Fraunhofer

IGD

FRAUNHOFER INSTITUTE FOR COMPUTER GRAPHICS RESEARCH IGD

Artificial intelligence in visual computing

OUR YEAR 2018

RESEARCH IN ACTION

Dear friends and partners,

Germany and artificial intelligence? If you give credence to the pessimists, the USA and China are way ahead of us. But it is not that simple. There are aspects of AI where Germany can make its mark. Take small-data AI, for example. This comes into its own when there is insufficient training data available to support artificial intelligence based on machine learning. In these instances, domain expertise is required to fill in the gaps – the sort of knowledge that Germany possesses. And when it comes to the quality of data employed, Germany is well placed to take the lead in the longer term. Until now, both domestically and internationally, quality has been a major failing: Many algorithms leverage data that are of uncertain quality. Moreover, it is important that the underlying data are collected in line with basic human and privacy rights, and not the values of the developers. Machine learning and the corresponding outcomes are shaped by the training data used – so neutral data are essential.

Artificial intelligence requires the right environment

But that is not the only challenge that calls for Germany's skills. Understanding how AI systems arrive at their decisions is also important: An AI system is perfectly adept at recognizing a

EDITORIAL

picture of a parrot. But if the image is distorted by a layer of "visual noise," the algorithm can be fooled, e.g., into thinking it is seeing a bookcase. And the question is: Why? Being unable to identify the root cause of this and similar false positives can be a serious problem and an obstacle to system certification. Consequently, consideration is being given to establishing AI engineering as a discipline in its own right, similar to software engineering.

Society's needs are a further driving force. Fraunhofer IGD has always built its R&D work around the human factor. And this will be a vital part of AI as well. Algorithms should be judged by how well they support people. One example of how we put this goal into practice is the Fraunhofer lighthouse project MED²ICIN: Seven Fraunhofer institutes, with Fraunhofer IGD as the lead, are developing digital twins of patients, creating the basis for cost-effective and personalized healthcare.

Spin-offs

However, even the very best new technology can only benefit society as a whole if it is brought to market. With this in mind, Fraunhofer IGD has long been committed to supporting spin-offs. And it has done so very successfully. The Massachusetts Institute of Technology (MIT) notches up two spin-offs per

thousand staff. At Fraunhofer IGD, we do far better. Our network grants budding in-house entrepreneurs access to coaches, investors, and other key contacts with whom we have been collaborating effectively for many years – providing entrée into an ecosystem that is ideal for ensuring fledgling businesses will survive and thrive. Fraunhofer Venture is part of this supportive network. It has the knowledge needed to work with spin-off founders to find the most suitable business model for all sides and to ensure compliance with the legal imperatives of Fraunhofer-Gesellschaft. And Fraunhofer IGD continues to offer advice and assistance after the business has been launched. For instance, we collaborate with spin-offs in joint research projects, leading to the development of solutions that help secure the long-term viability of these young companies.

This report provides you with insights into our many AI-related technologies. Be sure not to miss the article on our very latest spin-off.

Dieter W. Fellner, Professor   Dr. Matthias Unbescheiden

You can also read this annual report online:
fh-igd.de/JB18-en

RESEARCH LINES

RESEARCH AT FRAUNHOFER IGD IS DIVIDED INTO FIVE STRATEGIC LINES:

HUMAN-C

COMPUTER VISION 2

COMPUTER GRAPHICS 1

Computer graphics – i.e., image synthesis – is a core discipline within visual computing, and involves the development of technologies and methods to generate images using information. Highly standardized data models are employed for diverse applications. In particular, Fraunhofer IGD researches efficient, flexible methods to keep pace with the latest developments; for example, for shared usage of resources, real-time capabilities, and the latest trends in personal transportation.

Computer vision – understanding and interpreting digital images and videos – is gaining importance in auto-mation and engineering. Deploying computer vision technologies in conjunction with sensors helps ensure high process reliability. In this context, Fraunhofer IGD is developing new and enhanced technologies for augmented reality, material acquisition and 3D reconstruction – to capture, track and reproduce objects, their position and their texture at high speed and with high fidelity.

MODELING 5

Models are a key component of visual computing. They comprise an abstract view of selected aspects of reality within an information processing system. Fraunhofer IGD researches both traditional 2D/3D and more complex, higher-dimension models for use in real-world scenarios. In many cases, supplementary information is added to make models suitable for new applications and connected solutions.

(INTERACTIVE) SIMULATION 4

One of the main challenges of computer graphics is the support and acceleration of simulation. A simulation is the virtual replication of the behavior of physical objects and phenomena, such as passenger behavior during the evacuation of a ship. Fraunhofer IGD uses the latest methods, including integrated modeling, simulation and visualization, to accelerate the design process, and enable users to directly interact with and modify the simulation.

COMPUTER INTERACTION 3

Interactions between man and machine are beginning to resemble natural human behavior. At the same time, ever-growing volumes of data are creating challenges for both visualization and interaction. Researchers at Fraunhofer IGD are developing technologies that enable humans and computers to work together more effectively. In this context, IGD researchers are exploring new interaction modalities, intelligent environments and visualization methods. Moreover, they are improving human-computer interaction in complex, data-intensive applications where robust security is critical.

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.

INTERACTIVE SIMULATION

Designing a component is a challenging task. It starts with an idea. But the end product must not only fulfill its defined operational functions and requirements, it must also be cost-effective to manufacture. Plus, there are statutory constraints in terms of the environment, product liability and safety. As a result, product development is a highly complex undertaking. There is also a growing focus on the energy and material inputs for production and disposal. For these reasons, engineers need tools that enable them to simulate even the tiniest of modifications to products interactively, and more or less in real time – tools that make the impact of design changes visible at a glance.

In 2018, IGD unveiled RISTRA (Rapid Interactive Structural Analysis), a new, interactive simulation software solution. This delivers enormous time savings by offloading key compute tasks from the CPU to the graphics card. The goal is to allow the simultaneous computer-aided design of a component and the simulation of its structural strength in a single operation. Previously, the iterative process comprising geometric modeling, initialization, simulation, and analysis of the results entailed the deployment of multiple computer-aided tools, typically on multiple computers. Simulation required the most time of all, taking anywhere from several minutes to many hours or even multiple days, depending on the computer and the complexity of the task. Once the results are (finally) available, it is possible to make changes to the design and load parameters. Frequently, engineers will rely on their experience and simply "try out" how a change (for example, to material thickness) impacts component strength. And then they start all over again. They compute a new network structure as input to enable a new simulation to be run. And that can eat up a lot of time. Often, the goal of arriving at the ideal design cannot be achieved due to a lack of time, budget, or both.

RISTRA streamlines and accelerates the entire process, enabling a much more direct, intuitive way of working. This naturally leads to better results, not just in terms of the time needed for development but also in the quality of the design. At the core of the new solution is an efficient equation solver for structural mechanical behavior. Depending on the complexity of the design, this can often involve many millions of equations. Mechanical simulation is based on the calculation of the impact of predefined loads on the component structure. To this end, the software solution harnesses the massively parallel processing power of standard, low-cost graphics cards. A typical CPU might have four to eight cores. In contrast, a graphics card may have as many as 5,000. Compared to conventional simulation methods, the time needed for the calculations is so short that the engineers can see the results on their screens in almost real time. RISTRA can simulate a model with more than 1.3 million finite elements in just 1.83 seconds – more than 80 times faster than a commercial software solution that required 150 seconds in a comparison test. A false-color model visualizes the results, making the stresses in the material and any distortions instantly recognizable. The engineer is then able to identify weaknesses and potential improvements, and can immediately correct the design – allowing multiple iterations within a short timeframe, helping to achieve the ideal end result.

