Fraunhofer
IVI

FRAUNHOFER INSTITUTE FOR TRANSPORTATION AND INFRASTRUCTURE SYSTEMS IVI

INSTITUTE REPORT 2019

FRAUNHOFER INSTITUTE FOR TRANSPORTATION AND INFRASTRUCTURE SYSTEMS IVI

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Director
Prof. Dr. Matthias Klingner

THE ART OF RESEARCH

In Leonardo da Vinci's time, there would have been no need for a further interpretation of our annual report's motto. »Art« referred to all things that humans produced through their creative efforts and actions in the ancient times. From the canon of the »seven liberal arts«, namely arithmetic, geometry, logic, rhetoric, grammar, the theory of music and astronomy, which marked the beginnings of our scientific thinking, to medicine and midwifery, the art of living or Ovid's art of love, and further on to craftsmanship and the art of mining – countless examples of art in almost all areas of life can be found throughout the ages. According to the values at the time, the art of engineering, which is the core of our daily work here at Fraunhofer, would have been classified as one of the »mundane«, »unholy« arts. But being down-to-earth, not following an elitist cult or a dogmatic zeal, is exactly what has made our institute so successful in these recent years. The Fraunhofer IVI is extremely well set up for the years to come – this is not only evident from the current revenues, but also from the unanimous vote by the auditors of the strategy process that was successfully concluded in 2019.

Nevertheless, the potential of industry-oriented research must be regarded as ambivalent in the light of the current economic situation. At times, it seems to be a sacrilege to openly question highly charged societal developments, and yet, it cannot be disregarded that especially in Germany, important industry sectors are undergoing profound transformation processes whose serious outcomes are hard to predict. Even as pristine nature is currently experiencing a renaissance as an alternative to the world created by humans, wealth, security and justice are precious assets that bring about economic growth and constitute social cohesion within society.

With its mobility-related topics, widely applied technologies for the consolidation of national civil security and contributions for the development of rural areas, the Fraunhofer IVI is at the heart of this societal transformation. As a result of these exciting scientific and technological challenges and the excellent business resulting from this development, the need to recruit new highly qualified staff arises. The founding of an application center at TH Ingolstadt, the renovation of the Dresden institute's west wing and the close university cooperation with TU Dresden – these are favorable preconditions for meeting the two core targets set during the strategy process: improving the environment for research excellence at the institute and continuing its successful economic development.

In our modern language use, the term »art« is reserved for objects and actions of an edifying nature that can be subsumed under the label of »fine arts« coined in the Age of Enlightenment. With this in mind, I take pleasure in sincerely thanking my colleagues for all that has been so successfully achieved this past year. Concluding with a quote by Goethe's Faust: »Come, no more words – but let us something do«, I hope all inclined readers will enjoy this year's institute report.

CONTENTS

FRAUNHOFER IN DRESDEN

Five institutes and five additional research institutions with a total of 2260 employees and an annual turnover of more than 240 million euros (2018) represent the Fraunhofer-Gesellschaft in Dresden.

INSTITUTES

- Fraunhofer Institute for Ceramic Technologies and Systems IKTS
- Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP
- Fraunhofer Institute for Material and Beam Technology IWS
- Fraunhofer Institute for Photonic Microsystems IPMS
- Fraunhofer Institute for Transportation and Infrastructure Systems IVI

BRANCHES AND RESEARCH INSTITUTIONS

- Dresden branch of the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Bremen
- Division EAS (Engineering of Adaptive Systems) of the Fraunhofer Institute for Integrated Circuits IIS, Erlangen
- Dresden branch of the Fraunhofer Institute for Machine Tools and Forming Technology IWU, Chemnitz
- Division Processing Technology of the Fraunhofer Institute for Process Engineering and Packaging IVV, Freising
- Project Group ASSID (All Silicon System Integration Dresden) of the Fraunhofer Institute for Reliability and Microintegration IZM, Berlin

FRAUNHOFER-GESELLSCHAFT

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

At present, the Fraunhofer-Gesellschaft maintains 74 institutes and research units. The majority of the more than 28,000 staff are qualified scientists and engineers, who work with an annual research budget of more than 2.8 billion euros. Of this sum, over 2.3 billion euros is generated through contract research. Around 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Around 30 percent is contributed by the German federal and state governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

International collaborations with excellent research partners and innovative companies around the world ensure direct access to regions of the greatest importance to present and future scientific progress and economic development.
With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies, and helping to train the urgently needed future generation of scientists and engineers.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry and in society. Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

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

FRAUNHOFER IVI

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The complete list of international partners can be found on the website:
s.fhg.de/partner-international

