Fraunhofer IGD

*Event guide*

# WELCOME TO THE COMPUTER GRAPHICS NIGHT

**THURSDAY**
**DECEMBER 01, 2022**

# CONTENTS
## PROGRAM

# GRADUATION



*THIS SECTION HIGHLIGHTS, IN ALPHABETICAL ORDER, ALL VISUAL COMPUTING DISSERTATIONS PUBLISHED BETWEEN NOVEMBER 1, 2021 AND OCTOBER 31, 2022.*

FADI BOUTROS

# Efficient and High Performing Biometrics: Towards Enabling Recognition in Embedded Domains

Zur Erlangung des akademischen Grades Doktor-Ingenieur (Dr.-Ing.)
Genehmigte Dissertation von Fadi Boutros aus Idlib, Syria
Tag der Einreichung: April 22, 2022, Tag der Prüfung: June 14, 2022

1. Gutachten: Prof. Dr. Arjan Kuijper
2. Gutachten: Prof. Dr. Dieter W. Fellner
3. Gutachten: Prof. Dr. Kiran Raja
Darmstadt

TECHNISCHE UNIVERSITÄT DARMSTADT

Computer Science Department

Interactive Graphics Systems Group


## Abstract

The growing need for reliable and accurate recognition solutions along with the recent innovations in deep learning methodologies has reshaped the research landscape of biometric recognition. Developing efficient biometric solutions is essential to minimize the required computational costs, especially when deployed on embedded and low-end devices. This drives the main contributions of this work, aiming at enabling wide application range of biometric technologies.

Towards enabling wider implementation of face recognition in use cases that are extremely limited by computational complexity constraints, this thesis presents a set of efficient models for accurate face verification, namely MixFaceNets. With a focus on automated network architecture design, this thesis is the first to utilize neural architecture search to successfully develop a family of lightweight face-specific architectures, namely PocketNets. Additionally, this thesis proposes a novel training paradigm based on knowledge distillation (KD), the multi-step KD, to enhance the verification performance of compact models. Towards enhancing face recognition accuracy, this thesis presents a novel margin-penalty softmax loss, ElasticFace, that relaxes the restriction of having a single fixed penalty margin.

Occluded faces by facial masks during the recent COVID-19 pandemic presents an emerging challenge for face recognition. This thesis presents a solution that mitigates the effects of wearing a mask and improves masked face recognition performance. This solution operates on top of existing face recognition models and thus avoids the high cost of retraining existing face recognition models or deploying a separate solution for masked face recognition.

Aiming at introducing biometric recognition to novel embedded domains, this thesis is the first to propose leveraging the existing hardware of head-mounted displays for identity verification of the users of virtual and augmented reality applications. This is additionally supported by proposing a compact ocular segmentation solution as a part of an iris and periocular recognition pipeline. Furthermore, an identity-preserving synthetic ocular image generation approach is designed to mitigate potential privacy concerns related to the accessibility to real biometric data and facilitate the further development of biometric recognition in new domains.

# ROBERT GREGOR

Robert Gregor

## Similarity-based Techniques for Automated 3D Restoration of Digitized Cultural Heritage Artifacts

**Dissertation**

zur Erlangung des akademischen Grades
Dr. techn.

eingereicht an der

**Technischen Universität Graz**
Institut für Computergrafik und Wissensvisualisierung
Fakultät für Informatik und Biomedizinische Technik

Gutachter
Univ.-Prof. Dipl.-Volksw. Dr.rer.nat. M.Sc. Tobias Schreck
Technische Universität Graz

Externer Gutachter
Prof. Dr. Ioannis Pratikakis
Democritus University of Thrace

Dipl.-Inf. Robert Gregor
Matrikel Nr.: 01653839

Zürich, 16.11.2021

# ABSTRACT


## Abstract

The Advances of 3D digitization methods and their growing adoption in the field of Cultural Heritage (CH) open up the possibility to improve over the state of the art in 3D Restoration of CH artifacts by the aid of 3D Shape Analysis and Processing techniques.

In recent years, the use of digitized 3D representations of CH objects has seen broad adoption. However, the predominant purpose of 3D digitizations currently often is linked to archival and more direct dissemination of the artifacts to larger audiences.

In spite of the rapidly growing number of digital libraries that provide access to 3D representations of CH artifacts, 2D or 3D content-based techniques are not yet broadly established in context of information retrieval across such collections. Instead, retrieval based on metadata or unstructured text are much more common. Non-withstanding, that their procurement is a laborious and often error-prone task that demands for specifically trained CH domain experts.

