Fraunhofer
IGD

FRAUNHOFER INSTITUTE FOR COMPUTER GRAPHICS RESEARCH IGD

Smart connections: How the Internet of Things makes our lives easier

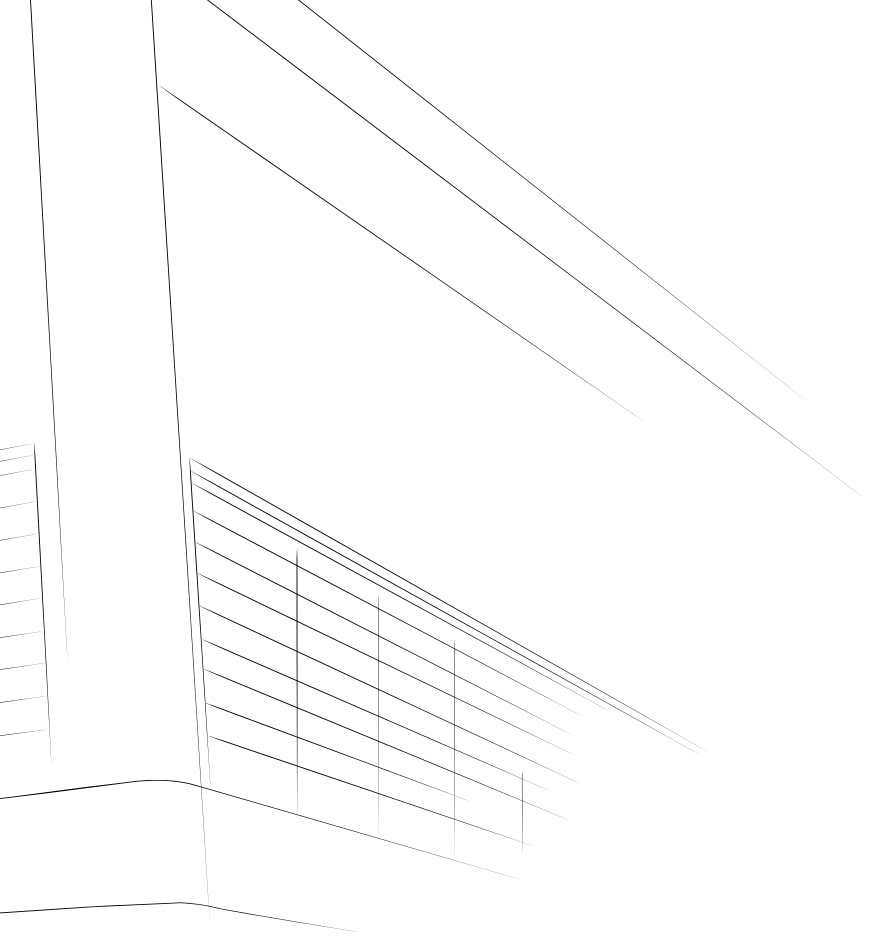
OUR YEAR 2020

RESEARCH IN ACTION

Dear friends and partners,

Are you also somewhat relieved to put aside the calendar for 2020? The sudden spread of the Covid-19 pandemic confronted us all with huge challenges. At the same time, we had to—and still must—find answers to some fundamental questions: How do we prepare our country for the coming years? How can we effectively improve living conditions? And more generally, how do we generate and visualize knowledge? If the past year has shown us anything, it is the following: Science, research, business, politics, and society as a whole are willing to tackle these challenges—actively, with circumspection, and ultimately highly successfully.

We are very proud of Fraunhofer IGD's contribution. Not simply because it was apparent and tangible how we stand united in difficult times—we also managed to enable working from home for the majority of tasks within a matter of days. With our solutions for the visualization and analysis of Covid-19 data, we supported the battle against coronavirus effectively from very early on. Public health protection agencies, for instance, made use of our simulation technology to study aerosol dispersion patterns and leveraged our classification of changes in the lungs of Covid-19 patients.



EDITORIAL

People as our focus

From the very outset, research at Fraunhofer IGD has focused on people—with regard to the further development of digital working and smart cities, care for older citizens and the sick, and in medicine. Our tool is visual computing. And two fields that were key to our activities in the past year demonstrate how effective this approach is:

Solutions integration in long-term care

Almost one in five Germans is already over 65. Nationwide, around three million people require long-term care. The Internet of Things can help seniors, in particular, to continue to live in their own homes. But we must first put the foundations in place. We are contributing our expertise, acquired over a period of 15 years, to a variety of research projects in order to integrate multiple sensor types and to visualize data from diverse sources. The results allow us to accurately assess potentially critical situations in people's homes. These systems "recognize" the circumstances and can intervene to provide assistance or to respond to dangers.

Digital technology as an enabler

Digital transformation opens up immense opportunities for successfully shaping our future. But we will only be able to put these options to good use if we have a robust digital infrastructure. In 2020, Germany generated around 72 billion gigabytes of data traffic via its wired broadband communications, and this will continue to grow. The expansion of the fiber-optic network is therefore essential. In this context, new technologies developed by Fraunhofer IGD markedly simplify planning work and accelerate the corresponding processes. These are merely a few examples of what we see as Fraunhofer IGD's mission: To generate images from data of highly diverse types—because pictures help us to understand. They enable the literally circumspect (from the Latin circumspectus, meaning to look around) planning of the next steps. Human beings are visual animals—and we intend to continue our research in the coming year with this focus. We look forward to it.

Dieter W. Fellner, Professor

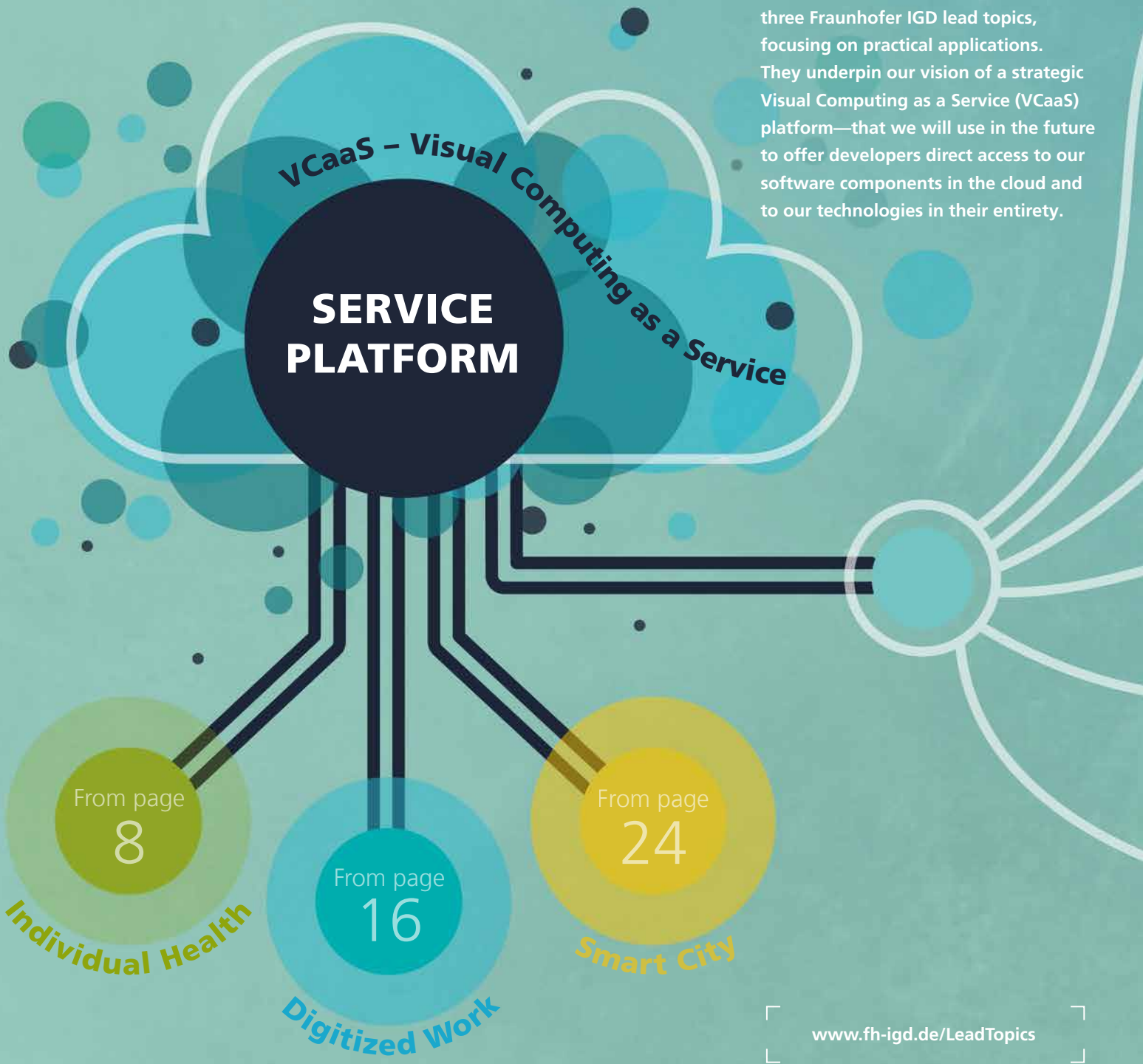
Dr. Matthias Unbescheiden

You can also read this annual report online:
www.fh-igd.de/JB2020-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 SIX 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.

ML

MACHINE LEARNING

By leveraging algorithms to identify patterns and correlations, machine-learning models are able to intelligently process data and draw conclusions. On this basis, we perform image-based quality control and implement automated data analytics for production chains. In addition, we harness machine learning for medical applications, including diagnostics, as well as for AR/VR technologies and counting fish stocks.

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

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.


0.7
0.5
0.2
Surface/Volume Ratio
Volume
Radius
Spherical Disproportion
Cohort Details
PATIENT LIST
PATIENT DETAILS
OUTLIER PATIENTS
Comparing the Primary Patient with Patient 'XV3338':
Surface
1
0.7
0.5
0.2
Surface/Volume Ratio
Volume
Radius
Spherical Disproportion
Surface:
10.77 / 9.93
Volume:
9.86 / 11.93
Spherical Disproportion:
9.95 / 11.12
Radius:
10.53 / 6.46
Surface/Volume Ratio:
14.05 / 7.94
TIs 0.2
TIb 0.2
MI 0.8
13.12.2019
13:07:31
C1-6-D
25Hz/16.3cm
85°/1.2
Abdomen/ABD
HI L 6.40 - 3.50
Gn -4
C9/M4
FF4/E3
SRI II 3/CRI 3

A helping hand in a crisis: **Health@Hand** visual control center for healthcare and administrative data

In these extraordinary times, medical professionals in hospitals need to monitor and manage fast-changing circumstances. Multiple patients, admitted at differing times, have to be supported by falling numbers of staff available for diagnostics, treatment, and care. As a result, employees have to apportion their time and efforts in line with the severity and progression of the disease, and with each patient's current condition. This requires a high degree of visibility. Fraunhofer IGD's Health@Hand visual control center visualizes health and administrative data via a digital twin of the specific department or hospital. It clearly displays all relevant data for doctors and nurses to view via a desktop computer or tablet—they can then see where, for instance, a mobile ventilator is currently located. The software provides simple access to all digitally available patient data, including vital signs in real time.