PARTNERS

- Research organizations and universities
- Industry and economy
- Public institutions
- Transport associations and providers
- Energy suppliers

IN ALLIANCES

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Alliance Manager
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ACADEMIC COOPERATION

- Technische Universität Dresden
- Technische Universität Bergakademie Freiberg
- Technische Hochschule Ingolstadt
- University of Nevada, Las Vegas, USA

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APPLICATION CENTER

Connected Mobility and Infrastructure

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FACILITIES AND LARGE EQUIPMENT

- Vehicle hall with adjacent test track
- Test vehicles and demonstrators
- Measurement technology
- Test rigs

Software for
- Simulation
- Big data
- 3D construction
- GIS

COMPETENCIES

Digital business processes

Autonomous utilities systems

Propulsion technologies

Ticketing and fares

Logistics

Identification of traffic situations

Transportation ecology

Mobility and travel assistance

Sensor and actuator systems

Electromobility

Vehicle and road safety

Autonomous systems

Vehicle technologies

Multi-axle steering and guidance systems

Intelligent transport systems

System modeling and process control

Stationary energy storage systems

Civil security

Vehicle connectivity

Transport planning

ADVISORY BOARD

MEMBERS *(as of 2019)*

Burkhard Ehlen,
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Hochschule Ruhr West

Mario Herber,
Senior Chief Superintendent
Commanding Officer of the Special Task Force Saxony,
Saxon State Office of Criminal Investigation

MinR Hans-Peter Hiepe,
Manager of the project group »Agency for disruptive innovations«,
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German Aerospace Center e. V. (DLR)

Lars Seiffert,
Board of Operations and Human Resources,
Dresdner Verkehrsbetriebe (DVB) AG

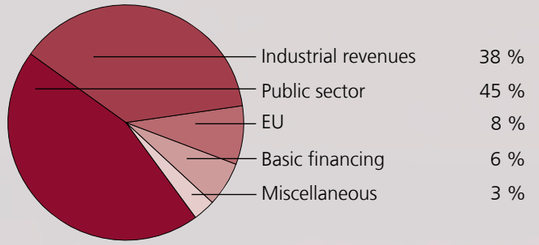
Carsten Utikal,
Consultant – Federal-State-Research Institutions,
Saxon State Ministry of Science, Culture and Tourism (SMWK)

CHAIRMAN

Prof. Dr.-Ing. Christian Lippold, Chair of Road Planning and Road Design,
Institute of Transport Planning and Road Traffic, »Friedrich List« Faculty of Transport and Traffic Sciences, TU Dresden

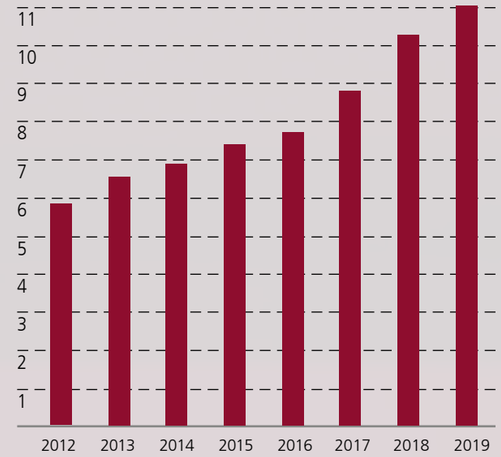
ECONOMIC DEVELOPMENT

OPERATING BUDGET



FINANCIAL DEVELOPMENT

in € million



EMPLOYEES

113	84	7	22
Research fellows	Research assistants	Trainees	Administrative and technical staff

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RANGE OF SERVICES

- Design and dimensioning of electric powertrains in commercial and special-purpose vehicles
- Implementation concepts for electric buses
- Fast-charging concepts for electric vehicles
- Electrification and automation of agricultural machinery
- Characterization and monitoring of energy storage systems/high-voltage batteries

- Control center for autonomous driving in yards
- Fully automated maneuver planning for heavy goods vehicles

- Analyses, surveys and development work in the field of vehicle and traffic safety
- Monitoring and analysis of technical systems
- Functional safety of commercial vehicles (ISO 26262)

AutoTruck – Autonomous, Connected, Electric

Highly and fully automated driving is a megatrend within the entire automotive sector. In this context, the AutoTruck project provides groundbreaking insights and technologies for autonomous driving in yards.

The automation of commercial vehicles in secured areas is an ideal migration path. These so-called automation zones cover areas that are equipped with specific automated driving infrastructure. Among others, this infrastructure includes communication technologies, digital maps, monitoring systems and a control center that processes all data generated within the automation zone.

Based on this information and the control center's HMI, users will be able to efficiently control and monitor more than ten autonomous vehicles during their completion of tasks. No human drivers will be required in the automation zones. Depending on the application scenario, drivers will take over the vehicles only if they need to exit the automation zone.