Fraunhofer IGD has identified design engineers at major corporations and the vendors of corresponding software solutions as potential licensees. A partnership has already been formed with Meshparts GmbH. General Manager of Sales, Timo Ziegler, explains why the company decided to license RISTRA: "Fraunhofer IGD's approach enables extremely fast equation solving and highly precise results. We are delighted by the possibilities that
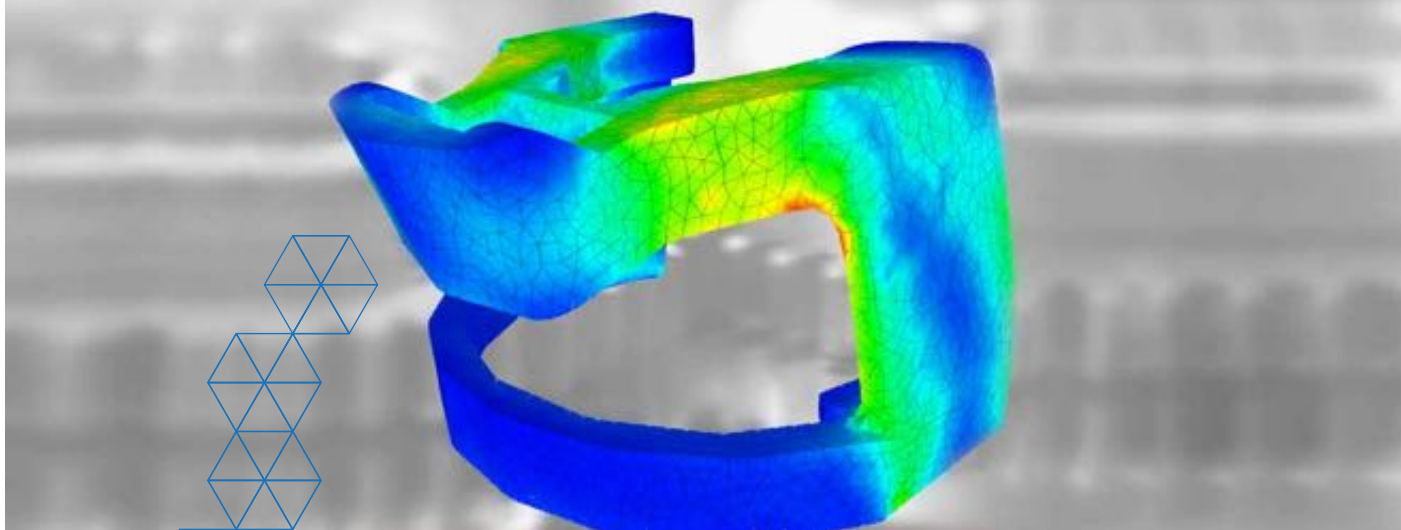
Fraunhofer IGD has revolutionized the design-engineering process for mechanical components. The result is a faster, more intuitive way of working with direct feedback.

the interactive simulation offers our users. IGD will partner with us to ensure user-friendly implementation. We are proud to be the first organization to bring such high-performance interactive simulation to market." Meshparts intends to incorporate RISTRA into its own simulation program, with go-live scheduled for early 2019.

RISTRA currently supports the following aspects of structural mechanics: Geometric linear elasticity, linear isotropic and anisotropic materials, and linear, quadratic and cubic functions for tetrahedra. But more is to come. Fraunhofer IGD is looking to further increase the speed of processing and plans to extend the solution to include geometric non-linear elasticity and non-linear materials. ■

Discover more on numerical simulation in product development:
fh-igd.de/JB18-10-en

SHAPING THE FUTURE WITH FRAUNHOFER

The term "predictive maintenance" refers to the Industry 4.0 vision of global, digital monitoring and proactive servicing of equipment. This approach identifies faults and automatically initiates their resolution – before they lead to failure and unplanned downtime. Fraunhofer IGD's augmented reality technologies can make a decisive difference in these and other scenarios. JHT GmbH – a mid-size German business that designs and builds specialized machinery such as coating and laminating systems, including end-to-end solutions – is already putting these AR solutions into practice. We spoke to project leader Alexander Krause.

What is your business's vision?
We want to take communication between the customer and their machines to a whole new, intuitive level. For us, a human-machine interface is the epitome of Industry 4.0. And we are convinced that AR technologies can offer benefits for development, quality assurance and sales.

How do you and Fraunhofer IGD collaborate?
In early 2018 we were eager to turn our Industry 4.0 ideas into reality. However, many elements were simply not yet technologically feasible. Fraunhofer IGD had been working on several of these aspects and was looking for a suitable demonstration system for a trade show – and that is what brought us together. As is the case in any partnership, it is important that both sides benefit. We wanted to collaborate within the scope of a new project, with the aim of advancing the predictive maintenance vision. Unplanned downtime is a nightmare for any equipment operator – an efficient production system is vital to safeguarding competitiveness. We currently have plans for a trial system that we can use to investigate new technologies for ourselves and that Fraunhofer IGD can use to try out its solutions under real-world conditions.

What advice do you have for businesses interested in an active role in research projects?
For a mid-size business with limited budgets and human resources – but that does not want to just play catch-up with the latest developments – interdisciplinary collaboration with research teams can be highly advantageous. It is time well spent, since results are aligned with your own needs. Only enterprises that think ahead, and bring their own ideas and real-world requirements to the table, can shape tomorrow's technologies. ■
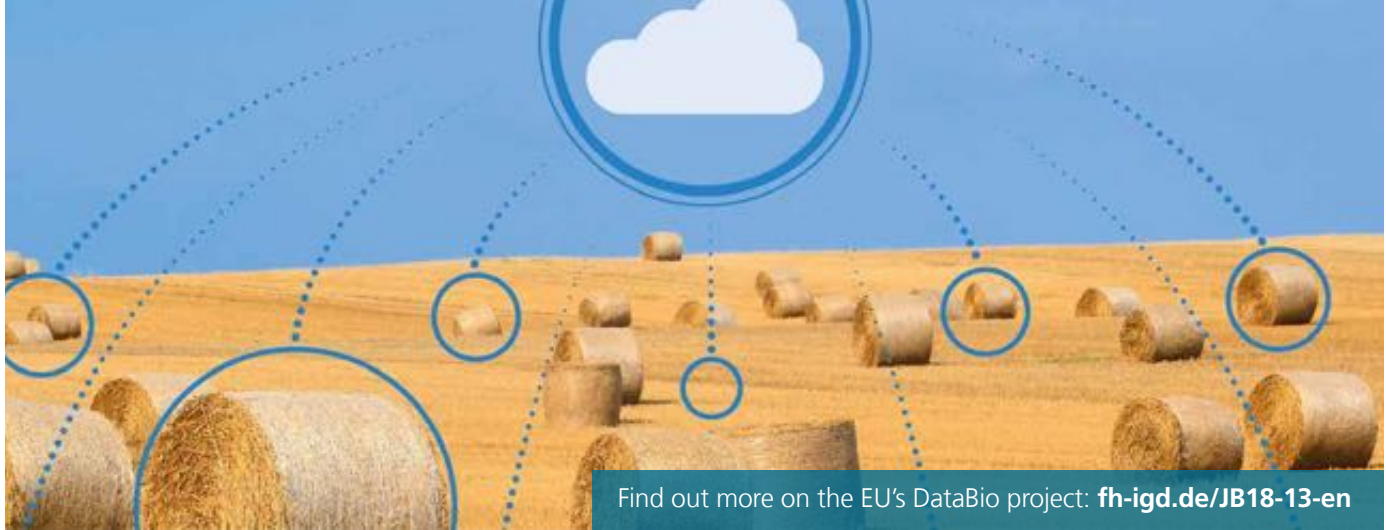
Find out more on the EU's DataBio project: **fh-igd.de/JB18-13-en**

BIG DATA: AGRICULTURE'S SECOND HARVEST

Observing plant growth can be laborious – nature documentaries, for instance, generally use time-lapse photography. At the same time, for farmers, their harvest is their livelihood. It is therefore vital to monitor crops carefully, not only with the naked eye but also with satellites. Fraunhofer IGD helps farmers process and understand the corresponding data.

Satellite images are no longer simply a useful extra in agriculture; in light of the enormous size of many fields, they have become essential. Combined with data from sensors down on Earth, they deliver vital insights into the state and development of crops – at least in theory. In practice, however, the volume of data generated is so immense as to overwhelm the user, making systematic analysis in a reasonable timeframe virtually impossible. This is where Fraunhofer IGD comes in, along with a number of partners within the European Union's DataBio project. The goal is to establish an effective infrastructure that enables access to huge amounts of data, and supports subsequent processing and visualization.

Fraunhofer IGD's Spatial Information Management Competence Center specializes in the interactive and seamless usability of big data with georeferencing. Precision farming, as it is known, is a recently developed method for high-resolution soil mapping and for maximizing yield. In addition to the ongoing collection of real-time data, it is important to consider historical data when attempting to forecast the probable success of planting seed. The information gathered by means of satellite and ground sensors is passed on to Fraunhofer IGD. Our technologies enable highly efficient data storage and management, paired with innovative methods for analysis and research. This offers a major advantage over conventional

image visualization, familiar from static maps: The data remain interactive in nature. Analysis results can be newly aggregated, filtered and visualized in line with the user's evolving needs – to quickly evaluate and find answers to a specific question or problem.

One relevant use case based on the new technology comprises the identification of undesirable plants in monocultures. Agricultural crops have very specific needs in terms of soil and light. Other species are therefore extremely unwelcome. Satellites can be employed to produce infrared images; plants reflect this light in diverse ways, enabling weeds to be rapidly pinpointed. The interactive element is not limited to individual fields but can be applied to broad areas featuring differing types of terrain. One pilot project has already succeeded in creating an interactive analysis of vegetation across large parts of Greece.