A number of functions were added to Health@Hand during the lastest development stage. These capabilities are especially useful when workloads are high. For example, users can now monitor environments outside the hospital building, e.g., in temporary treatment areas. Furthermore, there is a traffic light system for patients' infection status, and an overview of employees currently on shift. Consequently, Health@Hand can be deployed as a visual control center for data analysis and decision-making in emergency and crisis scenarios. The solution is a single point of access for all information needed to assess the situation and determine a course of action. Critical issues can be addressed faster and tasks completed more efficiently. ■

www.fh-igd.de/Corona-en

#WeKnowHow

FRAUNHOFER VS. CORONA

Throughout the coronavirus pandemic, visual computing solutions have supported medical professionals—helping to treat infected patients and to safeguard society against SARS-CoV-2.

Smart ultrasound software: **POCUS4Covid19** enables better diagnosis and monitoring of Covid-19 infections

POCUS4Covid19 is a pioneering software solution that helps physicians to monitor the progress of Covid-19 disease among their patients. Thoracic ultrasound scans have emerged as an effective method, alongside CT scans and X-rays, of diagnosing viral lung infections, including those caused by SARS-CoV-2. Ultrasound scans are free from radiation and can be repeated as many times as required. They can be performed at the patient's bedside, and the equipment is easy to disinfect. Recognizable changes in image data allow physicians to assess the progress of disease. However, the patterns captured during thoracic scans can be difficult to evaluate. The POCUS4Covid19 software solution identifies defined indicators automatically through quantitative, computer-assisted image analytics. This allows interpretation on the basis of objective parameters, and swift, simple assessment—even by staff not specially trained in the use of lung ultrasound. The software therefore offers tangible benefits in the treatment of patients with acute symptoms. It allows quicker diagnosis of Covid-19 and supports ongoing monitoring of the patient's condition. For example, one indicator of infection with Covid-19 is B-lines that reflect fluid accumulation in the pulmonary interstitium caused by viral pneumonia. The development team is working on the automatic recognition and quantification of these B-lines in image data. DEGUM, the German Society for the Use of Ultrasound in Medicine, is currently defining further Covid-19 indicators as the basis for future updates of the POCUS4Covid19 software. ■

www.fh-igd.de/Pocus-en

CorASiV software for public health protection agencies visualizes infection data, focusing on where and when the virus is being transmitted

Since the outbreak of the coronavirus pandemic, public health protection agencies have been flooded with data. All this information has to be entered, harmonized, and consolidated, yet many of these organizations lack the necessary software and staff. Employees need to search in legacy computer systems—sometimes manually—for data, or compare lists to find certain individuals, trace their contacts, and consolidate these data. These tasks take considerable time and effort, exacerbating personnel shortages and adding to employee and doctor workloads.

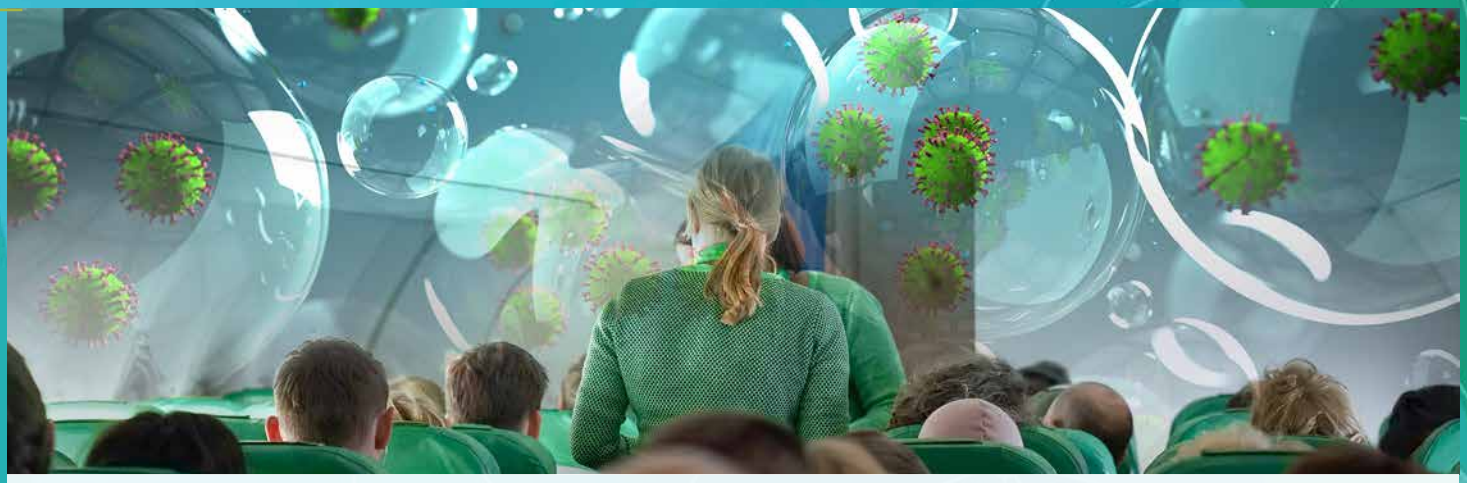
CorASiV digitally processes the data entered by public health agencies in compliance with data protection regulations, and visualizes the information in diverse ways. It displays on a map all the individuals whose data have been captured—with their place of residence and their current infection status—enabling each agency to assess the area under their supervision for possible local correlations.

The software solution visually depicts infection progression over time by identifying people who have contracted Covid-19 within similar periods. This allows staff at the health institutes to gain a more precise overview of how the disease is spreading—all at the press of a key. The map visualization helps health professionals to better understand the infection process, and to manage mitigation efforts in a more timely, targeted way. ■

www.fh-igd.de/Corasiv-en

#WeKnowHow

FRAUNHOFER VS. CORONA



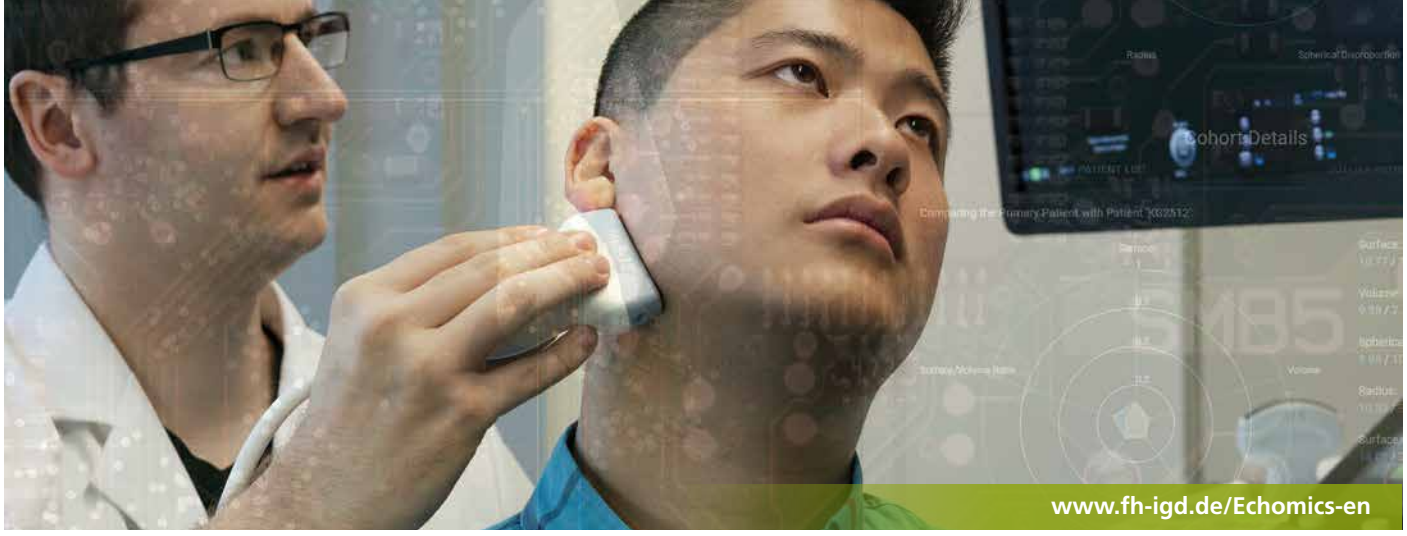
HYGIENE SOLUTIONS FOR AIRCRAFT – Simulating and predicting the dispersion of virus-containing aerosols

According to the latest available knowledge, the pathogen SARS-CoV-2 is primarily transmitted through droplets. Consequently, virus-containing aerosols pose the greatest threat of infection. These minuscule droplets suspended in the air make indoor environments especially risky.

The Fraunhofer project Avator focuses on air-purifying technologies, dispersion analysis, and hygiene solutions. It not only examines how aerosols spread, but also how contaminants can be removed from the air—particularly indoors. The first tests and simulations have demonstrated that improved ventilation significantly lowers aerosol concentrations and limits their dispersion radius.

However, a simulation that could provide meaningful insights might require hours or even days of processing. Even then, concrete conclusions cannot be drawn, as interactions between people are random in nature. Researchers at Fraunhofer IGD are therefore combining agent-based, highly efficient simulation using graphics cards (GPUs) with machine learning. Specifically, simulated agents generate random interactions where they come in close proximity to each other; the corresponding aerosol dispersion is also simulated, and neural networks identify any patterns. In order to generate the high number of simulations required for machine learning, the researchers leverage a GPU-accelerated solver, running the various scenarios on graphics cards. The machine-learning model analyzes these scenarios and helps recognize the virus's movements and behavior—for instance, its residence time in unventilated environments.

The results of this research benefit all operators of indoor spaces. In particular, means of transport, such as aircraft and trains, manufacturing environments, and areas where large audiences gather—as well as classrooms and open-plan offices—need to be addressed. ■



SMART ULTRASOUND

Fraunhofer IGD has been developing new ultrasound applications since the 1990s, to the benefit of many patients. In the future, its ECHOMICS project will enable physicians to identify malignant lymph nodes in the throat by means of ultrasound imaging, potentially obviating the need for invasive biopsies. The new sonAR method allows medical professionals to take advantage of augmented-reality headsets to view ultrasound images at the right sectional plane—for simpler examination and improved safety for closed biopsies.

Ultrasound imaging, or sonography, has been used for medical purposes since the late 1940s. In essence, it transmits sound waves into the body; these bounce off the different tissues, creating "echoes" that manifest as various gray tones on screen. Ultrasound is now firmly established in medicine, especially as an initial diagnostic tool. It is relatively inexpensive, there is no exposure to radiation as there is with X-rays, and it is easy to use.