The areas of application are diverse and include transport tasks in logistics centers, ports, airports, as well as tasks in agriculture and construction. Trucks, swap bodies and trailers in depots can be moved fully automatically from their parked positions to the loading bays, and several machines can work cooperatively on fields.

In public transport, on the other hand, the challenges are significantly higher, especially in terms of safety. Therefore, practical application in this area can be expected in the long term rather than the medium term.

In the past three years, the Fraunhofer IVI has developed several key technologies for automation zones. These include the TruckTrix® maneuver planning algorithm, the HelyOS control center, and the AutoTruck itself. TruckTrix® calculates manageable paths for vehicles with and without trailers within a matter of minutes. This eliminates the necessity of setting routes in advance and creates the option of calculating optimal paths in real time based on the requirements of current situations.

The HelyOS control center is the automation zone's command center. Here, users can see which autonomous vehicles are currently available in the yard. Then they can create missions with only a few mouse clicks, send them to the vehicles and monitor the progress. The vehicles complete the missions independently and in an intrinsically safe way. Users only need to set the sequence of driving tasks which are then carried out fully automatically by TruckTrix® and other systems.

The Fraunhofer IVI has assembled the AutoTruck as a demonstrator vehicle that can be operated fully automatically. It is equipped with steer-by-wire and drive-by-wire systems, environment sensors and positioning systems.

INTELLIGENT TRANSPORT SYSTEMS

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RANGE OF SERVICES

- Testing of connected automated driving within the Digital Test Bed Dresden/Saxony
- V2X communication, roadside units, C-ITS facilities
- Traffic detection, information and management
- Information and navigation applications
- Data/semantic technologies for mobility services
- Mobile apps, applications for frontend, backend, cloud
- Fare-based solutions for conventional, electronic and mobile ticketing

With the help of data space concepts, Mobility Data Space merges local, regional and national data platforms into one mobility data ecosystem that for the first time allows safe data processing while simultaneously guaranteeing data sovereignty.

In the years to come, mobility solutions will increasingly adapt to the individual demands of travelers, e. g., through new on-demand mobility services and autonomous vehicles in private and public transport. Real-time traffic data and data about travelers' requirements and the availability of services provide the basis for these new offers. Secure and sovereign data supply, as well as protected data processing in distributed systems, will be essential success factors for tomorrow's mobility solutions.

The Mobility Data Space project initiates the establishment of a national mobility data ecosystem. To this end, the Mobilitäts Daten Marktplatz (Mobility Market Place, MDM) of the Bundesanstalt für Straßenwesen (Federal Highway Research Institute, BASt) and further local transportation data platforms will be extended to include industrial data space (IDS) connectors. These connectors are protected environments that run software modules for the exploitation of mobility data. A usage control mechanism ensures that the software modules process the data only in the way intended by the data providers.

This way, it is possible for the first time to provide mobility data in a secure and competent way, while simultaneously ensuring that data sovereignty remains exclusively with the data providers. Because of this feature, the platforms offer a high level of privacy and are more attractive to data providers. The different data platforms will be connected with the help of data space concepts so that regional data can be accessed and processed on a national level. In addition, it will be possible to integrate cloud resources in the data space in order to carry out secure, extensive mobility data analyses and mergers in big data analytics scenarios.

Within the project, new local traffic data and nation-wide mobility data will also be harvested from Deutsche Telekom's vehicle fleets and mobile network. For the first time, this data will be provided to the platforms for secure processing in novel data-driven business models.

Fraunhofer scholars contribute to the project their experience in the field of mobility data and platforms, as well as their expertise on the industrial data space. Furthermore, they support their partners in the development and improvement of data platforms and services. It is planned to disseminate the Mobility Data Space via the International Data Spaces Association, which currently unites over 100 members from industry and science working on the application of data space concepts.