Large sets of heterogeneous data do not just represent a challenge and opportunity for agriculture. Government agencies and insurance companies can also make use of these technologies – for instance, following a natural disaster, to identify affected areas and to make a direct comparison to the situation beforehand to assess damage. ∎

THE MOVIE STAR FROM DARMSTADT: OUR "CUTTLEFISH" 3D PRINTER DRIVER

From April 2019, film fans can delight in LAIKA's new animated movie *Missing Link* – with witty dialogue and characters that are brought to life in remarkable detail. It is the US production company's fifth stop motion feature, and the first to make use of Stratasys J750 3D printers and Fraunhofer IGD's Cuttlefish 3D printer driver. Stop motion animation creates the illusion of movement by playing a series of still images in rapid sequence. To make *Missing Link*, elaborate and sophisticated puppets are moved in small increments. Photographs are taken after each of these changes – enabling the individual stills to be combined to form a complete motion picture. Twenty-four images translate into one second of film. To animate the puppet faces, LAIKA printed over 106,000 highly detailed, color 3D printed faces, each with a slightly different expression.

The greatest challenge is that a huge variety of colors are used to create lifelike models – but each shade must correspond exactly to the one used in the previous frame. This is where Cuttlefish is truly in its element. Academy Award® nominee Brian McLean serves as LAIKA's Director of Rapid Prototype and has a long history of using 3D printers in stop motion. In fact, in 2016 he was awarded a Scientific and Engineering Oscar® plaque for pioneering the use of 3D printing in stop motion animation. "We have been using 3D printers for stop motion since LAIKA's first film *Coraline*. For our recent film *Missing Link*, we leveraged Fraunhofer IGD technologies and it afforded us unrivaled color consistency and geometric accuracy. By combining the Cuttlefish software with Stratasys J750 hardware we were able to create the most sophisticated color 3D printed faces ever produced."

Cuttlefish is a universal printer driver, meaning it can be employed for diverse 3D printing technologies. The driver makes it possible to simultaneously work with multiple printing materials. In addition, it enables the shapes, colors, and subtle color transitions of the original to be reproduced with high fidelity, and allows objects to be simulated onscreen prior to printing. In 2018, Fraunhofer IGD's developers overcame their latest hurdle: With Cuttlefish, it is now possible to print translucent, i.e., partially to fully transparent, materials. Moreover, the dispersion of light through the object and changes in hues and surface textures in accordance with incidental light can be taken into account. ∎

Learn more on 3D printing: **fh-igd.de/JB18-14-en**

Further information on the Ocean Technology Campus: **fh-igd.de/JB18-15-en**

DEEP-DIVE RESEARCH: UNDERWATER

Underwater research is not easy. Which is why the German federal government and the State of Mecklenburg-Western Pomerania have put their trust in Fraunhofer IGD. Rostock will soon have a new underwater laboratory to develop and test the latest technologies – directly in the deep.

A school of cod, including many juveniles, darts through the water seemingly unobserved on the hunt for crabs, mussels, and fingerlings. It is important that the fish are not aware of being watched: The aim is to not disturb them. However, they are being followed – by a small, unmanned underwater vehicle that tracks their behavior, conducts analyses in-situ, and sends the results back to its human colleagues on land. And all in real time.

The cameras mounted on the vehicle not only record the fish, they also analyze image data on location in the sea. This includes counting the animals, automatically classifying them by species, and measuring the dimensions of individual fish to estimate their weight. To this end, researchers use a pre-trained neural network to help them differentiate between types of fish and to correctly interpret what they are seeing.

Tracking fish populations is just one example – other potential use cases include monitoring and inspecting sub-aquatic infrastructure, or documenting dives. The challenging conditions in ocean environments make vigorous testing vital to the development of reliable solutions. Up to now, however, opportunities to trial complex underwater technologies under real-world conditions have been few and far between. This will change in the future, with the completion of an undersea testing laboratory in Germany's Rostock district.

An underwater area of at least 100 hectares near Nienhagen will be divided into multiple test fields for diverse types of research. Specifically, there will be dedicated zones, for example, for detecting unexploded ordnance, for terrain with cables and pipelines, and for replicas of offshore infrastructure and simulated obstacles.

The focus of Fraunhofer IGD's research is on enhancing underwater image processing, plus developing both remote-controlled and autonomous sub-aquatic vehicles. These robots are deployed where humans would have great difficulty accessing a site (such as offshore infrastructure, pipelines), or would face significant personal risk (for example, due to ordnance).

The underwater laboratory is intended to be the heart and home base of a globally unique Ocean Technology Center – a center for expertise and innovation in underwater technologies. The lab gives businesses and research organizations the opportunity to collaborate closely, with the aim of developing new products and services.

The German Bundestag has approved millions of euros of funding for the project. Additionally, the State of Mecklenburg-Western Pomerania has also pledged financial support. ■

INDIVIDUAL HEALTH

DIGITAL SOLUTIONS FOR HEALTHCARE

Our visual-computing technologies are laying the foundations for truly personalized medicine. We support healthcare professionals with intuitive decision-making tools – by combining artificial intelligence with smart big-data analytics, integrated data systems, and AR technologies for the operating room.

HARNESSING ARTIFICIAL INTELLIGENCE FOR SMART, PERSONALIZED HEALTHCARE

Artificial intelligence is opening up new possibilities for personalized medicine – from prevention to diagnosis, treatment, and follow-up care.

Each person is unique – not only in terms of personality but also when it comes to maintaining their health and how they respond to medical treatment. What aids one person may prove ineffective for another. Digital healthcare solutions can help determine the best course of action in each specific situation, but this typically requires large volumes of data. We develop solutions that can effectively analyze these data by means of visual computing, across the entire patient journey.

Patient admission and assessment: Virtual biopsies and more

When someone is admitted to the hospital – say, with a tumor in the head and neck region – the next step is in-depth diagnostics. The structure and location of body parts, such as organs, tissues and tumors, must be identified and marked in medical images. However, completing this task manually for three-dimensional scans, including MRI and CT, takes extreme amounts of time and effort. Our software not only supports medical professionals with the analysis of images, it also automatically performs a virtual biopsy. The tumor is pinpointed, marked, and displayed in 3D, allowing over one hundred parameters to be extracted from the CT scan. Initial results show that the corresponding analysis is not only faster, it also delivers information that would otherwise have required an invasive operation and subsequent laboratory tests of excised tumor tissue. By leveraging artificial intelligence, it is possible to automate the segmentation and analysis of images that are otherwise difficult to interpret.

Smart hospital: Treatments

Medical professionals also want to know whether there is a noticeable correlation between someone they are about to treat and other patients. To this end, they consolidate data from people with similar symptoms, disease progressions, or other commonalities, such as age and sex, into cohorts. We have developed a software tool that helps doctors create suitable cohorts, explore them for significant correlations, visualize attributes, and identify clinically relevant hypotheses faster and more easily. What would take many hours to do manually is achieved in a matter of seconds via this automatic process – freeing up more time to focus on treating the patients themselves. In addition, using artificial intelligence when forming a hypothesis helps ensure that no potentially important factors are overlooked.

Visual control center frees up more time for patients

A digital twin of the patient unites all relevant parameters to help enhance care. Our Health@Hand visualization solution combines all digitally available data, including patients' real-time vital signs, and makes this information available at a glance. As a digital control center, Health@Hand provides and visualizes all relevant information at the click of a mouse. This allows crucial data to be captured significantly faster. Moreover, the control center goes beyond depicting an individual patient; it displays a real-time 3D model of the entire hospital department as well as its equipment and supplies. Doctors and nurses can view the department's

digital twin on a desktop PC or tablet to immediately determine, for example, where a portable X-ray machine is presently located. Key metrics for the department can either be shown in their entirety, or focus can be placed on specific details: For instance, a single room or a defined time period. The aim is to simplify department monitoring, allowing issues to be identified and resolved faster.

Prevention and follow-up care in the age of digital health

To help people at home maintain good health, continuously captured vital signs can be fed directly into Health@Hand. To analyze the health of a particular individual, data relevant for decision-making is consolidated from diverse hospital databases – enabling entirely new findings and insights. As a result, it is possible to identify patterns in patient health sooner and make an earlier prognosis. This is ideal, for instance, for diabetes. The doctor can immediately see whether blood sugar levels are outside the normal range, and can respond accordingly. In addition, vital signs and activity data captured by wearables, such as fitness trackers and smartwatches, can be transmitted to the system. Health@Hand can therefore act as a personal health assistant, making a valuable contribution to disease prevention. ■

ARTIFICIAL INTELLIGENCE IN MEDICINE: TIME FOR A CHECKUP

IS ARTIFICIAL INTELLIGENCE ABOUT TO REPLACE DOCTORS?