ECHOMICS recognizes malignant lymph nodes in the throat without an invasive biopsy

Many organs can be examined using ultrasound technology. The soft parts of the throat are readily accessible—and this is exactly where the ECHOMICS technology currently being developed by Fraunhofer IGD is deployed. The aim is to harness ultrasound to detect neck lymph nodes where the malignant cells of a squamous cell carcinoma have spread. Carcinoma is the most common form of oral and throat cancer. "The ECHOMICS software enables rapid analysis without the need for tissue samples," explains Matthias Noll, Deputy Head of the Visual Healthcare Technologies Competence Center. ECHOMICS leverages radiomics, biomarkers, and visual markers extracted from images of the lymph nodes. They form the basis for identifiable signatures, allowing a known tissue type to be categorized in relation to a cancer diagnosis. In addition, IT experts at Fraunhofer IGD are testing up to 4000 additional ultrasound-specific markers. Ultrasound examinations could potentially make biopsies unnecessary, sparing patients an invasive procedure and allowing treatment to commence sooner.

sonAR enables doctors to view the right ultrasound image plane

The use of sonAR improves diagnostics and treatments. It enables medical staff to view ultrasound images in the right slice of a 3D space. An AR headset with semi-transparent mirrors displays the ultrasound image in the doctor's field of vision—instead of on-screen, as is typically the case. The sectional plane of the body appears precisely on top of the depicted structures. As Noll explains: "This allows the doctor to perform the examination directly on the patient; they do not have to repeatedly turn to face the screen of the ultrasound system." This approach offers a number of advantages: sonAR can improve the success rate of ultrasound-guided biopsies by making the process less dependent on the skill of the physician. To date, around ten percent of closed biopsies have to be repeated or changed to open biopsies because they were not successful. "sonAR shows the ultrasound plane directly on the patient, so the doctor can see exactly where their cannula is and better adjust the puncture channel," says Noll. The sonAR developers also believe the technology can enhance the safety of other surgical procedures. ■

AN END TO STAND-ALONE SOLUTIONS

Systems that reduce the workload on care professionals

The coronavirus pandemic has underlined the key role of care staff, but this profession has been under pressure for a long time. To ease this burden, Fraunhofer IGD is investigating how the Internet of Things (IoT) and artificial intelligence can be leveraged in care facilities and retirement homes.

In a globalized world, pandemics and demographic change (aging society) will continue to be key challenges—particularly when it comes to medical treatment and long-term care. The German Federal Ministry of Health has called for greater efforts to secure urgently needed "relief by medical and technological advances and digital transformation."

To meet the complex requirements of the care sector, the institute is looking to use IoT technologies to overcome compatibility problems between diverse standards and products. But this task is also about considering people, and people within a specific environment—which includes processes in care and retirement homes, and the systematic integration of the systems deployed.

Stand-alone solutions, limited functionality, a lack of standardization

To offer care staff reliable support requires overcoming the hurdles presented by the siloed solutions currently on the market. Conventional local motion detectors and other sensors are often imprecise. They simply respond to heat or light, unable to detect whether a patient is genuinely struggling to get up from bed or simply wishes to retrieve a blanket that has slipped onto the floor. Plus, it is generally not possible to combine diverse systems. There are too many communication and wireless transmission standards. Frequent false alarms triggered by individual innocuous events that do not require action add to care professionals' workload. The only way to recognize genuine anomalies at an early stage is to have integrated technologies and AI-assisted software.

When embedded into an open system, IoT technologies, such as smart flooring, motion detectors and other sensors, can already be employed to monitor circumstances in rooms. In the future, it will be possible for artificial intelligence to go a step further and to autonomously analyze the situation. An AI-supported system learns to recognize human habits and patterns of behavior; when there are anomalies, it can issue an alert.

Reduced workload for staff, patient involvement—care in the future

AI-supported software—and its combination with Internet of Things devices—is able to detect irregularities in a given room, eliminating the need for time-consuming in-person checks by staff. An alarm system with an intercom function allows the patient to cancel false alarms. And for medical checkups, patients can play an active role by means of user-friendly instruments, e.g., by entering their own blood pressure readings. The data are also automatically transferred to an electronic patient record. This meets the need for documentation, offers visibility into the care provided, and allows transparent external communications. And that eases the staff workload further, enabling them to spend more time on their core tasks—high-quality human interaction. ■

VIRTUAL TRAINING

Virtual training helps medical professionals familiarize themselves with new equipment. These courses are especially beneficial when numerous people need to gain the corresponding skills, or when the devices are large and expensive—and are therefore not readily available for training purposes. The Machine@Hand training tool offers highly realistic 3D models of ultrasound, X-ray, MRI, CT, and any other equipment, allowing physicians and nurses to experience how these systems are operated. Instructors can create the training modules themselves without the need for programming skills and can modify content or add tailor-made information or guidance. The trainee can then learn independently and from anywhere by means of a VR headset. As a result, training can continue to take place even when in-person group and practice sessions are not possible—for example, during the coronavirus pandemic. It is also possible for the virtual training modules to be attended by multiple people simultaneously, enabling them to practice teamwork. ■

www.fh-igd.de/MachineAtHand

Experience Machine@Hand at the Hannover Messe in April 12-16, 2021!

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.

GREATER INSIGHT INTO PRODUCT DESIGN

Interactive visualization streamlines product development

In product development, manufacturing, and logistics, it is not generally possible to optimize all parameters equally; there is usually a trade-off. However, support is available to decision-makers who need to weigh the various options and, where criteria are potentially in conflict, find the best possible compromise quickly and communicate it effectively—by means of interactive visualization.

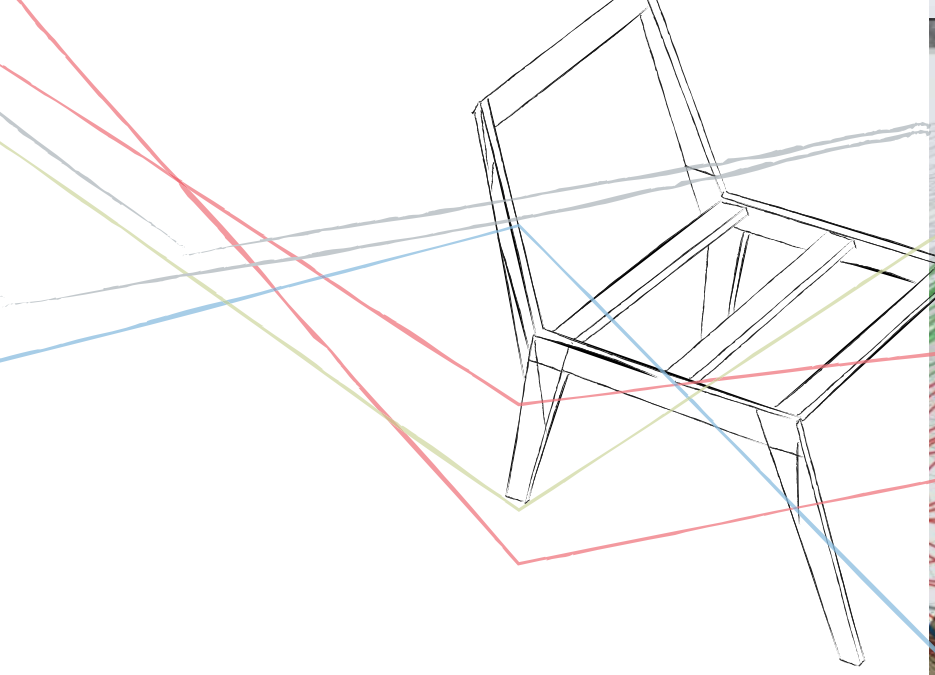
It is harder than ever to develop a successful product—expectations are rising in terms of quality, sustainability, energy efficiency, and more. And when faced with a complex, multidimensional challenge of this kind, there is frequently no way to arrive at an ideal solution for every objective. Instead, there are a number of so-called Pareto optimal states: One attribute cannot be improved without negatively impacting one or more of the others. In this situation, visualization software can help—by illustrating the complex interactions between all parameters and attributes of a proposed product. In cooperation with the Linz Center of Mechatronics (LCM), Fraunhofer IGD has created PAVED (Pareto Front Visualization for Engineering Design). This interactive tool effectively visualizes interrelationships between individual criteria, offering a robust and reliable basis for decision-making: Could we design the product in a different way? Transparent, easy-to-understand comparisons also make it easier to coordinate activities with the customer. Visualization therefore streamlines the entire product development process.

All product parameters in a single interactive visualization

The PAVED software was initially developed to improve the design of electric motors. This work was based on technical data and mathematical simulations from the researchers in Linz. Electric motors are a prime example of the trade-off challenge, as a large number of variables impact parameters such as efficiency, power, stable operation, and cost—and they are not always intuitively understood. PAVED visualization takes the form of highly precise curves that display how the various individual parameters interact, and what exactly happens if you change any particular value. This can be performed quickly and easily using a slider bar. The software displays how the change in value impacts the other criteria in real-time—allowing the user to experiment with "what would happen if" scenarios to assess variations in design. This makes it possible to instantly recognize conflicts and correlations. For example, an increase in motor power means a rise in cost. To maintain visibility despite so many design options, the software allows the user to define favorites and to color them, ensuring they remain instantly recognizable.

Visualization makes hidden correlations visible

The tool does not replace the expertise of experienced engineers. Instead, it helps them to make the most efficient use of their skills by allowing them to try out unconventional ideas on-screen. "It is often a matter of nuance. A tiny adjustment of one particular value, even something such as the thickness of a material at a specific position, can have an unpredicted impact on other parameters," explains Lena Cibulski, project leader. In other words, visualization makes correlations visible that the experts would not have expected or otherwise uncovered.



www.fh-igd.de/Paved-en

Hands-on: You can try out the visualization tool for yourself at paved.iva.igd.fraunhofer.de

Transparent communication of design options

Visualization not only supports the nuts-and-bolts of development work; it is also an excellent aid when presenting ideas to customers or management, allowing them to see at a glance the various options. "There is no single right solution," says Cibulski. There are a broad variety of design variants with differing attributes and advantages—and the choice is down to the decision-makers in accordance with their priorities. The software is highly intuitive, allowing non-engineers to judge for themselves the various alternatives and to identify the best possible compromise. The solution can be deployed locally or on the internet. Customers or business partners, for instance, can launch the solution simply by clicking on a link—and can then compare and contrast all product variants for themselves. This facilitates communication and streamlines coordination. Its added value could benefit other industries as well. "Our software can be employed to good effect in any field that has to address many different design variants with, at times, incompatible quality criteria that call for a trade-off," explains Cibulski. She names a number of examples, such as planning the supply of electricity to a building or the development of complex production systems in a factory. And although PAVED was originally conceived for engineering, its visualization capabilities can also help decision-makers in the world of politics and society generally to better evaluate consequences and arrive at the best possible choices. ■

GOLDEN GLOBES 2020

Fraunhofer Cuttlefish software plays a starring role

Missing Link won the Golden Globe award for Best Animated Feature—every single facial expression in this stop-motion movie, totaling over 106,000, was printed in 3D. The LAIKA studio had already employed 3D printers for animated films before, but *Missing Link* saw them make use of Cuttlefish, the 3D printer driver developed by Fraunhofer IGD. The adventure movie starring the lonely Sasquatch was also nominated for the Oscar® for Best Animated Feature.

The greatest challenge was the use of a large number of colors to create highly lifelike models of the adventurers, researchers, and Mr. Link himself. Every tone had to exactly match the one seen in the previous frame. And this is where Cuttlefish was in its element. Brian McLean, LAIKA's Director of Rapid Prototype, explains: "We have been using 3D printers for stop-motion productions since *Coraline*, LAIKA's very first feature film. For our latest production, *Missing Link*, we deployed Fraunhofer IGD technology, as it offers us unique color consistency and geometric precision. The combination of Cuttlefish software and Stratasys J750 hardware enabled us to create the most sophisticated 3D color textures ever produced."

