using Autoencoders"

Fadi Boutros
"Reducing Ethnic Bias of Face Recognition by Ethnic Augmentation"

www.fh-igd.de/Publications


Career paths
UNIVERSITIES
Bachelor's
Master's
Doctorate
Professorship
Exchange between universities and Fraunhofer
Research assistant
FRAUNHOFER
Master's thesis
Dissertation
Leadership role
Spin-off
Transition to business world
BUSINESS
Enterprises
Start-ups
ESC
www.fh-igd.de/career

"We wanted to harness interfaces to 'close the gaps' in our own technology. We collaborate very closely with Fraunhofer and have a strong market focus—it's a win-win for both sides." Dominik Ewald (center) and his co-founder / CEO Chaitanya Dhumasker (right) and CTO Jan Apel (left)

SUCCESSFUL KNOWLEDGE TRANSFER
COLLABORATION BETWEEN FRAUNHOFER IGD AND A START-UP

As described in Fraunhofer-Gesellschaft's statute, one of the organization's core tasks is to: "Work toward the translation of scientific findings into practical applications, and unite the forces of applied research and industrial practice." With this aim in mind, support is provided in many ways to enterprises and start-ups seeking to take Fraunhofer technologies to market. Just one example is a "tandem"—where a company and a Fraunhofer research department join forces.

In the case of start-up MonitorFish and Fraunhofer IGD's Maritime Graphics Competence Center in Rostock, Germany, the topic in question—fish—comes as no surprise. MonitorFish only entered the market in early 2017. Its Berlin-based founders were on a mission to improve fish health in aquacultures, and were looking for a suitable partner. They found what they sought at a "Start-Up Meets Fraunhofer" event in late 2017: What could be a better match than a Fraunhofer facility right on the coast? In Rostock, researchers have long focused on processing and enhancing underwater images—which is essential to effective environmental monitoring, as Dominik Ewald, CTO at MonitorFish, knows. "Throughout my career, I have dealt with food lifecycles and aquaculture. When it comes to aquaculture, there is still a lack of a meaningful monitoring system." No sooner said than done. By April 2018, the tandem had put together a persuasive pitch, winning a budget of 70,000 euros at Fraunhofer Demo-Days. The result was their joint project Optofish, which involves capturing and analyzing data on fish numbers, health and habitat in real time. It leverages artificial intelligence algorithms that semantically correlate animal welfare data with underwater images. Fish farmers are able to use software to keep an eye on the health of their stock, and quickly intervene when necessary. This improves animal health and, ultimately, has cost benefits. FTTF (Fraunhofer Technology Transfer Fund) is providing additional support for the project, allowing it to advance to a second phase.

The joint follow-up project Internet of Aquaculture was launched in summer 2019. It aims to take the market-readiness of the tracking and image analysis technology a step further—and make the vision of improving and safeguarding aquacultures a reality. "We are now working on initial ideas that would see our platform solution being applied to other livestock systems, and we have already launched a number of partnerships on the international market," reports Ewald. ■

"Fraunhofer's support and funding was essential to our current success."
Friedrich Lämmel

WHAT'S BECOME OF ...?

MHEALTH PIONEERS GMBH

In 2017, a research group at Fraunhofer IGD's site in Rostock gave rise to a Berlin start-up specializing in digital health data: mHealth Pioneers GmbH now has a headcount of ten, and is growing rapidly. Its mission is to simplify the home measurement of health-related parameters, by means of intuitive devices such as smartphones, wearables, and connected medical products. The Thryve data engine forms the basis for the enterprise's work. As CEO and former Fraunhofer employee Friedrich Lämmel explains: "Even though our original use case has since evolved, having the backing of the Fraunhofer name was a decisive factor in the spin-off's early success—particularly on the highly regulated and challenging healthcare market." mHealth Pioneers GmbH plans to continue growing in 2020, expanding its Europe-wide base of customers, establishing clinical trials for six types of disease, and collaborating with pharmaceutical companies on drug development. ■

www.fh-igd.de/Spin-offs

NETWORKING

Ambient Assisted Living

Big Data and Artificial Intelligence

Generative Manufacturing

Numeric Simulation of Products and Processes

FRAUNHOFER ALLIANCES

Institutes with diverse skills collaborate within Fraunhofer Alliances, working together to develop target business areas and to market their services.

Fraunhofer ICT Group

In the Fraunhofer ICT Group, institutes that work in information and communication technology (ICT) jointly market their services in research and development (R&D).