Absolutely not. We are working to reduce the workload for medical professionals, help them be better informed, and support them during decision-making. Artificial intelligence is not meant to – and is not able to – make medical decisions. That would be terrible in healthcare – people should not be reduced to numbers, and algorithms should not be a replacement for doctors.

DO DOCTORS WANT TO MAKE USE OF ARTIFICIAL INTELLIGENCE?

Healthcare professionals are willing to accept digital assistance once it becomes clear how artificial intelligence can support them in their day-to-day tasks – and once they are reassured that they remain in overall control. Doctors, understandably, want and need to know exactly what artificial intelligence does.

HOW DO I, AS A PATIENT, BENEFIT FROM ARTIFICIAL INTELLIGENCE?

An individual surgeon may have treated a particular type of tumor 10 or 15 times over the course of their career. The computer has access to significantly more cases – AI can analyze them in a matter of seconds and make this knowledge available to medical staff. Additionally, the analysis of CT scans, for instance, is now conducted via software. Previously, doctors had to examine the images layer by layer, taking up precious time that can now be spent on the patient. In some cases, the virtual biopsy may even spare the patient an operation.

WHAT ABOUT DATA PRIVACY?

Ethics committees review and approve all projects, plus the patients themselves must give their consent. We collaborate with university hospitals active in research. Our data are pseudonymized – meaning the person receiving treatment remains anonymous to us, although the doctors we work with know their identity. This arrangement is mandated, ensuring the patients as well can benefit from findings.

MAKING TOMORROW'S VISION TODAY'S REALITY

Cost-efficient, personalized medicine

October 2018 marked the launch of MED²ICIN, a four-year lighthouse project led by Fraunhofer IGD and involving six further Fraunhofer institutes. The researchers' goal is to create a holistic digital model of patients – a digital twin – combining all available information relevant to individuals' health. Previously, these data resided in a diverse range of systems, distributed across place and time. By consolidating them into a single virtual model, the data can be leveraged for more targeted and effective prevention, diagnostics, treatment and care – and enable the more intelligent use of healthcare funds and resources.

More on the lighthouse project: **fh-igd.de/JB18-21-en**

How stressed are we really?

A new project at Fraunhofer IGD in Rostock aims to develop a sensor-based assessment system to objectively detect stress. Psychological stress is a leading cause of absence from work. Moreover, employers have a responsibility to identify and respond to stressors in the workplace. These efforts can entail a host of checklists, questionnaires, interviews, or group discussions. But the answers given are subjective, the analyses time- and resource-consuming – and the findings limited. Researchers are exploring the use of a headband equipped with an array of sensors to measure stress (specifically negative emotions) objectively – via vital signs data, while simultaneously capturing relevant information on the ambient environment, such as noise levels, lighting and temperature. The data collected via the headband are transmitted to software specially developed for this project. This provides employees with personalized feedback, and enables the employer to analyze the work environment and make improvements. The Central Innovation Programme for SMEs (ZIM, initiated by the German Ministry for Economic Affairs) is providing funding for the Fraunhofer project. ■

SMART CITY

INNOVATIVE, DIGITAL, AND SUSTAINABLE

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.

DIGITAL REVOLUTION: PRESERVING CULTURAL HERITAGE IS KEY TO THE FUTURE

In 2018 – the EU's European Year of Cultural Heritage – Fraunhofer IGD hosted the Cultural Heritage and Digitization Symposium. The international event drew a number of guests, and was held in cooperation with Darmstadt, Germany's City of Science – whose Mathildenhöhe Artists' Colony has been placed on UNESCO's tentative list for consideration as a World Heritage Site. Within the scope of the symposium, Fraunhofer IGD's CultLab3D research project was honored with the EU Prize for Cultural Heritage/Europa Nostra Award 2018.

An elegant cookie jar adorned with rich colors rotates on a large screen. The artifact was created in an artist's studio in Mathildenhöhe around 100 years ago. "Art Nouveau, meaning 'new art,' has been made here since the turn of the 20th century, during the transition to modernism," explains Philipp Gutbrod, Director of the Mathildenhöhe Institute in Darmstadt. "It was ahead of its time." In the following years, good design would extend into even the most commonplace items – embellishing and enlivening the everyday.

But however simple an individual object may be, its digital 3D depiction is anything but. "We were very excited by the precision of the cookie jar's virtual replica," says Gutbrod, who also spoke at the Cultural Heritage and Digitization Symposium held by IGD in August 2018. The jar is part of the Mathildenhöhe Museum's collection, and its digital counterpart is a first example of the possibilities opened up by digital transformation in the context of smart cities. In this case, the focus is on preserving the cultural heritage of the city of Darmstadt – and, by extension, Europe.

A collective memory in 3D

Cultural heritage is at the very heart of collective memory: It is a source of identity. But how can it be persevered, considering its deliberate destruction during war, its erosion through weather and pollution, and its inevitable degradation in the face of time? It has long been possible to scan books and documents – indeed, entire collections – in 2D quickly, and on a large scale. When it comes to 3D, however, efforts are time and again hampered by museums' constrained budgets – and by the technological difficulties associated with making 3D scanning efficient in practice.

In Darmstadt, the Fraunhofer IGD research team led by Pedro Santos (Cultural Heritage Digitization Competence Center) has risen to this challenge. It has creatively combined algorithms with innovative, automated scanning technology for 3D digitization. Within the scope of the CultLab3D research project, the team developed the first scanner that can capture data on objects of diverse sizes, shapes, and materials on a huge scale, fully automatically, and visualize these in 3D.

Santos observes: "Scanning artifacts needs to be cost-efficient on a larger scale." Simply digitizing individual objects is not enough to preserve cultural heritage. At the same time, however, public funding for these aims is less than generous. "You can only really make serious money with historical and cultural artifacts on the black market – and that, in turn, makes issues such as data theft and misuse all the more pressing," warns Santos.

Bearing this in mind, the CultLab3D project takes a variety of factors into account. It not only addresses problems such as speed, and sufficiently high resolution and color calibration in the digital replica – it also considers issues such as the storage of raw data files, and data protection. The project aims to enhance programs through annotation and to enrich replicas
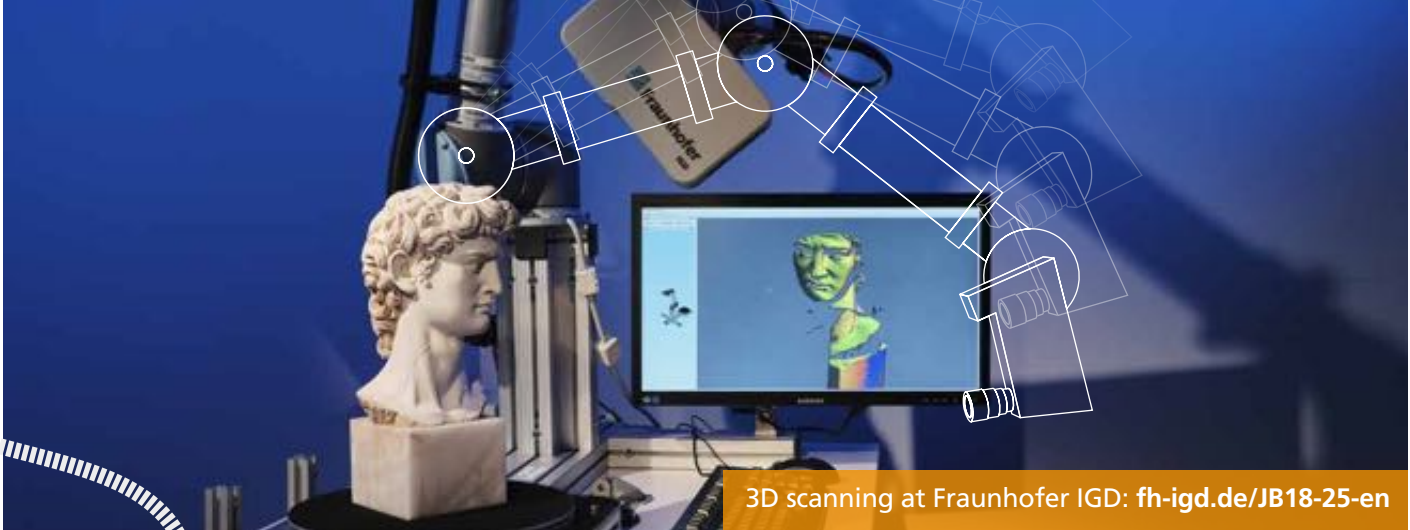
3D scanning at Fraunhofer IGD: **fh-igd.de/JB18-25-en**

with metadata. This would allow information (e.g., geometric identifiers) to be stored so that, for example, a search for a particular attribute would quickly yield results for similar objects across the world.