Due to declining cost of acquisition and the ease of dissemination via the internet on commodity hardware, a growing community of CH domain experts and computer scientists focuses on the digital restoration of 3D CH objects. Often, this enables restorations that were previously infeasible to conduct. With traditional methods, restoration costs, concerns of preservation or impracticability of physical access to originating artifacts or restoration results often are very problematic issues. For digital restoration, the vast majority of approaches relies on laborious, manual 3D modeling to restore missing geometry. This shares similarities to approaches used in CAD modeling or digital content creation (e.g. the movie industry) that require detailed manual input from CH domain

# ABSTRACT

experts which have been trained to use complex, general purpose 3D modeling software.

In order to reduce the manual effort involved in such tasks, this thesis proposes techniques that rely on feature-based notions of similarity to automate the processing of digitized 3D CH artifacts. Among the research that has been published in pursuit of this thesis is the proposal of an automated restoration workflow for defective CH artifacts and a technique for efficiently merging geometry of 3D CH Object fragments.

Furthermore, this thesis proposes several approaches towards more systematic evaluation of automated 3D CH Restoration techniques. A problem that has frequently been encountered during research is the lack of freely available data, that can either be used directly for systematic quantitative evaluation or even for relying on supervised machine learning techniques, that recently gained substantial popularity in other, technically related domains.

Aimed at increasing automation in the archival of 3D CH Objects, a technique is proposed for cross-modal, content-based retrieval in collections of 2D and 3D digitization of 3D CH Objects. Adoption of this technique could contribute to further improving data quality and ease of access to larger quantities of defective 3D CH objects.

In conclusion, this thesis aims to provide a collection of tools for 3D Shape Processing in the CH Domain. Based on the experience gained by working with real 3D CH data during the course of research, this encompasses the aspects of adopting similarity-based techniques, evaluation methodology, generating test data sets and finally, gaining a better understanding on how such techniques can be adopted and combined to improve the level of automation in digital 3D CH restoration.

ANDREAS WIRTZ

# Automatic model-based teeth segmentation, numbering and 3-D reconstruction using routinely collected images



vom Fachbereich Informatik
der Technischen Universität Darmstadt
genehmigte

DISSERTATION

zur Erlangung des akademischen Grades eines
Doktor-Ingenieurs (Dr.-Ing.)
von

Andreas Wirtz. M.Sc.

geboren in Bonn, Deutschland

| | |
|---|---|
| Referenten der Arbeit: | Prof. Dr. Arjan Kuijper<br>Technische Universität Darmstadt |
| | Prof. Dr. techn. Dr.-Ing. eh. Dieter W. Fellner<br>Technische Universität Darmstadt |
| | Prof. Dr. Reinhard Klein<br>Rheinische Friedrich-Wilhelms-Universität Bonn |
| Tag der Einreichung: | 04.11.2021 |
| Tag der mündlichen Prüfung: | 20.12.2021 |

Darmstadt 2021

Darmstädter Dissertation
D 17

# Abstract

Oral health issues like tooth decay affect billions of people worldwide. The early detection as well as the treatment of those problems is an important part of today's healthcare. Since the teeth cannot be assessed by visual inspection only as they are partly embedded in soft tissue and bones, medical imaging techniques are employed to provide the required information. The manual analysis of such images is time consuming and prone to inter- and intra-observer variability. For this reason, computer aided systems which automate the extraction of clinically relevant information can be of great benefit to medical professionals. A mandatory step to provide such systems is the segmentation and numbering of individual teeth in the digital images. However, challenges like image quality and characteristics of dental radiographs, patient-specific variations, and the fact that the 32 teeth only belong to 4 different types makes it hard to accurately detect teeth boundaries and difficult to label an individual tooth.

In this context, this thesis focuses on the research questions of *teeth segmentation and numbering in panoramic X-ray images*, and *image-based 3-D reconstruction of the teeth from five colored photographs* which relies on accurate object-level segmentation and numbering of the 2-D teeth outlines (in the photographs). As both topics share the common aspect of segmentation and numbering, a general concept is presented which is also applied in a third application to localize landmarks for the analysis of dental cephalometric images.