Fraunhofer Network of Excellence

Subsea@Fraunhofer sees experts in IT, material science, engineering, electronics, sensors, energy, robotics, aquaculture and automation join forces to develop new solutions for the responsible use of ocean resources.

CLOSE COLLABORATION

To truly benefit society as a whole, the research community must make its findings and insights readily accessible to the worlds of business and politics. Against this background, Fraunhofer IGD is an active participant in networks, associations and organizations across a variety of fields. The institute provides expert advice and targeted input and, in turn, is itself open to new ideas and challenges. Diverse Fraunhofer-Gesellschaft institutes work closely together across multiple disciplines to create tailored answers to specific issues and challenges.

www.fh-igd.de/Networks

NETWORKS

Standardization

Khronos

Web3D

ProSTEP iViP

Mecklenburg-Western-Pomerania

IT Initiative MV

Logistics Initiative MV

The Maritime Economy

Maritime Cluster Northern Germany

Subsea Monitoring Network

German Association for Marine Technology

Center of Maritime Technologies

Ausschuss Maritime Wirtschaft der IHK

3D Maritim Network

E-Boot 4.0

IT Security

Competence Center for Applied Security Technology (CAST)

TeleTrusT – IT Security Association Germany

European Institute of Innovation and Technology (EIT)

EIT-Digital

EIT-Health

BITKOM

TDWI e.V.

Biometrics

DIN Standard Committee for Biometrics

European Association for Biometrics (EAB)

Geospatial Information

Open Geospatial Consortium (OGC)

Deutscher Dachverband für Geoinformation (DDGI)

AK 3D-Stadtmodelle

InGeoForum

Additive Manufacturing

ProSTEP AMI

ZIM Network MUPAM

2019 FRAUNHOFER IN NUMBERS

74

Institutes and research centers

Over

28,000

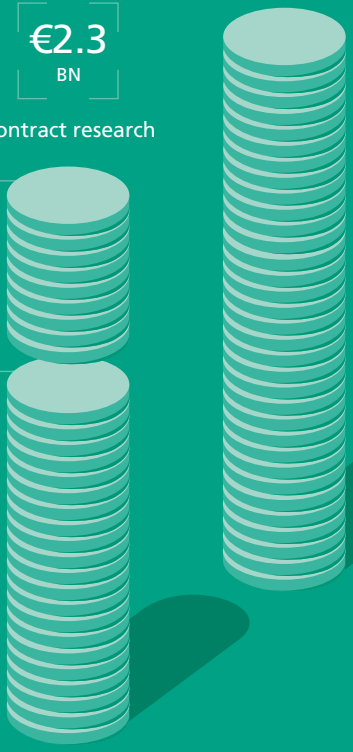
employees

€2.8 BN

Annual research funding

€2.3 BN

Contract research



30 %

Federal/state government

70 %

Industry and publicly funded research projects

FRAUNHOFER-GESELLSCHAFT

Fraunhofer-Gesellschaft's mission is research with a practical application. The organization was founded in 1949 and seeks to achieve outcomes that benefit the economy and society as a whole. Its contractual partners and customers include manufacturers, service providers, and the public sector.

Fraunhofer-Gesellschaft is Europe's leading organization for applied research. Across Germany, it comprises a total of 74 institutes and research centers. More than 28,000 employees conduct research projects with total annual funding of 2.8 billion euros. Of this amount, over 2.3 billion euros is from contract research. Some 70 percent of this subtotal is attributable to contracts from industry and to publicly funded research projects. Collaborative relationships with excellent research partners and innovative enterprises around the world ensure direct access to today's and tomorrow's leading economic and research hubs.

The clearly defined focus on applied research and key future technologies ensures that Fraunhofer-Gesellschaft plays a pivotal role in innovation in Germany, and in Europe as a whole. The impact of applied research goes beyond the direct benefit to customers: The research and development activities of the Fraunhofer institutes contribute to the competitiveness of their regions, of Germany, and of Europe. They drive innovation, strengthen technological capabilities, promote acceptance of new technologies, and provide vital training and skills development opportunities for the next generation of scientists and engineers.

Fraunhofer-Gesellschaft offers its employees possibilities for personal and professional development, equipping them for challenging roles within their institutes, at universities, in the business world and in society. By gaining practical training and experience at Fraunhofer institutes, students gain skills that open up excellent entry-level and development opportunities at enterprises.