Cuttlefish makes it possible to work with many print materials simultaneously to precisely reproduce the geometry, colors, and subtle color transitions of the original, and to simulate the print in advance on-screen. In 2018, the developers successfully took the next hurdle: Cuttlefish can now also print translucencies, i.e., partially or completely transparent materials. ■

www.fh-igd.de/Cuttlefish-en

NEW 2021: Virtual workshop series IGDigital. April 15, 2021 Webinar GraMMaCAD

AN ELEGANT, INTERACTIVE, AND INTUITIVE SOLUTION FOR CAD MATERIAL GRADIENTS

Functionally graded materials enable the design of components in line with specific needs. Researchers at Fraunhofer IGD are therefore developing their GraMMaCAD application to elegantly and intuitively define material gradients in CAD models. This opens up new possibilities for 3D printing with multiple materials and for fulfilling complex component requirements.

Fraunhofer Institute for Computer Graphics Research IGD's GraMMaCAD (Graded Multi-Material CAD) software is a valuable tool for industry players. It allows users to quickly and easily enrich CAD models with material distributions and gradients during virtual product development.

Previously, designers, engineers, and 3D printing service providers devoted considerable time to defining locally varying properties in CAD models—there was no single elegant solution that could make this cumbersome process interactive and intuitive. This raised the question: How can locally varying material information be generated within a virtual three-dimensional component in a simple way?

This is precisely where GraMMaCAD comes in. The software can generate volumetric material distributions and gradients—and to this end, it provides users with an easy-to-understand, interactive graphical editor. The starting point is a CAD model, generated with any leading CAD tool. GraMMaCAD supports a variety of common CAD formats, e.g., STEP, CATIA, JT, Pro/E and SolidWorks. The software then allows the user to select from three approaches for generating material distributions in the CAD model. The first approach allows one or more CAD surfaces to be selected. The second leverages auxiliary geometries, enabling the user to select one or more newly generated planes. Both options generate a graded material progression, starting from the selected surfaces, and can be interactively modified by the user. The third approach is ideal when the user wants to create gradients between parts of a CAD model. In this scenario, the user must first break the model down into subcomponents. GraMMaCAD can then be harnessed to generate the gradients between them, following the part's geometry. ■

www.fh-igd.de/Grammacad-en

Visit our demo at the Hannover Messe April 12-16, 2021!

FACT CHECK:
Augmented reality in quality control

How can AR be harnessed for quality assurance?

AR delivers valuable quality assurance information, as it can directly compare the data it captures on the production line with CAD data. As a result, quality control can be automated. Cameras take photographs of the component to be checked. Geometric CAD data are then placed on top of the image. This enables the inspection system to compare the component with the design data and to identify any defects. The system leverages AI algorithms but does not have to be trained using large numbers of reference images. There is also a mobile version, enabling inspection engineers to document required tasks more quickly, or to familiarize themselves with the procedure steps. For instance, they can wear a headset and use AR to see the information they need to verify CAD specifications.

Surely the technology entails too much effort and expense?

The effort and expense for a vision system for quality control differ only slightly with the inclusion of AR. The only addition is the installation of the AR software. And the cost is outweighed by a significant benefit: There is no need for the large amount of learning required by an AI-based vision system. Moreover, AR means greater flexibility because the system does not have to be retrained for each new part. The corresponding CAD model can simply be used. According to our calculations, this technology could deliver high six-figure savings in total for each production line. If inspectors use AR with a mobile device, the effort required is even lower. The user simply has to hold their smartphone or tablet over the component, and the comparison with CAD data can start immediately.

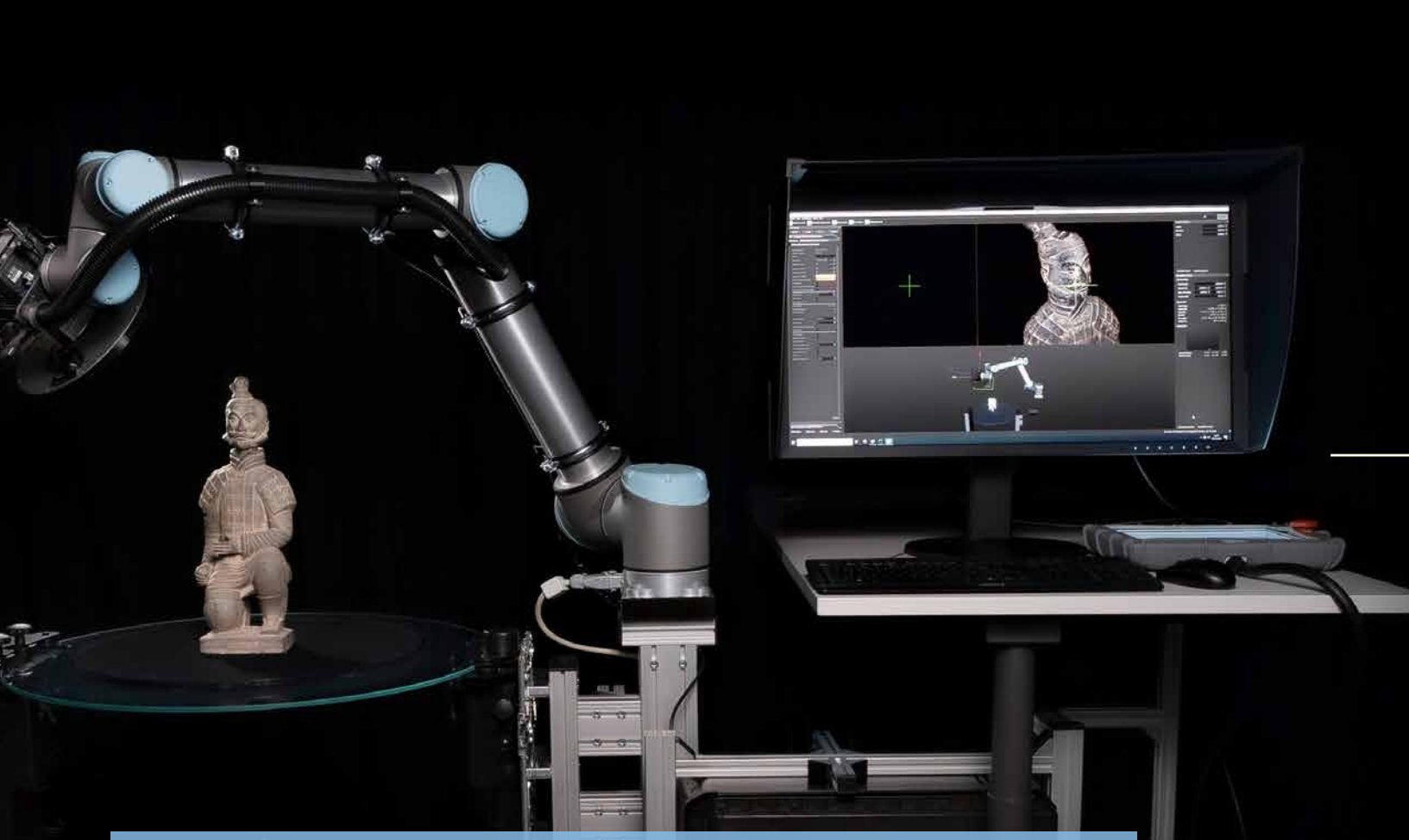
Is AR for quality assurance a far-off dream?

AR for quality assurance is no longer merely a vision. In a variety of projects, Fraunhofer IGD has collaborated with automotive industry players, such as Daimler, to develop an automated system that supports visual quality checks with the help of AR. Daimler factories in Bremen and Sindelfingen are already using the solution. Moreover, a Fraunhofer IGD spin-off offers a developer kit that enables companies to program their own inspection applications.

What are the greatest challenges at the moment?

When AR is deployed in manufacturing processes, the production environment can be a challenge. The systems sometimes have to contend with difficult conditions. For example, lighting can vary considerably, and there can be complex overlapping surfaces. Research is being conducted into ways of achieving further progress—e.g., by deploying artificial intelligence. There is also room for improvement with headsets for AR applications. They need to be tailored to the needs of manufacturing; for example, as they lack functions such as object tracking.

Online interview with our AR expert
www.fh-igd.de/AR-interview-en



CULTARM3D

Developed by Fraunhofer—Powered by Phase ONE

The Department for Cultural Heritage Digitization at Fraunhofer Institute for Computer Graphics Research IGD, and the world's leading high-end camera manufacturer, Phase One, have signed a memorandum of understanding. Together, the two partners will cooperate to bring to market the world's first autonomous, color-faithful 3D digitization system, CultArm3D, based on CultLab3D™ technology.

Commencing in January 2021, the partners will enter a seed unit phase leading to a final product by 2022, when CultArm3D will be offered to initial customers on attractive early adopter terms.

CultArm3D combines best practices with ease-of-use for the many museums planning to embark on high-resolution 3D digitization of their collections. The 3D scanning results can be harnessed for scientific research, restoration, and preservation, for virtual and augmented reality applications, for 3D printing of works of art, or to engage with the general public.

CultArm3D delivers consistent high quality at high speed through autonomous adaptive scanning algorithms, creating detailed and color-faithful 3D representations of examples of cultural heritage, including objects with challenging surfaces, such as gold, brass, bronze and semi-translucent materials, e.g., ivory. ■

www.cultarm3d.de

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.

THE INTERNET OF THINGS— THE KEY TO SMART CITIES?

Up to now, integrated smart cities have been more concept than concrete reality, with solutions developed in isolation. Fraunhofer IGD is working on technologies to make the vision a reality.

The Internet of Things? The term might leave many people scratching their heads. But society has long learned to value the services IoT makes possible. For example, pressure sensors in parking garages can detect the presence of a car. As a result, information on how many spaces are available can be displayed on variable message signs several blocks away. Furthermore, in cities such as Darmstadt, Germany, street lighting is linked to motion sensors. By only switching on when needed—i.e., when pedestrians, drivers, bikers, etc. approach—the lights save electricity and cut costs. There are also sensors that measure sound levels: If deemed too high, the speed limit can be lowered to keep noise in check.

Just how "smart" are our cities?

Parking-space displays are useful, but the smart city vision goes much further. Daniel Fährmann of Fraunhofer IGD believes the majority of solutions are "siloed," i.e., isolated. Achieving a truly integrated smart city would mean moving away from these disparate, stand-alone technologies and moving toward a holistic, big-picture context. When applied to day-to-day life, that might mean, for instance, not only using sensor data to trigger individual actions—such as turning on streetlights when sensors detect movement—but combining data from multiple sensors in a way that adds greater value. The potential use cases are manifold and diverse. Many will likely emerge only after the corresponding technologies become available.

Platforms are still in their infancy—and so are smart cities

The first roadblock on the path to tomorrow's smart cities is sensor data—specifically, ensuring users are guaranteed constant and reliable access to these data. There are already platforms designed to make this possible. However, they function rather like containers that sensor operators can "fill" with data. And if the data are not added, or are only added irregularly, then the latest information is not available. Continuous updates take time and effort. And even when performed, the data are at best provided retroactively, and not in real time. A further shortcoming is the fact that the various data are not in a uniform format, hampering integration. So, explains Fährmann, although there are technological foundations for smart cities to build on, these are currently predominately stand-alone solutions.

Furthermore, there is a second obstacle on the road to the smart city: To increase the added value, data from multiple and diverse sensors must be merged in a meaningful way. This is referred to as multi-sensor data fusion—and this process, too, is currently in its infancy.