This thesis proposes to solve the segmentation and numbering in 2-D by encoding prior knowledge about the teeth shapes and spatial relations in a coupled shape model. Initial placement of the model is performed by exploiting the semantic segmentation performance of neural networks while dynamic adaptation strategies increase the robustness of fitting to model to unseen images. This enables the extraction of teeth contours from both panoramic radiographs and colored photographs. The proposed image-based 3-D teeth reconstruction utilizes the numbered teeth contours from the photographs to deform a mean model of the teeth by minimizing a silhouette-based loss. It is the first fully-automatic image-based teeth reconstruction that aims to reconstruct the majority of teeth and the first approach to perform a reconstruction only on the five photographs of orthodontic records. The landmark localization utilizes the segmentation and numbering concept to predict the location of 19 landmarks by exploiting the spatial relation between landmarks and other structures and refines those predictions using landmark-specific Hough Forests.

The teeth segmentation and numbering of 28 individual teeth in panoramic radiographs achieves average F1 scores of $0.823 \pm 0.189$ and $0.833 \pm 0.108$ on two different test sets. The image-based 3-D reconstruction of 24 teeth from five photographs achieves an average symmetric surface distance of $0.807 \pm 0.379$ mm. The landmark localization in cephalometric images reaches a success detection rate of 76.04 % in the clinically relevant 2.0 mm accuracy range.

# BEST THESIS AWARD



## THE JUDGING PROCESS

The judges select the bachelor's and master's theses they consider the best of those submitted for the Visual Computing Cluster between November 2021 and October 2022. These winning theses demonstrate high quality both with respect to scientific achievement and presentation.

The theses are chosen by the judges in collaboration with the theses supervisors. As the scope of visual computing is very broad, the winning theses are not ranked.

*THE WINNERS OF THE **BEST THESIS AWARD** WILL BE ANNOUNCED AT THE COMPUTER GRAPHICS NIGHT EVENT.*

## THE PRIZE

The winners receive a certificate, a book, and a trip to a Eurographics or equivalent leading visual computing conference, agreed by the winners with the judges.

# PANEL OF JUDGES
## BEST THESIS AWARD

### FINAL NOMINATIONS

**Florian Bierbaum** BACHELOR

Investigating the Generalizabililty of MasterFace Attacks on Face Recognition Systems

**Frederik Hartman** BACHELOR

Analyse von bewegten Bilddaten zur Stabilisierung einer Kameraposition bei ultramobilen Systemen durch Methoden des Optical Flow und Deep-Learning Verfahren

**Malte Ihlefeld** BACHELOR

Towards Quality-Aware Face Recognition

**Yannik Pflanzer** MASTER

An Evaluation of Classical and Deep Learning Techniques for View Interpolation in the Context of Digitizing Entire Objects

**Amin Ranem** MASTER

Continual Learning with Transformer Architectures

**Irena Ruprecht** MASTER

Crowd Simulation with Personality

**Jonas Stromberg** MASTER

Stable Search Radar

### THE JUDGES

*Prof. Tobias Schreck*
*TU Graz*

*Prof. A. Kuijper*
*Fraunhofer IGD*

# BEST PAPER AWARD



*THE FOLLOWING SECTION HIGHLIGHTS ALL NOMINATED PUBLICATIONS AND WORKS WORTHY OF DISTINCTION. THE WINNERS OF THE* ***BEST PAPER AWARD*** *WILL BE ANNOUNCED AT THE COMPUTER GRAPHICS NIGHT EVENT.*

# PANEL OF JUDGES
## BEST PAPER AWARD

### THE JUDGING PROCESS

The chair of the independent panel of judges receives forty selected papers for the Visual Computing Cluster in 2022 considered to be the best by the Fraunhofer IGD competence center heads and the professors of affiliated university groups. These papers span a wide range of research fields, including human computer interaction, computer graphics, computer vision, modeling, visual search and analysis and visual inference, medical computing and simulation.

The first task is to classify the papers into categories according to their impact on business, science, or society. Each paper is initially ranked by each judge based on three scores: 1) how relevant the paper is to the corresponding category, 2) the quality of the paper, and 3) how familiar the judge is with the topic (confidence value).

In the second step, scores for all papers are collected from all the judges, and the papers are each assigned to at least one category. Then the three best-ranked papers within an individual category are nominated. In addition, any papers that score at least one 'outstanding' grading by one of the judges are nominated.

Finally, the judges meet to discuss all nominated papers.
Two papers are selected as 'honorable mention' papers and one paper is selected as the 'best paper' for each of the categories.

### THE JUDGES

*Prof. R. Klein*
*Univ. Bonn (chair)*

*Prof. J. Gall*
*Univ. Bonn*

*Prof. Marcus Magnor,*
*TU Braunschweig*

*Prof. H. Müller*
*TU Dortmund*

*Prof. H. Lentsch*
*Univ. Tübingen*

### THE PRIZE

The honorable mentions and the best paper authors receive a certificate. The authors of the best paper in the categories "Impact on business," "Impact on science," "Impact on society" also receive a book and a monetary prize.

