We Are the Fraunhofer ITWM

Department “Image Processing”

Mathematical Models and Image Analysis Algorithms for Industry

The “Image Processing” department develops mathematical models and image analysis algorithms and converts these into industrial software, primarily for demanding surface inspections in production and for the analysis of microstructures.

The software required for image processing and analysis and system integration is developed in-house. Some software products have been maintained and marketed for more than 15 years. The available range of methods is constantly being expanded and improved.

Since 2016, domain-specific machine learning algorithms have also been developed, as well as methods for training them in a comprehensible, efficient and consistent manner. Optical and light microscopic images are generated in our own laboratory, 3D images and time series of 3D images using the department’s computer tomograph.

The scientific foundations include mathematical morphology, discrete geometry and topology, stochastic geometry, computer graphics and quantum computing.

www.itwm.fraunhofer.de/en/bv

Department “Financial Mathematics”

Methodological Competence in Financial Mathematics, Stochastics and Data Science

The “Financial Mathematics” department focuses on the business areas “Life Insurance”, “Settlement Audit” and “Flexible Loads in the Energy Industry”.

Its applications range from the classification of pension products and the support of digital business processes to risk controlling in the energy sector. The business areas are strengthened by a flexible modular system of research focuses.

Currently, this includes the modules of financial and actuarial mathematics, statistics, Machine Learning (ML), data science, stochastic simulation, time series analysis and quantum computing. In addition to long-standing research focuses, a strong network of national and international partners and collaborations has been established, particularly in the still young research area of quantum computing.

The department also includes the junior research group “Decision support for business processes using new AI methods”.

www.itwm.fraunhofer.de/en/fm

Division “High Performance Computing”

Innovation, Disruption and Holistic Thinking in the World of Distributed Computing

Simulations and calculations are the basis for many industrial and scientific applications. Increasingly stringent requirements mean that the complexity of hardware and software is constantly growing. This development requires new methods and solutions for high-performance computing and forms the scientific basis of the department.

The distribution of data and the communication of computing units play an important role in the efficient and high-performance execution of highly parallel calculations. Efficiency also plays a central role in the development of new processor and system architectures, in the development of tools and applications for quantum and neuromorphic computing, in finding optimized models for artificial intelligence and in the control of energy flows in the field of renewable energies.

The department is also the central point of contact for the optimization of algorithms in various domains and in particular in the field of seismic data processing.

www.itwm.fraunhofer.de/en/hpc

Department "Materialcharacterization and Testing"

Seeing through With Millimeter, Terahertz and Optical Waves

The "Materialcharacterization and Testing" (MC) department develops and builds industrial-grade systems for non-destructive testing using electromagnetic waves in the spectral range from visible light to radar frequencies. The necessary laser sources, electronic circuits, emitters and detectors, particularly in the terahertz and radar range, are partly developed and improved in-house. The necessary scientific foundations include lithographic know-how (2D and 3D structuring), in-depth knowledge of linear and non-linear optics, laser physics and quantum optics.

The department is an international leader in the development of model-based evaluation algorithms for layer thickness measurement and tomography with a priori information, which allow the reliable detection of defects in the volume. With the realization of the principle of measurement with undetected photons in the terahertz range, the department has broken new scientific ground, which in the long term will make it possible to dispense with the detection of terahertz waves in general. With the development of the first laser-based optical FMCW radar, the thickness measurement of cathode and anode layers in battery production has also been achieved for the first time.

www.itwm.fraunhofer.de/en/mc

Division "Mathematics for Vehicle Engineering"

Simulation-Supported Development and Production Optimization

The "Mathematics for Vehicle Engineering" (MF) division is divided into two departments, "Dynamics, Loads and Environmental Data" (DLU) and "Mathematics for the Digital Factory" (MDF), as well as the Tire Simulation project group and the MF Technical Center cross-sectional unit, which is responsible for testing and measurement technology.

The "DLU" department develops methods and tools for system simulation, taking into account environmental data and usage variability. In particular, the vehicle development attributes of operational stability, reliability, energy efficiency and ADAS/AD as well as the development of sustainable mobility solutions are addressed. In line with this, there is research and development in the area of vehicle-environment-human interaction and tire modeling and simulation. The "MDF" department bundles the activities for the development of software tools for virtual product development and creation.

www.itwm.fraunhofer.de/en/mf

Division “Optimization”

Interactive Decision Support Based on Models and Data

The “Optimization” (OPT) division comprises the three departments “Optimization in the Life Sciences” (OPT-LS), “Optimization – Operations Research” (OPT-OR) and “Optimization – Technical Processes” (OPT-TP). “OPT-LS” develops and provides innovative and customized mathematical-methodological approaches as well as software solutions and services for various fields of application in medicine, healthcare and social services, medical and bioprocess engineering.

“OPT-OR” develops individual (software) solutions for strategic, tactical and organizational issues in production and process planning with the declared aim of providing decision-makers from industry and society with tools for weighing up conflicting planning objectives.

“OPT-TP” deals with multi-criteria decision support based on modeling, simulation and optimization of technical processes in various manufacturing industries.

www.itwm.fraunhofer.de/en/opt

Department “Flow and Material Simulation”

Industrially Applicable Multi-Scale Simulation and Customized Software Solutions

The “Flow and Material Simulation” (SMS) department develops models, efficient solution methods and software for industrial problems of fluid and solid mechanics, heat conduction and electrochemistry, including fluid-structure interaction, reaction-convection-diffusion and multiphysics tasks, in heterogeneous media.

The “SMS” department thus offers expert research and development support in modelling, simulating and optimizing the production, function and application behaviour of porous and composite materials. It creates simulation-based digital twins down to the material level in order to sustainably improve your production processes (infiltration, foaming, pressing, etc.) and your product development (e.g. filters, batteries, textiles, lightweight components) as well as to quantitatively evaluate raw material and energy balances.

www.itwm.fraunhofer.de/en/sms

Department "System Analysis, Prognosis and Control"

Analysis and Prediction of Complex System and Process Behavior

The "SYS" department develops mathematical methods for the resource-optimized real-time operation of components, drives and systems. Areas of application include the energy sector and industrial production facilities in plant and mechanical engineering. The scientific issues include the development of real-time, multivariate signal analysis methods and ML algorithms, in particular deep neural networks, as well as their hardware connection and integration for condition monitoring and predictive maintenance.

In addition, "SYS" develops model- and data-based methods for the predictive control of drives and production systems with the target variables of quality, quantity and use of resources. The scientific challenges here lie in low data availability, data and information gaps and complex process diversity.

www.itwm.fraunhofer.de/en/sys

Department "Transport Processes"

Mathematical Modelling, Simulation and Optimization of Transport Processes

The core competence of the "Transport Processes" department is the mathematical modeling of complex industrial problems and the development of efficient algorithms for their numerical solution. The problems are located in a technical and scientific context (fluid dynamics, heat and radiation transport, structural mechanics, etc.) and, from a mathematical point of view, lead to differential equations, which in many cases can be characterized as transport equations. For years, the department has continuously pursued two scientific focal points with strong unique selling points: the mathematical modelling, simulation and optimization of the dynamics of threads, fibres and filaments and the development of the grid-free continuum mechanical simulator MESHFREE. In addition, new research topics are constantly being taken up with university partners.

One example is the transient simulation, optimization and control of energy and supply networks. Fluid dynamic shape optimization is an important topic for the future and one in which we have already built up considerable expertise.

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