Fraunhofer IGD research advances the vision

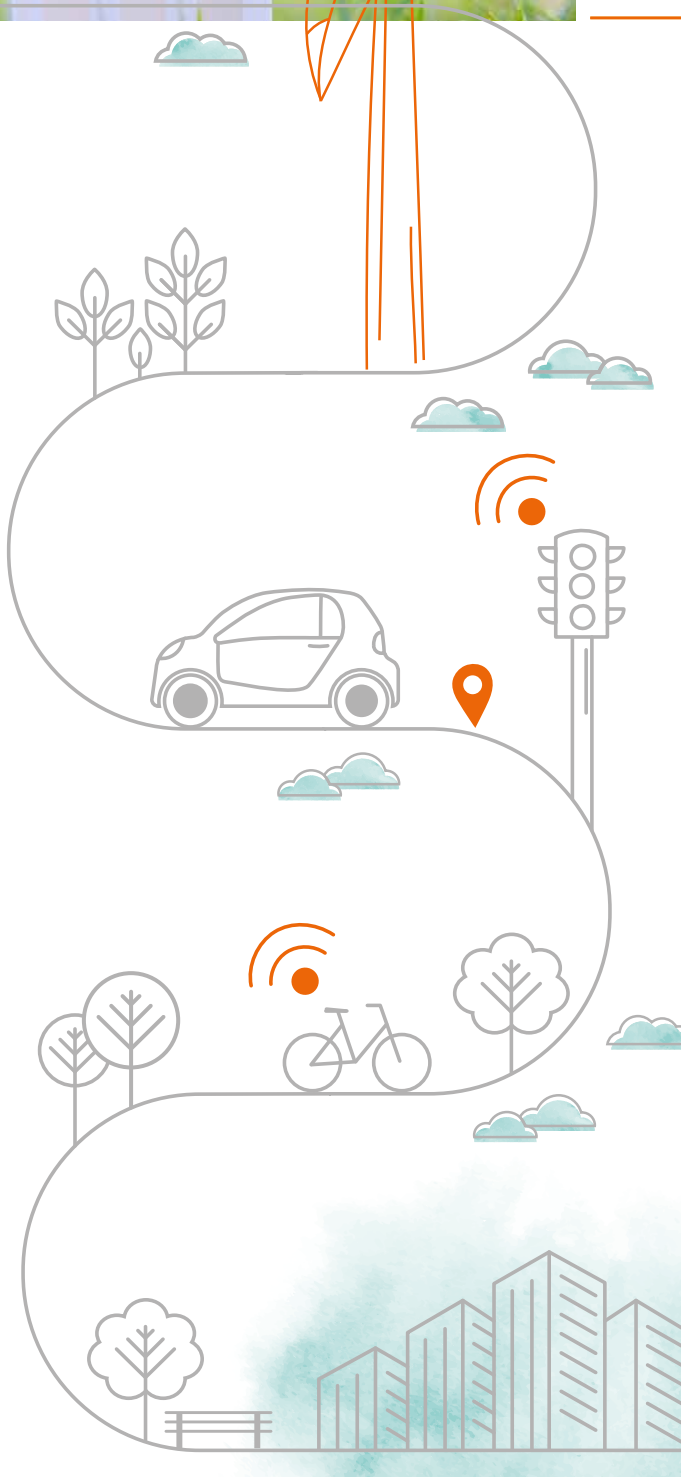
Fraunhofer IGD researchers are working hard on concrete solutions. They already have a platform: UniversAAL. This was originally developed for an entirely different issue, as an answer

www.fh-igd.de/SmartCity

to the question: How can the Internet of Things assist the elderly—enabling them to continue living in their homes in familiar surroundings for as long as possible, while being well cared for?

As Fährmann explains, the UniversAAL platform's latest task corresponds precisely to smart city needs. UniversAAL ultimately combines data from a variety of sensors in real time and saves this information in a consistent data format. Once the sensor operator has installed and enabled the platform, UniversAAL captures and consolidates sensor data autonomously—so the operator has one less item on their agenda. The platform is already deployed in smart living scenarios; now, the researchers need to apply it to smart city use cases.

Fährmann is tackling the second issue—combining data in a meaningful way—through sensor data fusion. To this end, the researcher leverages data from platforms in New York, which collect and store the data—as described above—retroactively and in a variety of formats. For example, what citizen complaints were received in various districts of New York? How can these data be used to infer atypical situations on the ground, i.e., for spatio-temporal anomaly detection? And how can sensor data help avoid adverse situations in the future? The researchers are turning to artificial intelligence, specifically, machine learning, for the answers—because human beings simply cannot keep pace with and keep track of all the available input. ■



www.fh-igd.de/Fiberglass-en

FRAUNHOFER TECHNOLOGY TRIALED UNDER REAL-WORLD CONDITIONS

Fraunhofer IGD has developed a software solution that further automates the planning process for the roll-out of fiber-optic broadband. Fibre3D enables Deutsche Telekom to submit applications to local government agencies without the need for costly and time-consuming site visits. This accelerates the approval process, ensuring there are no delays to the expansion of Germany's fiber-optic infrastructure.

Laying the very slender fiber-optic cables is one of the final steps in the complex process of expanding Germany's fiber infrastructure. It is preceded by significant planning effort and the submission of applications to local government agencies. Deutsche Telekom assists its staff by providing digital cartographic material. However, until now a small but key task could not be performed from an employee's desktop. For example, positioning the outdoor cabinets from where the fiber cables are routed from the network trunk line to individual households requires time-consuming on-site inspection.

Virtual 3D planning of distribution cabinet locations

The Fibre3D software package developed by Fraunhofer IGD allows planners to enter a 3D world and position the cabinets in a virtual space. Measurement functions and accurately scaled projections enable rapid verification of possible sites—even in challenging environments—while considering all possible factors, such as the prescribed available width of the sidewalk. Once digital planning is complete, it is possible to generate user-friendly photomontages suitable for submission with applications to government agencies. These realistic depictions also help the agency to complete the approval process.

A significant reduction in time needed for planning

An initial version of Fibre3D was deployed by Deutsche Telekom in four planning units in 2019. "In one case, a colleague was able to prepare 27 sites on just a single day and immediately submit applications to the local government agency—and it was digital from end to end," states Marius Kraus, Fibre3D Product Owner at Deutsche Telekom Technik GmbH. This would not have been possible if the company had been required to make on-site visits, take actual photos, and only afterward submit the application. "With the conventional process, our staff spent a lot of time on the road. Now, if one of the local agencies requests changes, these too can be completed far more quickly." adds Kraus.

Continuous improvement of the software

The software is gradually being rolled out to more and more regions. The first real-world trials of the tool identified additional requirements. For example, it is now possible to select the corresponding distribution cabinet sizes from an overview in the 3D view. "Feedback from the planners is exceptionally valuable, and we incorporate it into our further development and debugging work," states Pascal Bormann, a developer at Fraunhofer IGD. But it is not the only aspect of the project keeping his team busy: "Optical fiber is being introduced into ever-larger areas, presenting us with the technical challenge of processing ever-greater volumes of data." In the future, it is possible Fibre3D will be applied to other fiber-optic planning tasks. Currently, the developers at Fraunhofer IGD are seeking to visualize the network trunk line. As a result, planners would not only see the position of the distribution cabinets, but also the trench for the cabling between them and the trunk line. ■

MAKING TIRES FROM DANDELIONS

Approximately 10 to 40 percent of a car tire comprises natural rubber, traditionally harvested from the sap of the caoutchouc tree. However, this source is increasingly facing criticism. Its monoculture cultivation is harmful to the environment, raw materials must be transported long distances to tire factories, and there are only a few regions in the world where these trees can grow. In the long term, the caoutchouc tree will simply not be able to meet growing global demand. Moreover, the use of synthetic rubber as a substitute is limited by its material attributes. So what are the alternatives? One candidate is *Taraxacum kok-saghyz*, commonly referred to as Russian dandelion. This plant has long been known to have sap with a high concentration of natural rubber—on par with the caoutchouc tree itself. Researchers are now assessing whether it is possible to industrialize its cultivation under acceptable ecological and economic conditions. This poses a significant challenge, as the cost-effective farming of Russian dandelion in our climes would require effective control of indigenous weeds—without resorting to conventional herbicides, as these chemicals would cause collateral damage to the dandelion crop. Against this background, tire maker Continental is cooperating with research partners to develop an automated mechanical method of weeding. The system would entail the continuous removal of weeds by means of a special attachment on a self-driving tractor. The Rostock-based Fraunhofer IGD team is providing expert advice on autonomous image recognition: An intelligent camera with AI-based software can distinguish in real time between a Russian dandelion and a weed. The solution is currently being trialed in the German state of Mecklenburg-Western Pomerania. ■

Continental would like to express its thanks for the support received from the German Federal Ministry of Education and Research and the Ministry of Food and Agriculture on the basis of a resolution passed by the German Bundestag, and for the support of the Mecklenburg-Western Pomerania Ministry of Economics, Employment and Health by means of funds from the European Union's ERDF program in the period 2014 to 2020.

www.fh-igd.de/Fairport-en

SAFELY INCORPORATING DRONES INTO AIRSPACE

There is an urgent need for clearly defined rules to govern the growing number of drones in German airspace. No-fly zones are key to ensuring the safe and equitable integration of these unmanned aircraft. Highly precise geodata can help to automatically define and indicate these prohibited areas. With this in mind, the fAIRport project was launched in May 2020—with Fraunhofer IGD providing its expertise in object recognition, geodata visualization, and artificial intelligence.

The future of drones is bright and multifaceted: They can replace hazardous helicopter monitoring and maintenance flights along high-voltage transmission lines and gas pipelines. They can accelerate the delivery of medications, organs, and blood. And their deployment for search-and-rescue missions can save lives. Moreover, drones can help protect the environment by significantly reducing CO_2 emissions. Yet turning these possibilities into practical solutions will require safely integrating these unmanned flying machines into Germany's highly regulated airspace: Even when pilots have no line of sight to their drones, they must ensure their devices do not enter prohibited areas.

Using artificial intelligence to demarcate no-fly zones

DFS, Germany's air navigation service organization, plans to provide drone pilots with high-quality geodata indicating no-fly zones via the UTM (Universal Transverse Mercator) system for managing unmanned aviation—operated by its subsidiary Droniq. These zones include, for example, wind turbines, rail and road networks, industrial facilities, and locations where large numbers of people can be expected, such as campsites. To this end, Fraunhofer IGD is developing a method based on artificial intelligence that interprets high-definition satellite images—specifically, attributes that have not been cartographically processed, but which represent areas drones are not permitted to enter. Machine vision and learning methods are capable of reliably finding and accurately categorizing the corresponding structures, and can add further relevant information. Artificial neural networks are employed to recognize 3D objects via 2D satellite images. "For instance, we are now able to determine exactly how high a wind turbine is by the shadow it casts," explains project leader Mohamad Albadawi. Going forward, he and his team will teach the neural networks to perform further tasks, such as detecting additional important features, e.g., helicopter landing pads.

Comprehensive data make it possible to safely fly drones

The project goal is to make a geodata platform based on open standards available by 2023 and operated by wetransform, a Fraunhofer IGD spin-off. Via a dedicated interface, local government agencies will be able to add further information, for example, on mass gatherings such as markets or concerts, to create temporary no-fly zones. The platform will also continuously monitor and update existing flight-relevant data. This not only forms the basis for managing drone flights but also contributes to better airspace planning, helping to make general aviation safer. The Federal German Ministry of Transport and Digital Infrastructure (BMVI) has provided the fAIRport project with 1,205,000 euros in funding within the scope of the mFUND research initiative. ■

THE FUTURE OF AGRICULTURE:
Fraunhofer Center for Biogenic Value Creation and Smart Farming

A new Fraunhofer center has taken root. From 2021, the Fraunhofer Center for Biogenic Value Creation and Smart Farming will be helping to shape the future of agriculture. Its mission is to research and develop innovative farming technologies, with a focus on highly customized, automated, sustainable solutions—and Fraunhofer IGD will play a central role. The goal is to provide farmers with technical and methodological tools that empower them to overcome global challenges. These include, for instance, climate change, health hazards, and the need to address growing public demand for greater animal welfare, sustainability, and quality. The new center provides a virtual platform for collaboration across Fraunhofer institutes and across sites. It is organized into two independent initiatives in the German states of Mecklenburg-Western Pomerania and Bavaria.