Cultural artifacts per conveyor belt

The project has proved successful. CultLab3D allows the highly precise 3D scanning of objects on a conveyor. It supports high throughput (just 10 minutes per item) for objects weighing up to 50 kilograms. As a result, it also has potential applications in industrial scenarios – for instance, scanning and digitizing entire product portfolios for online retail. The fully automatic 3D process captures information from all angles, including data on the object's geometric shape, texture, and material properties. It can also be extended with additional scanning modules.

This is exactly why the head of Mathildenhöhe is so enthusiastic: He would not have been satisfied with a less precise depiction of the cookie jar. Just one percent (at most) of the approximately 20,000 items in the collection is on display – but soon, they could be available, virtually, to researchers in all four corners of the world. ■

The EU Prize for Cultural Heritage / Europa Nostra Award 2018 recognizes outstanding achievements in heritage conservation and management, voluntary work, research and education, and awareness-raising with regard to cultural assets that shape European identity. The 29 award winners from a total of 17 nations included Fraunhofer IGD's CultLab3D in the research category. CultLab3D received the accolade for its comprehensive approach to 3D mass digitization and the archiving of cultural artifacts. The prize was initiated by Europa Nostra in 1978. Since 2002, the award has been jointly organized with the European Commission.

An interactive information system on Murinsel

InfoLand software makes complex information interactive. Our application combines text with images, videos and 3D models in a virtual experience, and is compatible with almost all systems and end-points. The latest 3D Internet technologies intelligently link animated nodes to more detailed information, taking the user on an intuitive virtual journey. Content can be added to the presentation tool during active use and without the need for special programming skills. Since 2017, and through cooperation with Fraunhofer Austria, InfoLand has provided virtual guidance to visitors to the Murinsel, a floating venue that merges art and architecture on the Mur River in the heart of Graz. The building has become a modern landmark of Austria's second largest city.

PUTTING GEOINFORMATION TO SMART USE

Geospatial data are now captured in nearly all industries and fields. However, to realize their full potential, the data must be properly processed and analyzed, yielding actionable insights for decision-making. We are researching new ways to comprehensively integrate, manage and visualize geoinformation in the cloud.

Planning police operations using geoinformation

Fraunhofer IGD worked with Hesse Police Headquarters for Technology on a pilot project for the interactive planning of major police operations. Specifically, software visualizes 3D maps that include all relevant topographical features and man-made structures, with the aim of adding tactical value. The ability to assess lines of sight and to represent spectators' viewpoints in the third dimension has advantages, for example, when planning demonstration routes. Moreover, the option of adding further information to a particular scene – such as party tents and amusement rides to a visualization of a fair – gives police a detailed overview of escape and rescue routes. The software solution can also provide support for special forces, incident command and crime scene reconstruction. ◼

More on geoinformation for smart cities: **fh-igd.de/JB18-27-en**

VISUAL COMPUTING AS A SERVICE

THE PLATFORM FOR APPLIED VISUAL COMPUTING

Our work leads to developments tailored to specific real-world use cases. We make our technologies available to developers and users on a cloud-based platform via corresponding licensing models – ensuring our solutions are always accessible, integrated, scalable, and deployable in real time.

"AUGMENTED REALITY AS A SERVICE"
FAST, PRECISE, AND EASY TO USE – AR IN INDUSTRIAL ENVIRONMENTS

Fraunhofer IGD's instant3Dhub interactive 3D visualization platform and its VisionLib AR tracking technology will soon join forces. By combining the latest versions of these core technologies, users can, for the first time, run augmented reality applications in software-as-a-service (SaaS) infrastructure via the cloud. The laborious process of reducing large volumes of CAD data is therefore a thing of the past – and it is possible to exploit the full potential of native data. Additionally, the CAD data reside solely on the user organization's own infrastructure: Only the data required for the current visualization are transmitted in real time to mobile devices.

Augmented reality in industrial environments is no distant dream. AR has enormous potential for streamlining processes, from manufacturing tasks to quality assurance, maintenance, and repairs. Digital twins – virtual replicas of physical objects – play a key role. A digital twin is created using CAD data, plus additional information describing the attributes of individual components and materials. The availability of these data can have a decisive and positive impact on multiple process steps.

The volume of data associated with creating digital twins is enormous – and unwieldy. In order to visualize 3D models, the data are repeatedly pared down and the corresponding metadata are lost. Generating these 3D visualizations currently requires very specialized software and computers. In addition, visual processing for industrial scenarios takes considerable time and entails a highly specific skill set. Overall, these issues present substantial barriers to the very people who could gain the most immediate benefits – among them production workers, quality inspectors and procurement professionals.

The latest release of Fraunhofer IGD's instant3Dhub platform accelerates the visualization of 3D models on the basis of original CAD data. The solution enables users to rapidly and automatically visualize immense data volumes independent of the device used, e.g., AR head-mounted displays, tablets, or smartphones. A new feature is instant3Dhub's integration with the VisionLib augmented-reality tracking library, licensed

by a Fraunhofer IGD spin-off. This library is a powerful tool for capturing objects in 3D as the basis for AR visualizations. Tracking, (i.e., determining the exact position of objects in a camera-captured image), is a prerequisite for AR. It plays a crucial role in correctly displaying or superimposing additional information. And this precise positioning of information in relation to physical objects is essential, for example, when it comes to projecting welding points. In contrast to other solutions on the market, Fraunhofer IGD's model-based tracking technology harnesses the original CAD data – the same data that are also employed for the visualization of 3D models. This means IT experts no longer need to interactively pare down data, thereby losing valuable semantic information.

Siemens is already exploring the advantages of combining instant3Dhub and VisionLib for their electric drive technology. Each drive is custom-manufactured, so each has its own, unique set of CAD data – a digital twin that reflects all product attributes. In the future, Siemens will leverage AR technology throughout the entire product lifecycle of these drives, including for quality assurance, e.g., verifying that the manufactured part corresponds to the CAD model. "With instant3Dhub, we can ensure that the AR applications have access to a customer-specific CAD model throughout the entire process chain," states Dr. Christian Mundo, Digital Officer of the Large Drives business unit at Siemens. "There are obvious advantages. The comparison is performed automatically and

via the cloud. Instant3Dhub allows us to identify objects simply; metadata are continuously available for the corresponding model, and can be displayed on demand. This Fraunhofer technology is key to our AR applications. Further potential applications include training for our service engineers, plus on-site customer service deployments – for instance, to rapidly identify a defective part."

This latest innovation, however, does not mean the Fraunhofer researchers are about to rest on their laurels. They are currently working on data transformation for 3D printing directly from within an application – which could prove useful, for example, for making critical spare parts. They are also hoping to introduce collaboration capabilities, allowing multiple devices to take part in the same AR sessions to support remote maintenance. A further aim is to incorporate artificial intelligence, enabling the solution to recognize objects it has never encountered before. ∎

Experience instant3Dhub: **fh-igd.de/JB18-30-en**

Our spin-offs

Fraunhofer IGD spin-offs and start-ups help strengthen the competitiveness of industry:

Assisted Home Solutions GmbH
CONWEAVER GmbH
Darmstadt Graphics Group GmbH
exocad GmbH
ISRA VISION Polymetric GmbH
MedCom GmbH
mHealth Pioneers GmbH
PartMaster GmbH
Progether AS
Teambits GmbH
Visometry GmbH
wetransform GmbH

FRAUNHOFER MEANS (STARTING A) BUSINESS

Dr. Max Limper skillfully negotiates vertiginous walls with only thick floor mats to break his fall. In his professional life, too, the 33-year-old bouldering enthusiast displays agility and courage: After completing his doctoral thesis at Fraunhofer IGD, he established a spin-off enterprise, Darmstadt Graphics Group. Its business model is based on software that automatically makes three-dimensional data suitable for online publication.

Dr. Max Limper's thesis gave him much more than the two letters in front of his name. The subject is set to shape his future. His entire livelihood is built upon it: In August 2018, Limper and his Fraunhofer colleague Miguel Sousa established a spin-off, Darmstadt Graphics Group (DGG). Its business model is based on InstantUV, a software solution Limper developed while working on his doctoral thesis at Fraunhofer IGD and now markets under the name RapidCompact. Essentially, the software solution processes three-dimensional data and makes them suitable for publication on the Internet. The process is automatic and entails compressing the data without this being recognizable to the user. This function is particularly appealing to organizations such as museums and online stores. Previously, there was simply not enough time to create Internet-friendly 3D depictions of all exhibits or products. What used to take at least half an hour of someone's working day can now be completed by RapidCompact in around 30 seconds, and fully automatically.