# FINAL NOMINATIONS

## BEST PAPER AWARD

# IMPACT ON BUSINESS

Fang, Meiling (Fraunhofer IGD / TU Darmstadt GRIS)
Damer, Naser (Fraunhofer IGD / TU Darmstadt GRIS)
Boutros, Fadi (Fraunhofer IGD / TU Darmstadt GRIS)
Kirchbuchner, Florian (Fraunhofer IGD / TU Darmstadt GRIS)
Kuijper, Arjan (Fraunhofer IGD / TU Darmstadt MAVC)
**Cross-database and Cross-attack Iris Presentation Attack Detection Using Micro Stripes Analyses**

Terhörst, Philipp (Fraunhofer IGD / TU Darmstadt GRIS)
Fährmann, Daniel (Fraunhofer IGD / TU Darmstadt GRIS)
Damer, Naser (Fraunhofer IGD / TU Darmstadt GRIS)
Kirchbuchner, Florian (Fraunhofer IGD / TU Darmstadt GRIS)
Kuijper, Arjan (Fraunhofer IGD / TU Darmstadt MAVC)
**On Soft-Biometric Information Stored in Biometric Face Embeddings**

Boutros, Fadi (Fraunhofer IGD / TU Darmstadt GRIS)
Damer, Naser (Fraunhofer IGD / TU Darmstadt GRIS)
Fang, Meiling (Fraunhofer IGD / TU Darmstadt GRIS)
Kirchbuchner, Florian (Fraunhofer IGD)
Kuijper, Arjan (Fraunhofer IGD / TU Darmstadt MAVC)
**MixFaceNets: Extremely Efficient Face Recognition Networks**

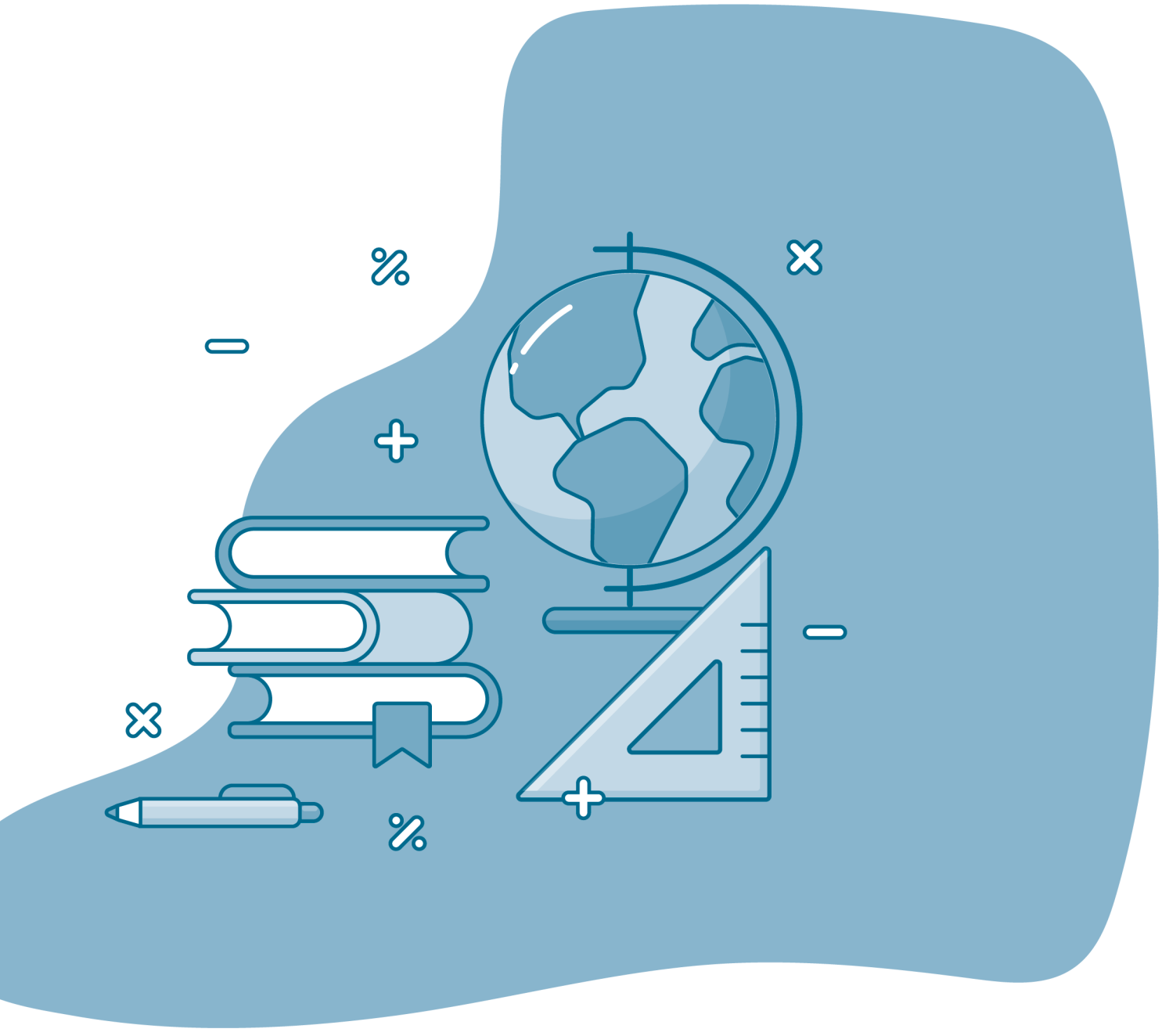
Kutlu, Hasan (Fraunhofer IGD)
Ritz, Martin (Fraunhofer IGD)
Santos, Pedro (Fraunhofer IGD)
Fellner, Dieter W. (Fraunhofer IGD / TU Darmstadt GRIS / TU Graz CGV)
**Fully Automatic Mechanical Scan Range Extension and Signal to Noise Optimization of a Lens-Shifted Structured Light System**