What exactly does biogenic value creation entail? In addition to food production, it is about the cultivation, supply, and processing of raw agricultural materials for energy generation. And in all instances, it is vital to strike the right balance—between economic viability, eco-friendliness, and acceptance by society. Smart farming, in turn, is about digital transformation. Large volumes of data can be captured and analyzed by various sensor technologies. Digital systems can then aid decision-making, for example, by helping farmers to redesign processes or optimize the use of fertilizers, animal feed, and medication. Furthermore, assistance systems and autonomous vehicles—on land, in the air, or on the water—can counteract staff shortages while increasing efficiency and effectiveness. ■

www.fh-igd.de/Smart-Farming-en

UNDERWATER TECHNOLOGIES

At the Rostock site—From vision to reality

2nd DIGITAL OCEAN CONVENTION
Rostock, August 25-26, 2021

The **Ocean Technology Campus (OTC)** is an innovative and productive environment for the development and testing of advanced technologies for the sustainable management of seas and oceans. In cooperation with industry players and researchers from a variety of disciplines, the Rostock site is destined to become a leading center for underwater research.

The **Digital Ocean Lab (DOL)**, a versatile underwater testing site near the coast, is the heart of the OTC. The DOL is uniquely equipped for a variety of use cases. It will be used to test, analyze, and enhance materials, modules, and entire underwater systems under controlled conditions in a real-world environment.

2013

The Subsea Monitoring Network (ZIM Network) recommends Rostock as the best site for an **underwater testing center**. This marks the beginning of the Ocean Technology Campus vision.

2016/17

Prognos AG conducts a **feasibility study** on the OCT with support from the Mecklenburg-Western Pomerania Ministry of Economics.

2018

The State of Mecklenburg-Western Pomerania includes the **Digital Ocean Lab** on its digital agenda; the German Bundestag approves special funds to establish the underwater testing site.

08/2020

The **Fraunhofer Smart Ocean Technologies research group** begins its work on the **OTC base camp** at the Rostock freight and fishing port.

09/2020

Start of planning for the new Fraunhofer IGD building at the OTC site.

One of the SOT research group's first projects focuses on **microplastics**—in particular, to better understand how plastic waste concentrates and distributes in the sea. With this aim in mind, the researchers are developing an autonomous analytics system for underwater vehicles. An optical sensor detects plastic particles, then deep-learning methods immediately analyze the corresponding images. This significantly accelerates the analytics process—which was previously extremely time-consuming. By adding various sensors to the system, it could soon be possible to filter, analyze, and extract water-borne organic and inorganic pollutants in situ. A further SOT project is dedicated to the repair and maintenance of offshore infrastructure.

Fraunhofer-Gesellschaft's **Smart Ocean Technologies (SOT)** interdisciplinary research team at the Rostock site develops pioneering marine technology and new solutions for managing oceans in a more sustainable way. The group is unique in Europe and conducts research on complex system solutions for underwater applications. Employees of the Fraunhofer institutes IGD, IGP, IOSB, and IKTS collaborate to combine computer vision, data mining, and machine learning methods, to test new forms of analytics, and to develop autonomous systems.

02 / 2021

The **Ocean Technology Campus** is one of seven new future research clusters. It stood out from 136 rivals in the German Federal Ministry of Education and Research's **Clusters4Future** competition—and will receive up to 45 million euros in funding.

2021 +

Fraunhofer IGD to move from southern Rostock to its new building in the freight and fishing port

The Digital Ocean Lab will be expanded to create an extensive Baltic Sea testing site.

Further enterprises establish locations at the OTC site.

https://fh-igd.de/Subsea-en

CYBERSECURITY

ATHENE
Nationales Forschungszentrum für angewandte Cybersicherheit

ATHENE NATIONAL RESEARCH CENTER FOR APPLIED CYBERSECURITY

ATHENE is a Fraunhofer-Gesellschaft research organization, with an active role played by Fraunhofer Institute for Secure Information Technology SIT, Fraunhofer IGD, and the Technical University (TU) of Darmstadt. ATHENE is the largest European research center for cybersecurity and the protection of privacy. It develops security solutions, regularly provides advice to businesses and public agencies, and supports the establishment of new enterprises—all to the benefit of the economy, the government, and society as a whole.

www.athene-center.de/en

SAFETY AND SECURITY IN SMART CITIES:
Rapidly recognizing and localizing crises, accidents, and attacks

Digitally connected cities host a growing number of data-generating devices—from traffic lights and security cameras, to distributed sensors that help measure air and water quality, for example. Every second, hundreds of thousands of measurements and data points are created, providing insights into urban life and happenings. Identifiable patterns emerge. And anomalies can flag up significant events.

Identifying accidents and more

As Florian Kirchbuchner, an expert in smart living and biometrics at Fraunhofer IGD, explains: "If, for example, lights go on all around a particular street at three in the morning, that can indicate that something, such as an accident, has occurred."

Machine learning and privacy must go hand-in-hand

As an active member of Germany's ATHENE research center, Fraunhofer IGD leverages large datasets in combination with machine learning to identify atypical situations. To this end, its experts not only evaluate data at the citywide level; they also analyze sensor data from individual buildings and citizens. Only this granular approach allows researchers to pinpoint potential correlations.

The more sophisticated the digital infrastructure, however, the more vulnerable it is to hacker attacks and data breaches. Kirchbuchner emphasizes: "Privacy and security must go hand-in-hand—we take this into account right from the outset, in the design and development of our software." ■

BIOMETRICS: State-of-the-art research from Darmstadt

Fraunhofer IGD is conducting research into technologies that have often been viewed critically, with the aim of making them more acceptable to society. This work has been highly successful, with results that are in high demand. These insights help make the deployment of these systems better, more secure, and more equitable.

Facial recognition in conjunction with fairness and privacy

Today's facial recognition systems use deep-learning methods to achieve outstanding accuracy. They are not only able to recognize a person's identity, but also indirectly other attributes, such as demographics, accessories, and state of health. This can jeopardize privacy and lead to the unfair treatment of the individual concerned. Generally, the subject has only given consent for facial recognition for a specific purpose. If the corresponding system indirectly processes other personal information, there is a heightened risk of misuse.

Indirect information processing makes the recognition system more powerful, but also makes it dependent upon such information: for example, a pair of glasses, age, or the color of the person's skin can lead to a much higher error rate. For this reason, Fraunhofer IGD is conducting applied research to create solutions that remove unwanted information from these recognition systems to ensure they are deployed fairly for everyone.

How suitable is an image for facial recognition?

To work well, facial recognition systems require good input. Images of low quality, with an unfavorable head position, or with poor lighting can lower performance. Conventional approaches are based on error-prone models where a suitable quality assessment must be defined in advance by humans, but which rarely corresponds to the quality perception of the facial recognition system. Fraunhofer IGD has developed a new solution that leaves the evaluation of suitable quality to the facial recognition system. The system assesses how robust its own identification function is when there are gaps in its neuronal network. The result is a stable, powerful method that does not require extensive machine training and that can be easily integrated into existing systems.

Face morphing—multiple faces combined

Face morphing is a serious issue. It entails combining multiple faces in a single image, allowing different people to use one and the same ID document, such as a passport. Morphing is able to deceive both automated checks and human border guards. The German government has recognized and responded to the danger it poses. In the future, photographers will be obliged to create passport photos in a digital format only, and to transmit the data via a secure connection to the corresponding ID-issuing authority. Alternatively, the photo can be taken directly on-site at the government agency's offices under supervision. It will no longer be possible to simply bring along a physical photograph to be inserted into the ID document. Fraunhofer IGD is working on recognition algorithms capable of detecting morphing. Researchers are also simulating new forms of attacks in order to be in a position to combat them before criminals put them to use. ■


Fraunhofer
IGD

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.

2020 FRAUNHOFER IGD IN NUMBERS

3

Institutes and research centers

Darmstadt
Rostock
Kiel

190

employees

143	Darmstadt
47	Rostock/Kiel

€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

Christian Altenhofen "Volumetric Subdivision for Efficient Integrated Modeling and Simulation"

Wentao Cheng "Methods for Large-scale Image-based Localization using Structure-from-Motion Point Clouds"

Hien Quoc Dang
"Adaptive Personalization in Driver Assistance Systems"

Tobias Ewald
"Analysis of Geometric Univariant Subdivision Algorithms"

Johannes Fauser "Preoperative Surgical Planning – Toward an Automatic Pipeline for Segmentation and Nonlinear Trajectory Planning in Robot-Assisted Interventions"

Biying Fu "Sensor-driven Applications for Human Activity Recognition in Smart Environments"

Fan Li "Data-driven, Context-aware Human Fatigue Management in Traffic Control Centers"

Johannes Sebastian Mueller-Roemer "GPU Data Structures and Code Generation for Modeling, Simulation, and Visualization"

Tobias Plötz
"Measuring and Removing Realistic Image Noise"

Nelson J. S. Silva "Adaptive User Interfaces Based on Visualization, Analysis and Prediction of Users' Interactions and Behaviors"

Best Paper

Honoring excellent scientific publications

Impact on Business
Winner: "An Experimental Overview on Electric Field Sensing"
Julian von Wilmsdorff, Florian Kirchbuchner, Biying Fu, Andreas Braun, Arjan Kuijper

Impact on Science
Winner: "Redefining A in RGBA: Towards a Standard for Graphical 3D Printing" Philipp Urban, Tejas Madan Tanksale, Alan Brunton, Bui Minh Vu, Shigeki Nakauchi