Limper's time at Fraunhofer IGD created the ideal springboard for his leap into entrepreneurship. As he recalls, "At Fraunhofer IGD, I was able to work on both fundamentals and their application – in a way that would not have been possible at a university or a Max-Planck Institute. That created a very interesting crossover." As an employee, and later Deputy Head of a competence center at Fraunhofer IGD, the IT expert was primarily involved in industrial projects. However, his doctoral thesis saw him focus on basic research – a project he worked on "in his spare time." He was able to make good use of his network of contacts at Fraunhofer IGD: He spent three months at the University of British Columbia (UBC) in Canada, where he was able to concentrate more on his basic research goals.

Fraunhofer-Gesellschaft also assisted Limper with his spin-off. By taking part in Fraunhofer's FDays® program in fall 2017, he was able to develop his initial entrepreneurial concept. "We were able to work with coaches from Fraunhofer Venture to take our business ideas further," states the passionate amateur guitar player. "We received seed funding from a business angel in fall 2018. And as of February 2019, our spin-off has been enjoying financial support from the Fraunhofer Technology Transfer Fund (FTTF), established jointly by Fraunhofer and the European Investment Fund." The undertaking is off to a promising start. DGG has already attracted its first customers, including Carl Zeiss. ■

SPECIAL – CYBERSECURITY

TRAILBLAZING EXPERTISE

In 2019 the Center for Research in Security and Privacy became the National Research Center for Applied Cybersecurity CRISP. CRISP is now a permanent Fraunhofer-Gesellschaft entity, comprising its Darmstadt-based SIT and IGD institutes, plus Darmstadt Technical University (TU Darmstadt) and Darmstadt University of Applied Sciences. More than 450 CRISP scientists are addressing key issues in cybersecurity, with direct benefits for society, business, and government. As a national research center, CRISP will be significantly expanded starting in 2019. The German Federal Ministry of Education and Research (BMBF) and the Hessen State Ministry for Higher Education, Research and the Arts (HMWK) are providing funding.

NEW VULNERABILITIES, NEW SOLUTIONS
CYBERSECURITY AS THE BASIS FOR GREATER DIGITIZATION

As digital transformation impacts more and more aspects of life, cybersecurity is becoming increasingly important. To better fend off manipulation and attacks, researchers are conducting analyses to identify vulnerabilities. The following case studies spotlight typical dangers and remedies.

Case 1: Smart home security check

When it comes to protecting one's own home, the stakes – and requirements – are high. Demand for household appliances and multimedia devices continues to rise, particularly for solutions that allow users to centrally and remotely manage functions. Intelligent heaters, electronic door locks, smart washing machines, etc., capture highly sensitive personal data. These data can be exploited to identify the user and draw conclusions on their activities, medical history and much more.

Should a hacker infiltrate the smart home system, the attack can spread throughout all connected devices. Against this background, Fraunhofer IGD and TU Darmstadt researchers in an interdisciplinary CRISP project are developing a smart-building demonstration environment that can be employed to simulate external attacks. The basis is Fraunhofer IGD's Smart Living Lab, which mimics a realistic apartment equipped with sensors for localization and activity recognition. The studies, data records, and manipulation attempts help provide key insights: How does normal activity differ from attacks? And how can these anomalies be detected and identified in data flows? The findings form the foundations for enhanced security solutions. In addition, the project aims to make a large proportion of data processing local, to avoid misuse of personal data from the very outset.

Case 2: Voice recognition security check

With so many PINs and log-ins for smartphones, tablets, desktop PCs and myriad other devices, it is no wonder users sometimes forget their passwords. Resetting them is usually simple – at least for personal accounts. When it comes to work environments, obtaining new credentials can be complicated. In major corporations, users typically need to apply for a new password via a cumbersome process. But there are solutions. For example, authentication by means of voice recognition software allows the user to set up a new password simply by making a telephone call. A personal identification number and a (relatively short) spoken sentence verify that the caller is who they say they are.

Fraunhofer IGD researchers are investigating a voice recognition system for potential vulnerabilities prior to its rollout. To this end, they tested the accuracy of the voice recognition function and its resilience to obvious attempts to circumvent it – such as playing recordings of a person's voice, or the use of voice-modifying technology available for free on the Internet. The system proved to be up to the task. And for project partners, this means the solution can be implemented with a clear conscience. Project Leader Olaf Henniger believes that voice, like artificial intelligence, will play an increasingly important role in human-computer interactions. "At the same time, artificial intelligence is being used to falsify voice signals. We will take new attack vectors such as this into account for future security evaluations." ■

HOME SWEET SMART HOME?
WE ASKED OUR EXPERTS

Not all careers commence at Fraunhofer. Florian Kirchbuchner served with the German armed forces for eight years before opting to study information technology with psychology at the Technical University of Darmstadt (TU Darmstadt). A lecture on ambient intelligence awakened his inner researcher, and he wrote his master's degree thesis at Fraunhofer IGD. Today, he is head of a competence center and works on smart homes.

Mr. Kirchbuchner, you have been Head of the Smart Living & Biometric Technologies Competence Center since 2018. What are your team's primary tasks?
We look at everything to do with people – we detect their activities, attempt to identify who they are, and how they are behaving. We then use this knowledge to develop systems that respond to the user's intentions.

Can you give us some concrete examples of smart home technologies? Has your research enriched your own life?
My apartment is now equipped with voice recognition systems and self-adjusting thermostats. I also use the face recognition function on my smartphone. Personally, I chiefly use these applications because they are convenient, but also to find out what the market currently has to offer.

Do you have any security concerns?
We need to be vigilant, and there will never be complete security. Above all, it is important to keep your personal data well protected.

So responsibility also lies with the user?
Exactly. And that requires the user to be informed. One problem is that it is not clear how data are connected. What happens to the data? Often, users do not hear that a company has been hacked until long after the event, via the media. And we need to take a nuanced approach to informing people. Younger generations are often much more tech-savvy, whereas seniors have a different understanding of privacy.

Your competence center is responsible for the sensors in the WoQuaz smart assisted-living complex in Weiterstadt. How have residents responded?
Their response has been relatively open-minded, as they knew what to expect when they moved in. Not all of them fully understand what exactly our sensors measure – for example, we can tell how often someone went to the bathroom on the basis of their activities. They don't realize this, despite knowing that we capture movement patterns for convenience functions. We talk to residents very frankly about this fact, and at that point we often get asked if they can disable these features. The advantage of our system is that every resident has their own control cabinet. They just have to flick a switch and our CapFloor system cannot see a thing. Awareness of this form of control is very reassuring to residents.

Do you cooperate with the cybersecurity experts from CRISP?
Yes, we are currently building a demonstration and simulation laboratory to test the security of smart home environments. To this end, we are creating a virtual smart home where someone moves around and generates data. We then launch targeted attacks on these data and work with the psychologists at TU Darmstadt to visualize these vulnerabilities. ∎

FACE MORPHING: A NEW THREAT?

No, we are not talking about amusing apps that swap our relatives' faces around, superimpose cute puppy-dog masks or display our unmistakable resemblance to a Hollywood star. When performed correctly, face morphing can pose a serious threat.
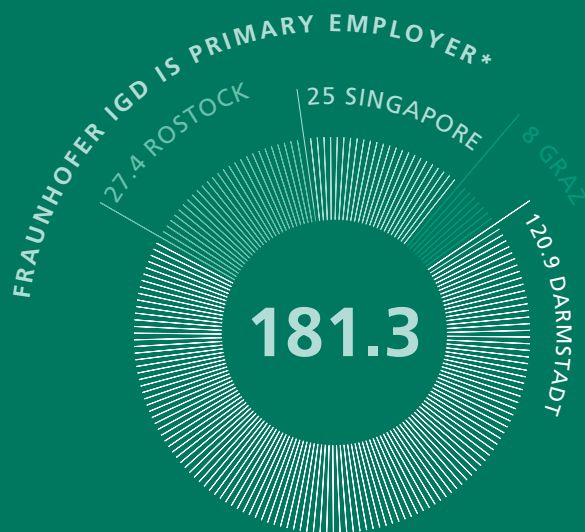
A single passport, multiple identities

Face morphing can be employed to assign multiple identities to a single passport photo. To morph photos of faces, the people depicted do not have to be related: A certain degree of similarity is sufficient. The artificial intelligence behind biometric facial recognition systems will recognize the successfully shared and merged passport photo as belonging to multiple people and will let them all through, with one and the same passport. This is possible if the facial nodal points that are key to recognition are perfectly aligned. And human intervention is not a solution either – the naked eye is unable to detect a morphed passport photo.