Mobility Data Space: Merge – Refine – Utilize

STRATEGY AND OPTIMIZATION

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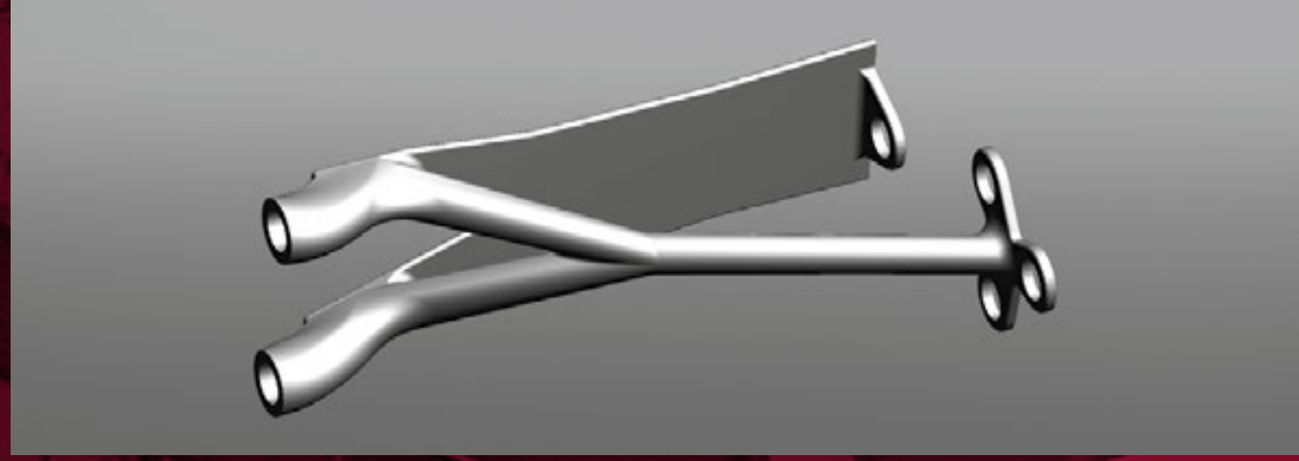

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RANGE OF SERVICES

- Operational command systems for firefighters, emergency service providers, civil protection services and police
- Analyses for the planning of fire control requirements and rescue service zones, as well as site optimization
- Evaluation of manufacturing processes with the help of AI methods
- Big/smart data-based data mining and machine learning
- Integrated cargo space and production planning
- Predictive analysis/condition-based maintenance planning

AMCOCS – 3D Component Certification in Aerospace

Making air-borne traffic safer is the declared aim of the AMCOCS project. To achieve this, artificial intelligence and big data services are utilized to accelerate testing and certification methods for components in additive manufacturing.

Additive manufacturing processes offer completely new approaches in terms of components design and production. The currently existing quality assurance procedures are extremely lengthy and expensive, which is an impediment to their broad application. Registering an additive manufacturing component for the aerospace sector takes about 1.5 years, during which the manufacturer has to complete a number of different certification tests and provide about 600 test specimens. Currently, the sector pursues the approach of registering the entire additive manufacturing process instead of the individual components. However, this approach also takes about 1.5 years and up to 2500 test specimens. In contrast to conventional formative and subtractive manufacturing processes, additive manufacturing lacks the empirical data and experience necessary to predict the quality of components.

The development of a digital, self-learning testing and certification platform that combines all data produced during additive manufacturing, post-processing and material parameter detection will accelerate the registration procedure by a factor of 3.

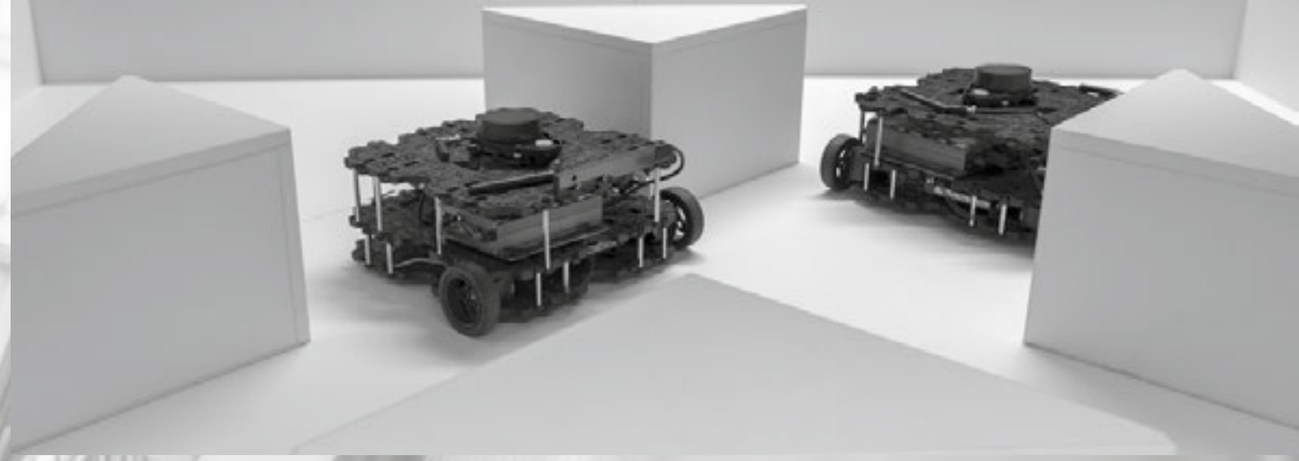
The platform continuously compares historical data with newly generated data and detects anomalies and deviations from the standard with the help of artificial intelligence, so that possible defects can be avoided through proactive alterations. This way, it is possible to make reliable prognoses not only about the quality of the printed components but also about the quality of the entire manufacturing process even before the start of printing.