Boutros, Fadi (Fraunhofer IGD / TU Darmstadt GRIS)
Damer, Naser (Fraunhofer IGD / TU Darmstadt GRIS)
Kirchbuchner, Florian (Fraunhofer IGD)
Kuijper, Arjan (Fraunhofer IGD / TU Darmstadt MAVC)
**Self-restrained Triplet Loss for Accurate Masked Face Recognition**

Suschnigg, Josef (Pro2Future Graz)
Mutlu, Belgin (Pro2Future Graz)
Koutroulis, Georgios (Pro2Future Graz)
Sabol, Vedran (Know-Center GmbH Graz)
Thalmann, Stefan (Univ. of Graz)
Schreck, Tobias (TU Graz CGV)
**Visual Exploration of Anomalies in Cyclic Time Series Data with Matrix and Glyph Representations**

# FINAL NOMINATIONS

## BEST PAPER AWARD



# IMPACT ON SCIENCE

Altenhofen, Christian (Fraunhofer IGD)
Ewald, Tobias (Fraunhofer IGD)
Stork, André (Fraunhofer IGD)
Fellner Dieter W. (Fraunhofer IGD / TU Darmstadt GRIS / TU Graz CGV)
**Analyzing and Improving the Parameterization Quality of Catmull-Clark Solids for Isogeometric Analysis**

Guthe, Stefan (TU Darmstadt GRIS)
Thürck, Daniel (NEC Laboratories)
**Algorithm 1015: A Fast Scalable Solver for the Dense Linear (Sum) Assignment Problem**

Zhang, Alex (Fraunhofer Singapore)
Chen, Kan (Fraunhofer IGD)
Johan, Henry (Nanyang Technological Univ., Singapore)
Erdt, Marius (Fraunhofer Singapore / Nanyang Technological Univ., Singapore)
**High-performance Adaptive Texture Streaming and Rendering of Large 3D Cities**



Brunton, Alan (Fraunhofer IGD)
Abu Rmaileh, Lubna (Fraunhofer IGD / NTNU, Norway)
**Displaced Signed Distance Fields for Additive Manufacturing**

Araslanov, Nikita (TU Darmstadt Visual Inference)
Roth, Stefan (TU Darmstadt Visual Inference / Hessian.AI)
**Self-supervised Augmentation Consistency for Adapting Semantic Segmentation**

Hesse, Robin (TU Darmstadt)
Schaub-Meyer, Simone (TU Darmstadt)
Roth, Stefan (TU Darmstadt Visual Inference)
**Fast Axiomatic Attribution for Neural Networks**