Fraunhofer-Gesellschaft is a recognized non-profit organization, named for physicist Joseph von Fraunhofer (1787–1826), born in Munich. He was a successful scientific researcher, inventor and entrepreneur. ■

FRAUNHOFER EXECUTIVE BOARD

Prof. Reimund Neugebauer
Prof. Ralf Boris Wehrspohn
Prof. Alexander Kurz
Andreas Meuer

FRAUNHOFER IGD

Institute Advisor Dr. Johannes Nowak

www.fraunhofer.de/en

WHAT WE OFFER

We leverage our expertise in applied visual computing to support our customers in industry, business, and the public sector—through visualization and simulation technologies for diverse applications.

Visual computing can be implemented wherever cutting-edge computer systems are deployed. Humans are visual beings, and these technologies have the potential to simplify and improve work processes. Particularly when it comes to engineering tasks or decision-making on aesthetics, customized visual computing solutions can improve quality and quantity. Fraunhofer IGD and its partners offer a variety of high-quality contract research and related services, and work hand-in-hand with customers to put them into practice.

Our offering and services at a glance

- Contract research for industry, business, and government agencies
- Development of concepts, models, and practical solutions
- Evaluation of software and hardware
- On-site support services for customers
- Information visualization
- 2D and 3D modeling
- Development of new technologies, prototypes, and complete systems
- Model simulation
- Licensing
- Training
- Studies and consulting

CONTACTS

Technologies and practical applications drive our core competencies. In our research, we employ a broad spectrum of methods that we continuously improve and evolve. Our comprehensive and interdisciplinary approach allows us to offer many diverse services, divided into our 13 competence centers.

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VISUAL ASSISTANCE TECHNOLOGIES

The VAT Competence Center develops solutions for the visualization of critical data, particularly in the mechanical and plant engineering and healthcare industries. Under Mario Aehnelt's leadership, the center's researchers work on technologies to support people in various aspects of their work, education, and personal lives. They also create solutions that provide information and documents in line with needs and contexts, and that enable intuitive human-computer interaction.

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VISUAL COMPUTING SYSTEM TECHNOLOGIES

Visual computing encompasses image- and model-based informatics, including virtual and augmented reality, data processing, and computer vision. The Visual Computing System Technologies Competence Center led by Dr. Johannes Behr is dedicated to making Fraunhofer IGD's basic technologies available to other research groups and to German industry.

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VIRTUAL AND AUGMENTED REALITY

Virtual and Augmented Reality is the name and focus of the competence center led by Holger Graf. The center researches technologies for object recognition and tracking using video camera images. The corresponding solutions are deployed on smartphones and tablets in scenarios that include industrial maintenance, 3D interaction, and assisted driving.

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VISUAL COMPUTING

High-quality visualization requires both modeling and simulation. Eva Eggeling's team merges these two challenging disciplines to create immersive environments. Fraunhofer Austria in Graz enables visualization to be deployed in diverse real-world scenarios, with the aim of continuously improving human-computer interaction.

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SMART LIVING & BIOMETRIC TECHNOLOGIES

The Smart Living & Biometric Technologies Competence Center led by Florian Kirchbuchner develops pioneering solutions for smart environments. The aim is to seamlessly integrate dynamic sensor systems, intelligent platforms, innovative interaction, and biometric systems in workplaces and homes, to assist people in day-to-day life.

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SPATIAL INFORMATION MANAGEMENT

Eva Klien heads the Spatial Information Management Competence Center. Its researchers use new, digital geographic information technologies to enable effective communication and collaboration. Furthermore, the center is breaking new ground in 3D geographic information systems in terms of comprehensive integration, management, and visualization.

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INFORMATION VISUALIZATION AND VISUAL ANALYTICS

The Information Visualization and Visual Analytics (IVA) Competence Center not only focuses on visual analytics, but also on semantics visualization and real-time capabilities. Jörn Kohlhammer's team develops solutions for interactive visualization involving large volumes of data, i.e., visual analytics technologies.

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MARITIME GRAPHICS

The Maritime Graphics Competence Center develops solutions for maritime applications. Its pioneering work benefits shipbuilding, ship operation and marine technology/research. Under the direction of Uwe Freiherr von Lukas, Fraunhofer IGD researchers unite technical expertise in (underwater) image processing and visualization with specialist knowledge of the needs and challenges of the maritime industry.

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INTERACTIVE DIGITAL MEDIA

Under the guidance of Wolfgang Müller-Wittig, Fraunhofer Singapore (established as a successor to the IDM@NTU Project Center) leverages its expertise in real-time rendering, virtual and augmented reality, and human-computer interaction to strengthen the interactive digital media market—and to develop solutions for other sectors, such as transportation, marketing and education. The Singapore site provides valuable insights into the regional characteristics of the Asian market.