Big data technologies enable real-time quality assurance and the digital experience gained ensures good reproducibility.

This way, the registration of a component produced through additive manufacturing will be reduced to approximately five months. In addition, through continuously growing data resources, the reduction of the registration costs by a factor of 2 seems realistic. This means that in an ideal scenario, the duration of the testing and certification process can be shortened by two thirds and the costs can be halved.
In addition, AMCOCS lays the groundwork for a new, data-driven business model.

Towards the end of the project term, the platform will be piloted as a prototype within the highly regulated aerospace industry sector.

FRAUNHOFER APPLICATION CENTER



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The idea to establish a Fraunhofer Application Center at the TH Ingolstadt (THI) was initiated by the presidents of both organizations, Prof. Dr. Walter Schober and Prof. Dr. Reimund Neugebauer. Following talks with the Fraunhofer executive board at the THI in October of 2016, the project has been systematically promoted. In December of 2016, a meeting was held at the Fraunhofer IVI to discuss potential topics for cooperation. During a visit in Ingolstadt on June 26th, 2018, the Bavarian Minister-President Markus Söder officially announced that a new application center for »Connected Mobility and Infrastructure« will be established at the THI under the coordination of the Fraunhofer Institute for Transportation and Infrastructure Systems IVI.

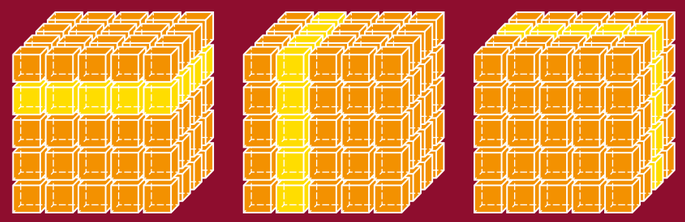
Since December of 2019, the new structural unit of the Fraunhofer IVI has been dealing with current and future topics of automated and cooperative driving maneuvers. By means of roadside protection systems and a high-performance car-2-infrastructure communication, their goal is to reduce safety risks of partially and fully automated traffic flows and make traffic more efficient in general. Diverse competencies in the fields of sensor technology, communication and artificial intelligence are combined, fostering synergies with the local industry and aiming for close cooperation with the city of Ingolstadt and its partners.

During a five-year start-up phase, which is supported by the Free State of Bavaria with funds of 2.5 million euros, the application center will acquire a team of 15 scientists and develop an efficient research infrastructure. The center will also establish cross-disciplinary collaboration with the THI's research units, including the »Center of Automotive Research on Integrated Safety Systems and Measurement Area« (CARISSMA) and the »Institute of Innovative Mobility« (IIMo) as well as the »Artificial Intelligence Network Ingolstadt GmbH« (AININ). Existing research infrastructures at the THI and the Fraunhofer IVI, as well as the planned urban test field for intelligent mobility IN2LAB in Ingolstadt, will serve as a basis for the application center with its profile defined by the three business units

– Security of infrastructure,
– Traffic control and management and
– Function monitoring of vehicles and infrastructure.

Plans for the coming years include the development of further technology fields in the areas of autonomous systems, digitalization of transport as well as vehicle and road safety.

»Connected Mobility and Infrastructure«



1 *Slices of a third order tensor.*

JUNIOR RESEARCH

INEXACT METHODS FOR THE SOLUTION OF LARGE SCALE HERMITIAN EIGENVALUE PROBLEMS

To improve the understanding of phenomena of physics such as quantum phase transitions, the calculation of extreme eigenvalues of high dimensional quantum systems provides an important basis. For this purpose, a method was developed which is able to deal with an extremely high problem dimension and to calculate eigenvalues close to phase transition.

Quantum systems are collections of interacting particles whose total energy is described by a Hamiltonian. In particular, we are interested in the most stable state with the lowest energy, the so-called ground state. Mathematically, this quantity is represented by the eigenvector corresponding to the smallest eigenvalue of the Hamiltonian.

An important property of quantum systems is that the dimension of the corresponding Hamiltonian grows exponentially with the number of particles considered. Already for 25 particles, the explicit storage of a single vector in the standard format is problematic and conventional solution methods reach their limits. In order to avoid this so-called »curse of dimensionality«, the underlying structure of the eigenvalue problem was exploited. It was assumed that all vectors can be approximated by a tensor format of low rank. This allows the storage of the vectors, but at the cost of an error being induced each time a vector operation is carried out.