Learning from fraudsters

Cyber attacks are a major problem; ideally, they can be thwarted at an early stage, before their impact is felt. However, the "bad guys" are often one step ahead, identifying vulnerabilities before developers are aware of them. For researchers at Fraunhofer IGD, that means turning their hands to the fine art of morphing. Using the MorGAN (Morphing through Generative Adversarial Networks) image generation methodology, we have created a database with more than 1000 morphed photos. Traditional solutions for the identification of morphing attacks have not been able to successfully pinpoint MorGAN images. The next step is for the scientists to find a way of outwitting their own devious technology. ∎

21% BASIC FUNDING

79% THIRD-PARTY FUNDING

BUDGET
€21.2
MN

FRAUNHOFER IGD IS PRIMARY EMPLOYER*

27.4 ROSTOCK   25 SINGAPORE   8 GRAZ

120.9 DARMSTADT

181.3

FRAUNHOFER IGD IS SECONDARY EMPLOYER*

8 ROSTOCK   3 SINGAPORE   0.5 GRAZ

31.5 DARMSTADT

43

*FULL-TIME EQUIVALENTS

FACTS AND FIGURES

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.

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.

TECHNOLOGY LABS

Fraunhofer IGD's dedicated labs demonstrate, test and evolve the technologies developed by the various competence centers. Additionally, the labs conduct experiments and studies within the scope of customer projects. Fraunhofer IGD has the following technology labs and demonstration centers:

- Acti Lab (Activity and Vital Signs Data Capture)
- Ambient Assisted Living Lab
- CultLab3D
- Definitely Affordable Virtual Environment (DAVE)
- Spatial Information Management Demonstration Center
- Biometric Systems Evaluation Lab
- Interactive Engineering Lab
- Interactive Showroom & Innovation Lounge
- High-Quality Image Acquisition and Output Lab
- Industry 4.0 Lab – Rostock
- Maritime Graphics Lab
- Visual Analytics Lab
- Visual Computing for Industry 4.0 Lab
- Visual Healthcare Technology Lab
- Visual Computing System Technologies Lab
- 3D Digitization Lab
- 3D Printing Lab

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. Dr.-Ing. Edgar Dörsam	TU Darmstadt	Darmstadt
Prof. Dr. rer. nat. Reinhard Klein	University of Bonn	Bonn
Prof. Dr. Stefanie Lindstaedt	Know-Center GmbH	Graz
Dipl.-Oz. Petra Mahnke	German Association for Marine Technology	Hamburg
MinR'in Dr. Ulrike Mattig	Hessen State Ministry for Higher Education, Research and the Arts	Wiesbaden
Dr. Torsten Niederdränk	Siemens AG	Erlangen
Prof. Dr. Albert Remke	52° North GmbH	Münster
Prof. Dr. Bernt Schiele	Max Planck Institute for Informatics	Saarbrücken
Prof. Dr.-Ing. habil. Heidrun Schumann	University of Rostock	Rostock

NETWORKS
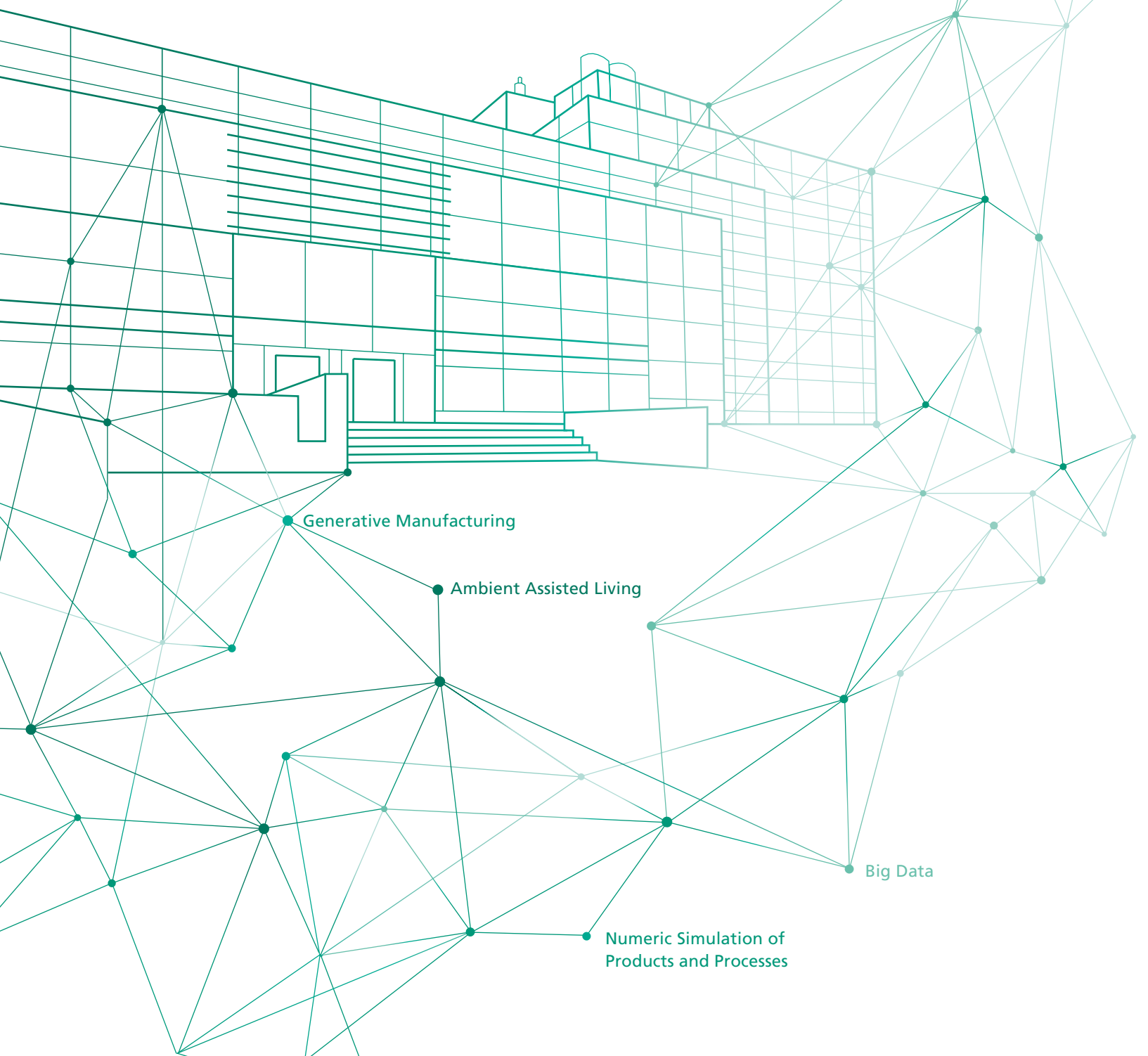
Generative Manufacturing

Ambient Assisted Living

Big Data

Numeric Simulation of
Products and Processes

Fraunhofer Alliances

Institutes or individual departments with diverse skills collaborate within Fraunhofer Alliances, working together to develop target business areas and to market their services. Fraunhofer IGD's competence centers are represented in the following Fraunhofer Alliances: Ambient Assisted Living, Big Data and Artificial Intelligence, Generative Manufacturing, and Numerical Simulation of Products and Processes. Within these alliances, the IGD competence centers cooperate with departments at other Fraunhofer institutes.

fh-igd.de/allianzen-en

Fraunhofer ICT Group

Institutes that work in related areas are organized into Fraunhofer Groups, and jointly market their services in research and development (R&D). Fraunhofer IGD is a member of the ICT Group, i.e., information and communications technologies. In total, the Fraunhofer ICT Group represents 21 member institutes with approximately 4500 employees and an annual budget of around 246 million euros – more than three quarters of which is from competitive research projects and contract research for businesses. This makes the Fraunhofer ICT Group the largest, most important service provider in applied research in information and communications technology in Europe. The Group offers key skills for the economy and society to realize the full potential of – and overcome the challenges associated with – digital transformation of all aspects of life. With its member institutes, the Group spans a broad spectrum of fields: From basic research to applied solutions in informatics, mathematics and ICT. The Group supports both national and international IT providers and users, particularly small- and mid-sized organizations.

Within the scope of interdisciplinary initiatives, the Fraunhofer ICT Group identifies and addresses key topics that will impact the future of the economy and society. To this end, the Group works closely with industry associations, scientific institutions, and political entities; it is also actively involved in public relations work, training and education.