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CULTURAL HERITAGE DIGITIZATION

The Cultural Heritage Digitization Competence Center led by Pedro Santos develops fast, cost-effective digitization methods to virtually reproduce physical objects with high fidelity. This involves the automatic scanning and capture of an item's geometry and texture, plus physical and visual attributes of the material. The objects are scanned using a variety of optical sensors and light sources; consistent ambient conditions are maintained to ensure high-quality results.

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INTERACTIVE ENGINEERING TECHNOLOGIES

The Interactive Engineering Technologies Competence Center led by André Stork creates solutions that streamline decision-making for engineers. To this end, the researchers harness computer graphics technologies, including interactive graphics and simulations, and modeling. Sophisticated simulation methods and interactive visualization provide assistance and deliver visibility into complex issues.

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3D PRINTING TECHNOLOGY

Philipp Urban leads the 3D Printing Technology Competence Center, which develops models, algorithms, and software to create printed 3D copies of objects with high fidelity. The goal is a 3D copier with which the original and reproduction are virtually indistinguishable. The latest developments explore 3D printing with multiple materials.

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VISUAL HEALTHCARE TECHNOLOGIES

New software is changing medicine and medical technologies. Imaging supports doctors in their day-to-day work and plays an essential role in hospitals. These technologies help staff with planning, simulating, and navigating surgeries. The Visual Healthcare Technologies Competence Center led by Stefan Wesarg develops solutions that enable doctors to use image data to improve diagnoses, treatment plans, and operations.

Do you have any questions, or are you considering collaborating with us? Our contacts in Germany, Austria and Singapore would be glad to help.

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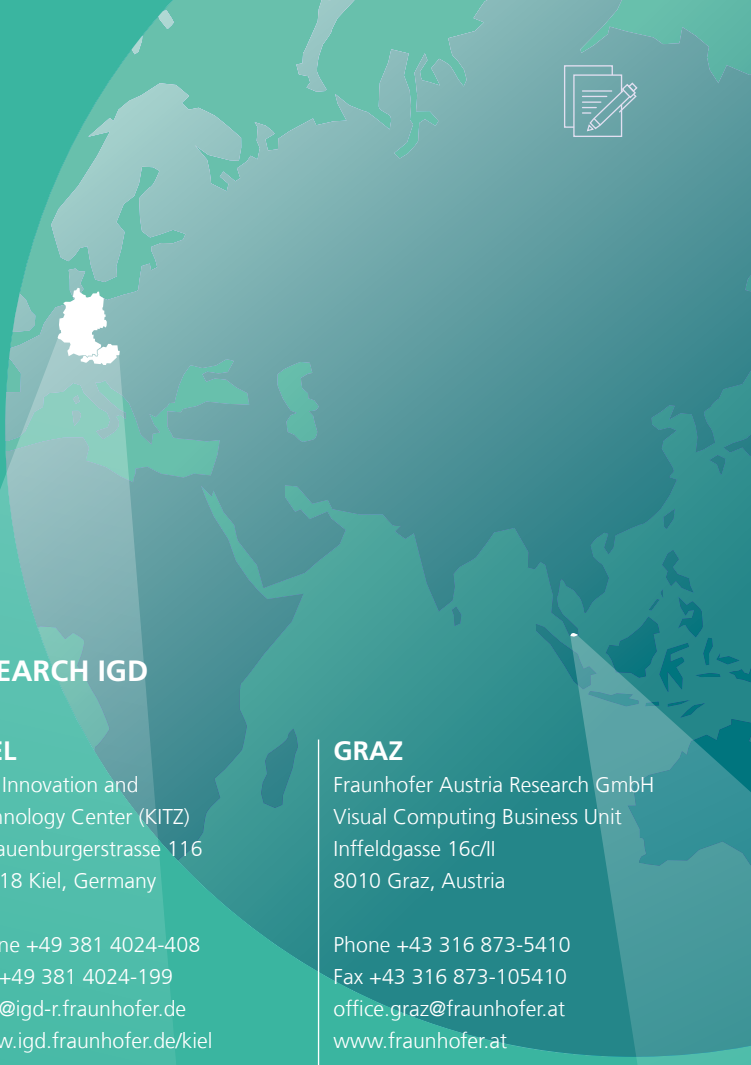

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