To deal with the effects of inexact operations, the so-called compensated Gram-Schmidt method was developed. Compared to standard methods, the orthogonality of the calculated subspace basis is better preserved. To achieve good eigenvalue and eigenvector approximations even in the case of small perturbations, the compensated Gram-Schmidt method is embedded in the inexact Arnoldi method.

The inexact operations influence not only the orthogonality of the calculated Krylov basis, but also the quality of the spectral approximations. This was investigated by a convergence analysis of the inexact Arnoldi method, where a priori and a posteriori results were derived.

Numerical experiments using the YZ model showed that the inexact Arnoldi method using a tensor format is able to solve eigenvalue problems of significantly higher dimensions than it would be possible in a matrix vector setting. However, it also became clear that the accuracy of the inexact Arnoldi method using a low rank tensor format to solve eigenproblems of extremely large dimension depends crucially on the available memory.

These results were obtained within the framework of the »Scalable Numerical Methods for Adiabatic Quantum Preparation« DFG project and were published as part of a dissertation at TU Berlin, Research Group Numerical Mathematics.

With special thanks to my supervisors Prof. Dr. Volker Mehrmann and Dr. Christian Schröder.

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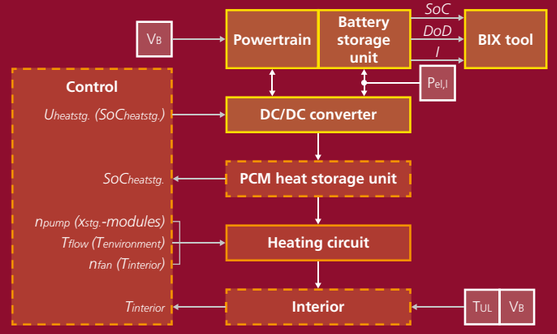

Pel,l – Electric charging capacity
TUL – Surrounding temperature
VB – Speed
— – Power flow
— – Control
– Characteristics given
– Existing el. model
– Existing th. model
– Th. model created

1 *Simulation model of electric bus with sub-models.*

JUNIOR RESEARCH

MODEL AND CONTROL DESIGN OF AN INNOVATIVE HEATING SYSTEM FOR ELECTRIC CITY BUSES

As electric heating systems significantly reduce the range of electric vehicles, conventional diesel generators are still widely used to supply electric buses with sufficient heat in winter. In this diploma thesis, a simulation model for an alternative heating system based on heat storage in a phase change material was created.

In order to achieve zero-emission heating of electric buses without a negative impact on range, the Fraunhofer IVI has developed a fast charging latent heat accumulator system in the course of the Heat2Go project. This heating system is charged at the same time as the traction battery following the opportunity charging principle. A phase change material (paraffin) acts as storage medium, storing heat during its melting process and emitting heat during its solidification. Both processes take place at a constant temperature. A hydraulic heating circuit transfers the heat to the bus interior. This new technology has been demonstrated in the Fraunhofer IVI's fast charging electric bus.

Within the scope of the diploma thesis, a thermal simulation model was created using MATLAB-Simulink. It consists of three sub-models: bus interior, heating circuit and accumulator unit.

Based on this model, a control system for the latent heat accumulator was designed and successfully tested, using the example of a real driving cycle (65 min) with different surrounding temperatures. An additional simulation proved that if the interior target temperature is lowered from 18 °C to 14 °C when outside temperatures drop below -10 °C, the latent heat accumulator is able to meet the heating requirements up to a temperature of -15 °C.

If the storage capacity is dimensioned lower than necessary for maximum heating requirements, the weight and costs of the system can be reduced. Tests carried out in the city of Leipzig investigated whether it is possible to reduce the number of storage modules (1.9 kWh each) from six to four. In order to still guarantee maximum heating performance, the accumulator unit needs to be recharged from the traction battery during the trip. This leads to deeper discharging of the battery. To investigate this extra strain, the model developed was combined with an existing model of an electric bus. With the help of the BIX tool by the Fraunhofer IVI, it was possible to prove that no negative effects on the battery's life are to be expected, and that cost-effective operation at lower heat storage capacity can be achieved.

The thesis was submitted to the Faculty of Mechanical Science and Engineering at TU Dresden.

With special thanks to my reviewers, Prof. Dr.-Ing. Clemens Felsmann and Dr.-Ing. habil. Joachim Seifert, TU Dresden, and my supervisor, Dipl.-Ing. Stefan Kuitunen.