# FINAL NOMINATIONS

## BEST PAPER AWARD

# IMPACT ON SOCIETY

Fang, Meiling (Fraunhofer IGD / TU Darmstadt GRIS)
Damer, Naser (Fraunhofer IGD / TU Darmstadt GRIS)
Boutros, Fadi (Fraunhofer IGD / TU Darmstadt GRIS)
Kirchbuchner, Florian (Fraunhofer IGD / TU Darmstadt GRIS)
Kuijper, Arjan (Fraunhofer IGD / TU Darmstadt MAVC)
**Cross-database and Cross-attack Iris Presentation Attack Detection Using Micro Stripes Analyses**

Burmeister, Jan (Fraunhofer IGD)
Bernard, Jürgen (Univ. of Zurich)
Kohlhammer, Jörn (Fraunhofer IGD / TU Darmstadt GRIS)
**LFPeers: Temporal Similarity Search in Covid-19 Data**

Terhörst, Philipp (Fraunhofer IGD / TU Darmstadt GRIS)
Fährmann, Daniel (Fraunhofer IGD / TU Darmstadt GRIS)
Damer, Naser (Fraunhofer IGD / TU Darmstadt GRIS)
Kirchbuchner, Florian (Fraunhofer IGD / TU Darmstadt GRIS)
Kuijper, Arjan (Fraunhofer IGD / TU Darmstadt MAVC)
**On Soft-Biometric Information Stored in Biometric Face Embeddings**

Matthies, Denys J. C. (Technical Univ. of Applied Sciences Lübeck)
Haescher, Marian (Fraunhofer IGD)
Chodan, Wencke (Fraunhofer IGD)
Bieber, Gerald (Fraunhofer IGD)
**DIY-PressMat: A Smart Sensor Mat for Posture Detection Applicable for Bed-exit Intention Detection, Pressure Ulcer Prevention, and Sleep Apnea Mitigation**

Terhörst, Philipp (Fraunhofer IGD / TU Darmstadt GRIS)
Kolf, Jan Niklas (Fraunhofer IGD / TU Darmstadt GRIS)
Huber, Marco (Fraunhofer IGD / TU Darmstadt GRIS)
Kirchbuchner, Florian (Fraunhofe IGD / TU Darmstadt GRIS)
Damer, Naser (Fraunhofer IGD / TU Darmstadt GRIS)
Morales, Aythami (Univ. Autonoma de Madrid)
Fierrez, Julian (Univ. Autonoma de Madrid)
Kuijper, Arjan (Fraunhofer IGD / TU Darmstadt MAVC)
**A Comprehensive Study on Face Recognition Biases Beyond Demographics**

González, Camila (TU Darmstadt GRIS)
Gotkowski, Karol (TU Darmstadt GRIS)
Bucher, Andreas (Univ. Hospital Frankfurt)
Fischbach, Ricarda (Univ. Hospital Frankfurt)
Kaltenborn, Isabel (Univ. Hospital Frankfurt)
Mukhopadhyay, Anirban (TU Darmstadt GRIS)
**Detecting When Pre-trained nnU-Net Models Fail Silently for Covid-19 Lung Lesion Segmentation**

# BEST INDUSTRIAL PROJECT AWARD



*THE WINNERS OF THE **BEST INDUSTRIAL PROJECT AWARD** WILL BE ANNOUNCED AT THE COMPUTER GRAPHICS NIGHT EVENT.*

# PANEL OF JUDGES

## BEST INDUSTRIAL PROJECT AWARD

### THE JUDGES

*Dr. M. Unbescheiden*
*Fraunhofer IGD*

*Dr. S. Wesarg*
*Fraunhofer IGD*

*P. Santos*
*Fraunhofer IGD*



### THE JUDGING PROCESS

The judges call for nominations for the Best Industrial Project Award. The submitted entries are evaluated in terms of economic criteria, such as project value/scope, the potential for follow-up projects, and technologies developed for other departments. Other aspects, including customer satisfaction, innovation, and utilization of publicly funded projects, are also taken into account.

### THE PRIZE

Up to three winning projects receive a certificate and monetary prizes for their competence center.

visual
virtual
digital

*OUR THANKS*
*TO OUR COLLEAGUES*
*FOR THEIR*
*EXCELLENT WORK AND*
*OUTSTANDING ACHIEVEMENTS*

## Venue (Live Broadcast)

Fraunhofer Institute for
Computer Graphics Research IGD
Fraunhoferstrasse 5
64283 Darmstadt, Germany

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# IMPRESSUM

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# SAVE THE DATE:

## COMPUTER GRAPHICS NIGHT
THURSDAY, NOVEMBER 30, 2023

COMPUTER GRAPHICS NIGHT
Thursday, December 01, 2022