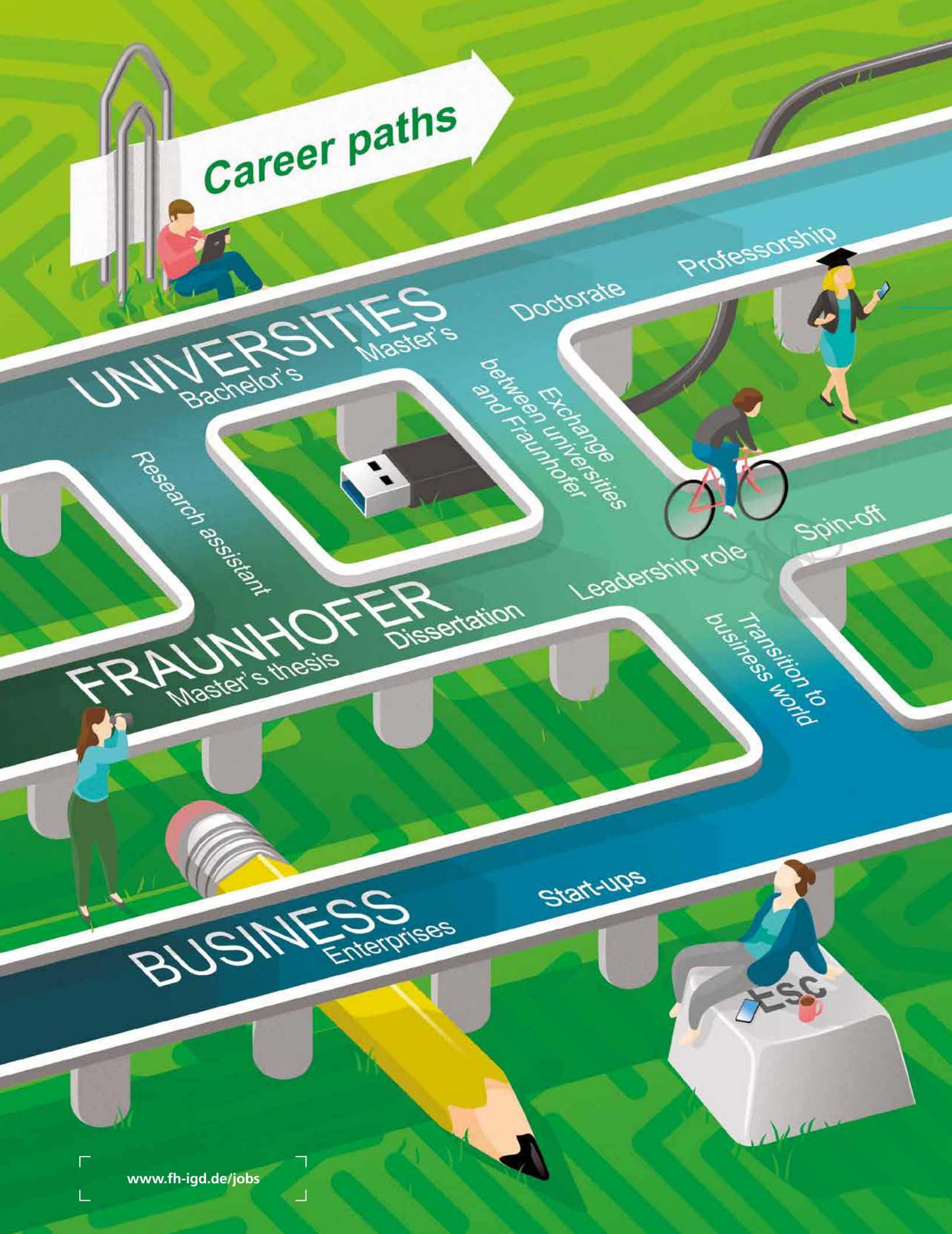
Impact on Society
Winner: "Detecting Face Morphing Attacks by Analyzing the Directed Distances of Facial Landmarks Shifts"
Naser Damer, Viola Boller, Yaza Wainakh, Fadi Boutros, Philipp Terhörst, Andreas Braun, Arjan Kuijper

Best Thesis

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

Steven Lamarr Reynolds
"A Visualization Interface to Improve the Transparency of Collected Personal Data on the Internet"
Tom Baumgartl
"Storyline Visualization for the Exploration of Disease Spreading"
Sofie Hofmann
"Neural Networks for Error Correction in Electromagnetic Tracking"

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
www.fh-igd.de/jobs

OUR SPIN-OFFS

DESION:
AI-assisted quality control of complex surfaces

The fashion industry has faced much criticism of late: Products are shipped long distances and less-than-perfect management of returns harms the environment. Desion aims to bring about positive change through AI-assisted quality assurance and has demonstrated that sustainable processes are already possible for clothing.

Automated systems prove their worth most where humans are prone to failure: with monotonous tasks, for example. When it comes to quality control, staff must first be taught how to identify anomalies and to accurately assess them. Artificial intelligence (AI) quality assurance systems, by contrast, perform tasks and improve algorithms through machine learning autonomously and continuously.

Dirk Siegmund, CEO of Desion, conducted research into this field while at Fraunhofer IGD and founded the spin-off in 2020. Headquartered in Darmstadt, Desion now has seven employees. Siegmund is motivated by the desire to achieve significant advances in quality assurance by automating the corresponding processes by means of vision (camera-based) systems. Automation offers companies a number of advantages: Results are reliable, precise, immediately available—and, above all, documented.

During the coronavirus lockdown, many people have used the time to go through their closets and to donate clothing they no longer need to charity. And although the recipient organizations welcome these acts of generosity, they have been struggling to cope with the workload. They need to identify the items suitable for re-sale as second-hand goods. With such high volumes, it is difficult to sort the incoming goods thoroughly and in good time.

When charities and, similarly, apparel manufacturers and mail-order companies are unable to keep pace with this task, the donations or returns often end up in an incineration plant—not resold or recycled—and will frequently be transported many thousands of kilometers to their final destination. In partnership with MEWA, Desion is already employing a more sustainable method. It automatically inspects items of work clothing—and, in the future, cleaning cloths—at regional centers, extending the service life of these products.

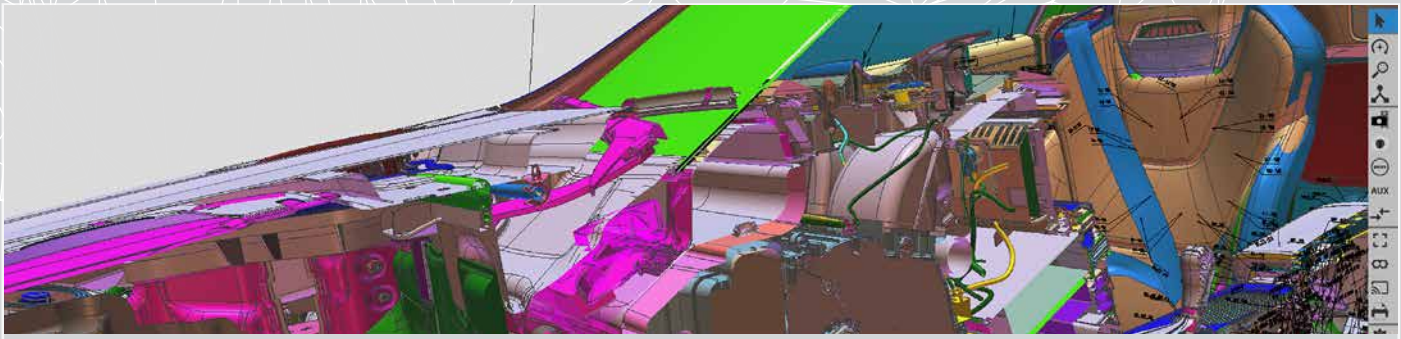
In collaboration with MEWA, Desion custom designed systems in line with the specific task to be performed. The turnkey equipment is then installed locally and can be put into immediate operation. The systems analyze images and image sequences with the help of AI. They are able to detect defects in materials, to categorize the items, and to identify poor quality—and not just with textiles: It is also possible to automatically inspect materials with complex surfaces, such as concrete, fluids, and even food. By detecting low-quality construction materials, for instance, the system saves valuable time and resources—a win-win for cost efficiency and sustainability.

And despite now running the spin-off business, Dirk Siegmund has not turned his back on research: He is currently studying for a PhD in computer vision at Darmstadt Technical University, aiming to further enhance AI-assisted quality control. ■

www.fh-igd.de/Spin-offs

SEED FUNDING FOR THREEDY

Fraunhofer IGD spin-off Threedy launched on December 1, 2020, with a strong tailwind. Its four founders were able to raise 1.8 million euros of seed funding—an investment led by the Industrial Technologies Fund of btov Partners, in association with High Tech Gründerfonds (HTGF) and Fraunhofer. The entrepreneurs, previously employees of the Visual Computing System Technologies Competence Center, are commercializing their instant3Dhub platform. This supports users of BIM solutions, plus visualization, VR, and AR applications, in the automotive, aerospace, and energy industries. Leading German automotive companies have already deployed the flexible platform, which enables them to leverage datasets of any volume. ■



WHAT'S BECOME OF ...?

VISIONLIB: Augmented reality for industry

Founded in late 2017, Visometry gained traction in early 2018. The spin-off from Fraunhofer IGD's AR/VR Competence Center develops and distributes the VisionLib software development kit (SDK) for augmented-reality tracking. Using computer-vision technology, VisionLib can identify and track objects on an industrial scale. In particular, it supports multi-object tracking: This combines 3D and CAD capabilities with image processing to the benefit of key industrial AR use cases across the value chain—from prototyping and production, to maintenance, training, after-sales, marketing and, since recently, quality control. And the 12-strong team is making its mark on the global AR market. Across the world, there are only a handful of vendors with comparable solutions.

Visometry co-founder and CEO Dr. Harald Wuest recalls the start-up's early days: "It was an exciting time. At the outset, there were just four of us. But thanks to good preparatory work and close collaboration, we moved forward very quickly and brought other IGD colleagues on board." At the end of its third year, the enterprise's prospects remain bright. After launching what was initially an SDK-only business, the Visometry team created a new product. It recently launched VisionLib ARO, a turnkey solution for augmented reality-based inspection and quality assurance. "We believed in the marketable benefit of VisionLib and AR from very early on. And customer feedback has confirmed as much. Thanks to ARO, mid-sized companies such as Krone can now perform quality checks six times faster and identify more defects—saving time and money. We are really curious to see what the future brings," says Wuest. ■

Ambient Assisted Living

Big Data and Artificial Intelligence

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.

Fraunhofer Cluster of Excellence Immune-Mediated Diseases CIMD

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

2020 FRAUNHOFER IN NUMBERS

75

Institutes and research centers

Over

29,000

employees

€2.8 BN

Annual research funding

€2.4 BN

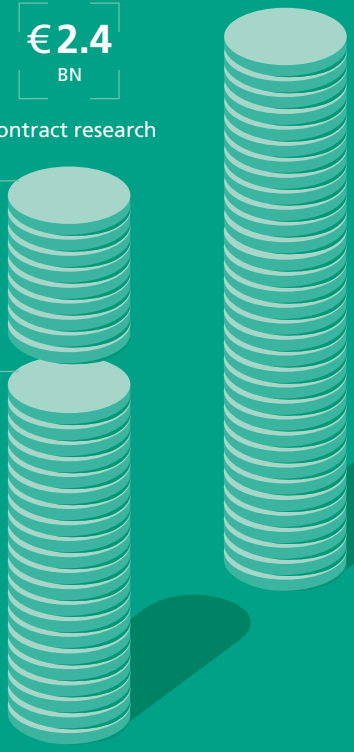
Contract research

30 %

Federal/state government

70 %

Industry and publicly funded research projects



FRAUNHOFER-GESELLSCHAFT

The Fraunhofer-Gesellschaft is the world's leading applied research organization. With its focus on developing key technologies that are vital for the future and enabling the commercial exploitation of this work by business and industry, Fraunhofer plays a central role in the innovation process. Based in Germany, Fraunhofer is an innovator and catalyst for groundbreaking developments and a model of scientific excellence. By generating inspirational ideas and spearheading sustainable scientific and technological solutions, Fraunhofer provides science and industry with a vital base and helps shape society now and in the future.

At the Fraunhofer-Gesellschaft, interdisciplinary research teams work together with partners from industry and government in order to transform novel ideas into innovative technologies, to coordinate and implement key research projects with a systematic relevance, and to strengthen the German and the European economy—with a commitment to creating value that is based on human values. International collaboration with outstanding research partners and companies from around the world brings Fraunhofer into direct contact with the key regions that drive scientific progress and economic development.