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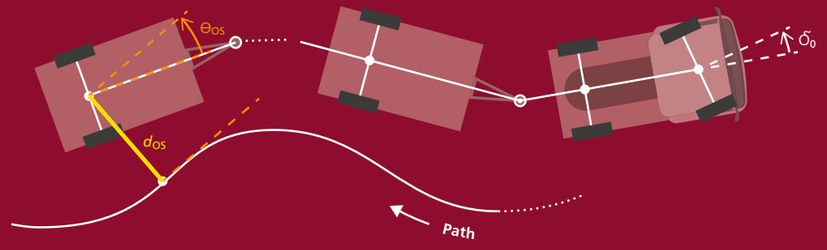

1 *Offset model describing last trailer with respect to the path.*

JUNIOR RESEARCH

REVERSE DRIVE CONTROL SYSTEM FOR SEMITRAILERS AND ROAD TRAINS

Reliable lane guidance is of the highest importance in highly and fully automated driving. This applies in particular to articulated vehicles in the commercial vehicles sector, such as road trains, because reverse driving is especially challenging for them. In the course of this diploma thesis, control algorithms for the reverse driving of different vehicle types were developed.

The thesis investigates the reverse driving process of vehicles with several unsteered trailers from a control technology perspective because this vehicle type needs an appropriate steering system to prevent folding of the individual segments.

Two particular vehicle configurations – more specifically, semitrailers and road trains – were chosen for the study due to the great practical importance of these vehicles types. In addition, the aim was to develop an approach as general as possible, which has, for instance, no limitations in terms of the number of vehicle segments.

A control algorithm that guides the last trailer along a path was developed based on the kinematic model of a generic n-trailer vehicle. The initial approach used was an exact input-output linearization of a path-dependent kinematic vehicle model (Figure 1).

The theoretical investigation of the model showed that vehicle stability depends on the location of the hitch point. Two cases need to be distinguished here. If the coupling is located behind the center of the rear axle, then this control approach is stable for n-segmented vehicles. For all other coupling locations, the control approach is unstable.

Since neither semitrailers nor road trains – which are especially important in practical application – can be controlled by this method, an additional approach was investigated. The aforementioned vehicle structures that are unstable in control can be recalculated into virtual vehicles that fulfil the requirement for stability.

Through this conversion, it was proven that the control algorithm is also able to guide semitrailers and road trains along a path in reverse, provided that the parameters lie within a defined range to ensure stabilty.

The control algorithms developed were validated both in simulations and with the help of scale model vehicles in the Fraunhofer IVI DriveLab – a demonstrator built especially for this purpose. The results will provide the basis for future research.

The findings presented above were submitted as a diploma thesis to the Faculty of Electrical and Computer Engineering at TU Dresden.

With special thanks to Prof. Dr.-Ing. habil. Dipl.-Math. Klaus Röbenack, TU Dresden, and Dipl.-Ing. Gunter Nitzsche, Fraunhofer IVI.

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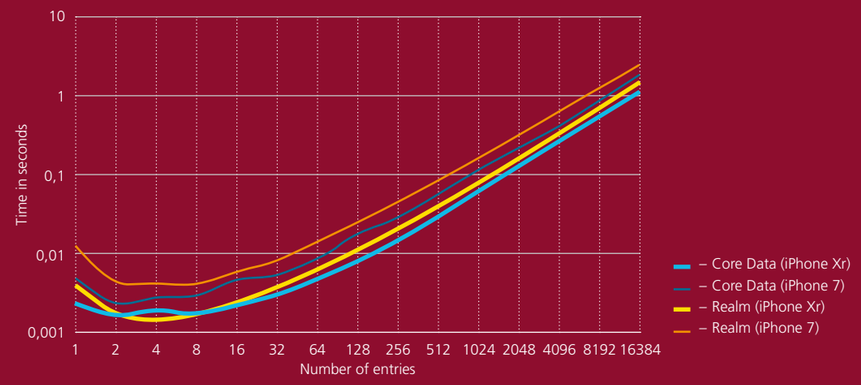

1 *Time of the creation process of new media entries.*

JUNIOR RESEARCH

COMPONENT FOR THE VISUALIZATION OF OPERATIONAL INFORMATION ON MOBILE DEVICES

During firefighting and rescue operations, the efficient exchange of information is essential. Receiving access to related information during their field missions will help emergency personnel to get a better overview of the current situation.

This thesis focuses on the design and development of a module for mobile devices that presents media files, documents and information to emergency personnel in a clear layout, enabling them to retrieve specific data in an efficient way. The finished product is an iOS framework that is able to extend an existing messenger service, as well as any other application that uses the framework's data interface, by an adaptive user interface.