Since January 1, 2016, Professor Dieter W. Fellner (Director of Fraunhofer IGD) has served as the chairman of the Fraunhofer ICT Group. Alexander Nouak is the managing director of the central office.

Fraunhofer ICT Group industries:

- Mobility and transportation
- E-government
- Public safety and security
- Manufacturing and logistics
- Media and creative industries
- Digital services
- Business and finance informatics
- Medical and healthcare systems
- Energy and sustainability

Fraunhofer ICT Group technologies:

- Numerical software and simulation
- Usability and human-computer interaction
- Reliable cyber-physical systems
- IT security and safety
- Digital networks and Internet
- Graphics and media technology
- Image acquisition and evaluation
- Big data management and analytics
- Automation technology and engineering

www.iuk.fraunhofer.de

2018 FRAUNHOFER IN NUMBERS

72

Institutes and research centers

Over

26,600

Employees

€2.5
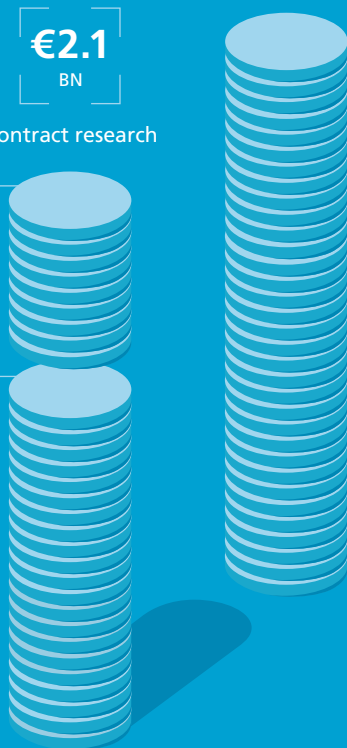BN

Annual research funding

€2.1
BN

Contract research

30 %

Federal/state government

70 %

Industry and publically 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 comprise manufacturers, service providers, and the public sector.

Fraunhofer-Gesellschaft is Europe's leading organization for applied research. Across Germany, it comprises a total of 72 institutes and research centers. More than 26,600 employees conduct research products with total annual funding of 2.5 billion euros. Of this amount, over 2.1 billion euros is from contract research. Some 70 percent of this subtotal is attributable to contracts from industry and to publically 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 EXECUTIVE BOARD

Prof. Dr. Reimund Neugebauer
Prof. Dr. Alexander Kurz
Dipl.-Kfm. Andreas Meuer

FRAUNHOFER IGD

Institute Advisor Dr. Birgit Geier

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.

www.fraunhofer.de/en

PUBLICATIONS

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 pages highlight a small selection of these.

Doctorates

Dr. Naser Damer
Application-driven Advances in Multi-biometric Fusion
Examiners: Arjan Kuijper, Dieter Fellner, Ramachandra Raghavendra

Dr. Tim Dolereit
A Virtual Object Point Model for the Calibration of Underwater Stereo Cameras to Recover Accurate 3D Information
Examiners: Bodo Urban, Uwe Freiherr von Lukas, Reinhard Koch

Dr. Fahimeh Farhadifard
Underwater Image Restoration: Super-resolution and Deblurring via Sparse Representation and Denoising by Means of Marine Snow Removal
Examiners: Bodo Urban, Uwe Freiherr von Lukas, Reinhard Koch

Dr. Ulrich Krispel
Generative Methods for Data Completion in Shape Driven Systems
Examiners: Dieter Fellner, Werner Purgathofer

Dr. Max Limper
Automatic Optimization of 3D Mesh Data for Real-Time Online Presentation
Examiners: Dieter Fellner, Marc Alexa

Dr. Denys J. C. Matthies
Reflexive Interaction – Extending Peripheral Interaction by Augmenting Humans
Examiners: Bodo Urban, Albrecht Schmidt, Katrin Wolf

Dr. Christoph Schinko
Shape Processing for Content Generation
Examiners: Dieter Fellner, Reinhard Klein

Best Paper

Award winners:
Steven Le Moan
Tejas Madan Tanksale
Roman Byshko
Philipp Urban

Title:
An observer-metamerism sensitivity index for electronic displays.
Journal of the Society for Information Display, 25 (9) 2017, pp. 554–560

Abstract:
The paper presents a new approach for predicting observer-metamerism for a particular multi-primary display. The index only requires the display primaries, and computes significantly faster than existing indices – and is therefore of potential interest in the design of future display systems.

Best Thesis

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

Simon Breitfelder
Example-based Synthesis of Seamless Texture Variations and Application to the Acquisition of Optical Material-Properties
Examiners: Prof. Dr. Arjan Kuijper, Martin Ritz (CHD)

Alexandra Moseguí Saladié
Creating face morphing attacks with Generative Adversarial Networks (Face recognition vulnerability and attack detectability)
Examiners: Naser Damer, Sule Yildirim Yayilgan

At the SIGGRAPH 2018 computer graphics conference, Fraunhofer IGD presented three publications describing pioneering developments in 3D printing, 3D web visualization, and optical material-behavior acquisition. The accepted papers underscore Fraunhofer IGD's leading international role at the forefront of computer graphics research.

3D Printing Spatially Varying Color and Translucency

In the 3D Printing Spatially Varying Color and Translucency paper, Professor Philipp Urban describes a technology that opens up entirely new possibilities in 3D printing. In essence, he and his colleagues Alan Brunton, Can Ates Arikan and Tejas Madan Tanksale developed an algorithm to make printing full color, translucency, and transparency possible – and combinable. This has potential for diverse scenarios, for example, in the film industry and for medical technology. In the paper, Urban demonstrates how it is possible, for instance, to realistically reproduce translucent materials or tissues such as skin. Engineers and designers can generate the corresponding 3D models with conventional modeling tools and save them in standard file formats. Moreover, they can employ multiple feedstocks to make replicas of objects. Users and customers can therefore print millions of designs already available on the Internet. The technology is incorporated into Fraunhofer IGD's Cuttlefish 3D printer driver, and customers have already put it to use.

Box Cutter: Atlas Refinement for Efficient Packing via Void Elimination

The second paper, Box Cutter: Atlas Refinement for Efficient Packing via Void Elimination, spotlights a method for optimizing textured 3D models. Dr. Max Limper and his colleagues Nicholas Vining and Alla Sheffer from the University of British Columbia UBC demonstrate how Box Cutter software is able to render the surfaces of 3D models in great detail, without the need for more memory. Refining packed atlases – a task that experts previously completed manually, entailing considerable time and effort – is now performed by an algorithm. According to Limper, potential applications include 3D visualization, computer games, VR technologies, and 3D web visualization. In all, faster loading will open up more opportunities for the deployment of 3D models.

Automated Acquisition and Real-Time Rendering of Spatially Varying Optical Material Behavior

A poster from Fraunhofer IGD entitled Automated Acquisition and Real-Time Rendering of Spatially Varying Optical Material Behavior was also accepted by SIGGRAPH. Martin Ritz and Pedro Santos presented conference attendees with a new, fully automatic method for the acquisition, i.e., capture, and highly realistic visualization of the optical behavior of materials. The surface appearance of objects varies considerably depending on the angle of light incidence, and this has previously been a major challenge in the production of realistic 3D models. In contrast to earlier approaches, the new method enables rendering in real time, transferring light-dependent surface changes to the virtual room. This leads to enormous savings in terms of memory, allowing captured data to be transferred to any 3D model. Potential applications include architecture and in the automotive industry, where a variety of materials for interiors can be tested, e.g., virtually under realistic light conditions prior to production of a prototype.

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.

Dr. Mario Aehnelt
Rostock | +49 381 4024-100
mario.aehnelt@igd-r.fraunhofer.de

VISUAL ASSISTANCE TECHNOLOGIES

The 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.

Dr. Johannes Behr
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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.

Dr. Ulrich Bockholt
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VIRTUAL AND AUGMENTED REALITY

Virtual and Augmented Reality is the name and focus of the competence center led by Ulrich Bockholt. 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.

Dr. Eva Eggeling
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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.

Prof. Jörn Kohlhammer

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INFORMATION VISUALIZATION AND VISUAL ANALYTICS

The Information Visualization and Visual Analytics 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.

Prof. Uwe Freiherr von Lukas

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MARITIME GRAPHICS

The Maritime Graphics Competence Center develops solutions for maritime applications. Its pioneering work benefits shipbuilding and ship operation plus with 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.

Prof. Wolfgang Müller-Wittig

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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.

Prof. Philipp Urban
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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.

HOW TO FIND US

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