Founded in 1949, the Fraunhofer-Gesellschaft currently operates 75 institutes and research institutions. The majority of our 29,000 staff are qualified scientists and engineers who work with an annual research budget of 2.8 billion euros. Of this sum, 2.4 billion euros are generated through contract research. Around two thirds of Fraunhofer's contract research revenue is derived from contracts with industry and publicly funded research projects. The remaining third comes from the German federal and state governments in the form of base funding. This enables the institutes to work on solutions to problems that are likely to become crucial for industry and society in the not-too-distant future.

www.fraunhofer.de/en

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Applied research also has a knock-on effect that is felt far beyond the direct benefits experienced by the customer: Our institutes boost industry's performance and efficiency, promote the acceptance of new technologies within society and help train the future generation of scientists and engineers that the economy so urgently requires.

Our highly motivated staff, working at the cutting edge of research, are the key factor in our success as a scientific organization. Fraunhofer offers researchers the opportunity for independent, creative and, at the same time, targeted work. We therefore provide our employees with the chance to develop the professional and personal skills that will enable them to take up positions of responsibility at Fraunhofer, at universities, in industry and within society. Students who work on projects at Fraunhofer institutes have excellent career prospects in industry by virtue of the practical training they enjoy and early interaction with contractual partners.

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur. ■

WHAT WE OFFER

We develop and enhance technologies, processes, and products for our customers, including prototyping and low-volume manufacturing. Our contract research services and innovative solutions span all areas of applied visual computing. Especially for small and mid-sized businesses without their own dedicated R&D departments, Fraunhofer IGD offers vital forward-looking expertise in visualization and simulation.

CONTACTS

Darmstadt ::: Phone +49 6151 155-0

VIRTUAL AND AUGMENTED REALITY
M. Sc. Holger Graf ::: holger.graf@igd.fraunhofer.de
- VR/AR applications for industry: planning, maintenance, assistance, and training
- Reliable tracking technologies: object recognition and tracking
- Image analysis for interactive classification of objects, 3D interaction, and assisted driving

SMART LIVING & BIOMETRIC TECHNOLOGIES
M. Sc. Florian Kirchbuchner ::: florian.kirchbuchner@igd.fraunhofer.de
- IoT-based assistance systems for smart living
- Dynamic sensor systems, smart platforms, and innovative interaction
- Biometrics and cybersecurity

SPATIAL INFORMATION MANAGEMENT
Dr. Eva Klien ::: eva.klien@igd.fraunhofer.de
- Digital transformation of infrastructure planning: point clouds, panoramic images, digital building/landscape models
- Interactive visualization (2D/3D) and cloud-based analytics environments
- Working with big (geo)data for environmental monitoring

CULTURAL HERITAGE DIGITIZATION
M. Sc. Pedro Santos ::: pedro.santos@igd.fraunhofer.de
- Fast, cost-effective digitization processes for virtual high-fidelity reproduction of physical objects
- Automatic scanning of geometry and texture, plus physical and visual attributes of materials
- Scanner with conveyor and mobile scanner arms for cultural and industrial use cases

INTERACTIVE ENGINEERING TECHNOLOGIES
Prof. André Stork ::: andre.stork@igd. .de
- Interactive modeling and simulation technologies for faster decision-making in virtual product development
- Ultra-fast simulation using massively parallel algorithms with graphics cards (GPUs)
- Integration of models of functionally graded components with simulations based on innovative representations

INFORMATION VISUALIZATION AND VISUAL ANALYTICS
Prof. Jörn Kohlhammer ::: joern.kohlhammer@igd.fraunhofer.de
- Visual analytics for cybersecurity
- Cohort and data analytics for medicine
- Visual analytics with engineering data

3D PRINTING TECHNOLOGY
Prof. Philipp Urban ::: philipp.urban@igd.fraunhofer.de
- Models, algorithms, and software for 3D printing
- Enabling technologies for high-fidelity printed copies of 3D originals
- Voxel-based, vendor-agnostic Cuttlefish driver for 3D printing with multiple materials and translucencies

VISUAL HEALTHCARE TECHNOLOGIES
Dr. Stefan Wesarg ::: stefan.wesarg@igd.fraunhofer.de
- Imaging-based software for medical use, medical technology, and cosmetic application
- Medical imaging: intelligent analysis and use of medical image data throughout treatment
- Smart machine learning: combining conventional image processing with neural networks

Rostock ::: Phone +49 381 4042-100

VISUAL ASSISTANCE TECHNOLOGIES
Dr. Mario Aehnelt ::: mario.aehnelt@igd-r.fraunhofer.de
- Visualization of critical data for manufacturing and healthcare
- Provision of requirements-driven, context-related information
- Virtual educational environments for intuitive human-computer interaction

MARITIME GRAPHICS
Matthias Vahl ::: matthias.vahl@igd-r.fraunhofer.de
- Digital solutions for maritime industries: shipbuilding, marine technology/research
- (Underwater) image processing and enhancement: environmental monitoring, quality control
- Visualization of large 3D models; augmented reality use cases in and on water

SMART OCEAN TECHNOLOGIES
Jan Witte ::: jan.witte@igd-r.fraunhofer.de
- Sophisticated solutions for underwater use cases
- Combining computer vision, data mining, and machine learning
- Firmware-related sensor and system integration and development of autonomous solutions

HOW TO FIND US

FRAUNHOFER INSTITUTE FOR COMPUTER GRAPHICS RESEARCH IGD

DARMSTADT

Fraunhoferstrasse 5
64283 Darmstadt
Germany

Phone +49 6151 155-0
Fax +49 6151 155-199
info@igd.fraunhofer.de
www.igd.fraunhofer.de

Director
Dieter W. Fellner, Professor
Phone +49 6151 155-100
institutsleitung@igd.fraunhofer.de

Deputy Director
Dr. Matthias Unbescheiden
Phone +49 6151 155-155
matthias.unbescheiden@igd.fraunhofer.de

Director's Office
Elke Emich
Phone +49 6151 155-101
elke.emich@igd.fraunhofer.de

ROSTOCK

Joachim-Jungius-Strasse 11
18059 Rostock
Germany

Phone +49 381 4024-100
info@igd-r.fraunhofer.de
www.igd.fraunhofer.de/rostock

Site Management
Prof. Uwe Freiherr von Lukas
Phone +49 381 4024-100
sekretariat@igd-r.fraunhofer.de

Research Group: Smart Ocean Technologies at OCT Base Camp
Am Alten Hafen Süd 6
18069 Rostock
Germany

KIEL

Kiel Innovation and
Technology Center (KITZ)
Schauenburgerstrasse 116
24118 Kiel
Germany

Phone +49 381 4024-408
info@igd-r.fraunhofer.de
www.igd.fraunhofer.de/kiel

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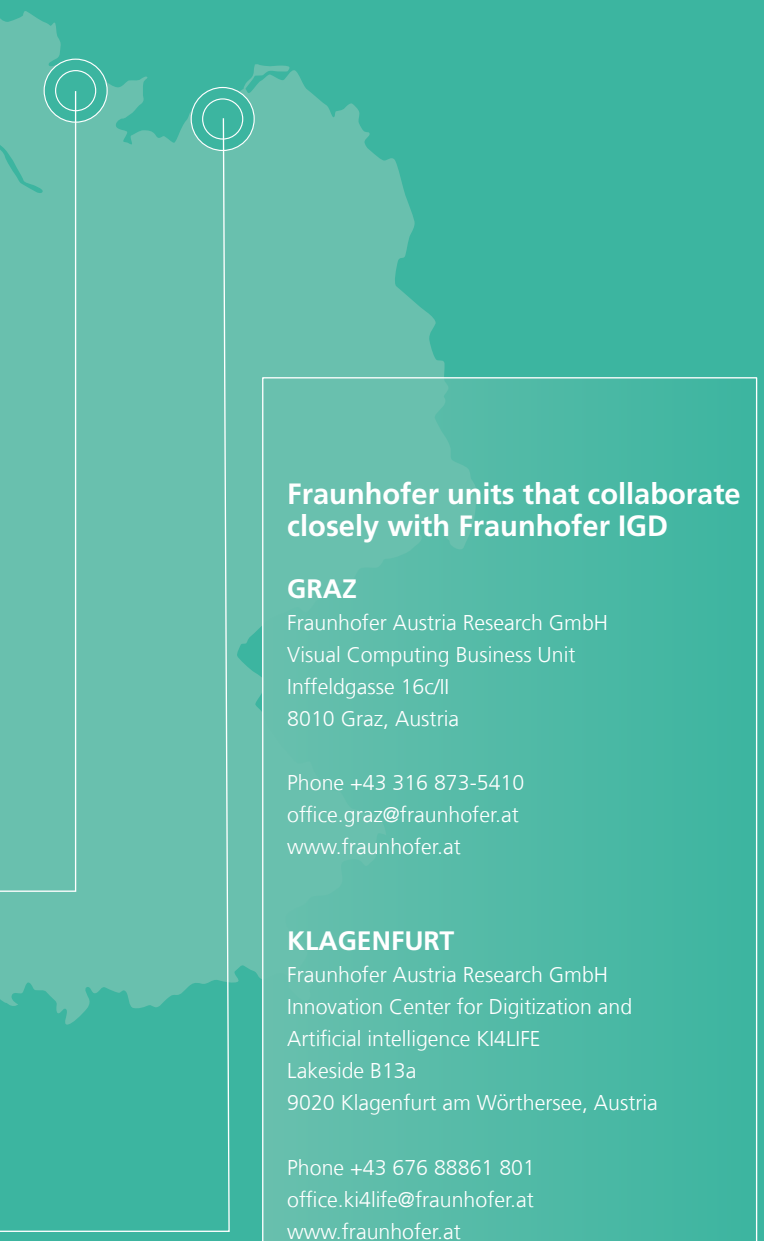

Fraunhofer units that collaborate closely with Fraunhofer IGD

GRAZ

Fraunhofer Austria Research GmbH
Visual Computing Business Unit
Inffeldgasse 16c/II
8010 Graz, Austria

Phone +43 316 873-5410
office.graz@fraunhofer.at
www.fraunhofer.at

KLAGENFURT

Fraunhofer Austria Research GmbH
Innovation Center for Digitization and
Artificial intelligence KI4LIFE
Lakeside B13a
9020 Klagenfurt am Wörthersee, Austria

Phone +43 676 88861 801
office.ki4life@fraunhofer.at
www.fraunhofer.at

SINGAPORE

Fraunhofer Singapore
50 Nanyang Avenue
Singapore 639798, Singapore

Phone +65 6790 6989
info@fraunhofer.sg
www.fraunhofer.sg

LEGAL NOTICE

Editor
Fraunhofer Institute for Computer Graphics Research IGD
Dieter W. Fellner, Professor

Editorial Team
Daniela Welling (Team Leader), Janine van Ackeren, Bettina Bergstedt, Heidrun Bornemann, Kathrin Krüger, Constanze Löffler, Svenja Prasche, Anahit Roth, Markus Strehlitz

Design
Carina Baier

Address
Fraunhofer Institute for Computer Graphics Research IGD
Corporate Communications
Fraunhoferstrasse 5 | 64283 Darmstadt, Germany
Phone +49 6151 155-146 | presse@igd.fraunhofer.de

For further information on projects, technologies and areas of expertise, plus contact addresses of our institute in German and English, please visit our website at: www.igd.fraunhofer.de/en
For general inquiries, please e-mail: info@igd.fraunhofer.de

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MANAGEMENT SYSTEM

V01-21-01