Since the data needs to be accessible at all times even when Internet access is limited, the use of a local database is necessary. An investigative evaluation determined the optimal database framework for the iOS platform. Because the design was supposed to support portability to other platforms such as Android, and the option of using diverse database frameworks was a requirement, a flexible architecture with a highly generic database adapter was designed following the MVVM (Model-View-ViewModel) design pattern.

A preliminary analysis showed that the Core Data framework native to iOS and the Realm framework for Android are most suitable.

In addition to different microbenchmarks that measure the reading and writing speed of a given database framework, a demonstrator app was developed that utilizes the resulting module and provides the implementation in Core Data and Realm. With the help of this app, the fully operable user interface was demonstrated and the performance differences between the database frameworks were analyzed in more detail.

During the course of the evaluation stage, it turned out that Core Data shows the best performance under the given conditions and is thus the favorable choice of local database for the iOS platform. With the help of the Realm framework, on the other hand, portability to Android was proven.

The results presented above were submitted as a Bachelor Thesis to the Faculty of Computer Science at TU Dresden.

I would like to thank my reviewers, Prof. Dr.-Ing. Wolfgang Lehner and PD Dr.-Ing. habil. Dirk Habich, as well as my supervisors, Dipl.-Inf. Alexander Krause, TU Dresden, and Dipl.-Ing. Candy Lohse, Fraunhofer IVI.

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HIGHLIGHTS

February 6, 2019
By invitation of the Saxon State Minister for Economic Affairs, Labour and Transport, a **delegation from the Netherlands** visited Saxony and spent an afternoon at the Fraunhofer IVI.

February 8, 2019
The **AMCOCS project** develops innovative approaches to functional safety in aerospace engineering. The consortium met at the Elbe Flugzeugwerke for the kick-off event.

March 6, 2019
The **Feldschwarm® project** presented its latest results during the intermediate evaluation. The main objective is the development of new concepts for sustainable agricultural machinery.

April 16, 2019
The official opening of the **floating autartec® house**, which features a multitude of visionary technologies, was celebrated with numerous invited guests.

May 21, 2019
Delegates from the **Chinese National New Energy Vehicle Technology Innovation Center** visited the institute with great interest. The main focus of the demonstration was the underfloor charging system.

June 14, 2019
This year, the **Dresden Science Night** took place for the 17th time. With the motto »Stop pillow fights and do science instead!«, the institute attracted many visitors.

June 17, 2019
The **»SIH test and demonstration field«** was launched in Köllitsch, Saxony. Cutting-edge developments in agriculture and forestry, based on novel 5G technologies, will be tested there.

June 21, 2019
The cooperation between Fraunhofer and the police has been further consolidated: a **police messenger system** for regular police service is the subject matter of the collaboration agreement.

June 21, 2019
The Advisory Board meeting of the **Cartox² project** was held this summer. The participants discussed the platform, which serves as the evaluation basis for communication security.

July 9 and July 16, 2019
The **TU Dresden Summer University** offers first insights into campus life to all prospective students interested in the STEM subjects. About 25 high school students came to get to know the institute.

July 11, 2019
With the signing of a cooperation agreement between the Fraunhofer IVI and Sensor-Technik Wiedemann GmbH, the new **Machine Automation Lab** was launched.

August 22, 2019
The **IoT-COMMs** research center of the Fraunhofer Cluster of Excellence »Cognitive Internet Technologies« presented its demonstrators at the Fraunhofer IWU and the Fraunhofer IVI.

August 28, 2019
The **Mobility Data Space** project initiates the building of a national mobility data ecosystem. The Fraunhofer-Gesellschaft hosted the kick-off meeting at the Fraunhofer Institute Center in St. Augustin.

September 2-6, 2019
Under the motto »Managing Change Actively«, Design students and Fraunhofer employees participated in the first **»Fraunhofer Pioneers Challenge«** in the Lausitz region.

September 13, 2019
This year, the Fraunhofer IVI participated in the **JUG Saxony Day** for the first time. More than 550 visitors came to the IT conference to learn about the institute and the digital future in general.

September 27, 2019
A **U.S. delegation** from the **Michigan State University** visited the institute. They were given insights into the areas of fully automated charging and autonomous driving.

October 2, 2019
For his **outstanding performance in Mechanical Engineering** studies, Fraunhofer IVI scientist Pascal Pfitzner was honored during the festive enrolment ceremony of HTW Dresden.

October 9, 2019
The **»Synchrone Mobilität 2023«** initiative has created more visibility for automated and connected driving. The closing event was held together with the project partners at the Dresden airport.

November 26, 2019
The Fraunhofer IVI will support three recipients of the **Deutschlandstipendium scholarship**. The students and their sponsors met for the first time in the TU Dresden banquet hall.

December 10-11, 2019
Experts in the field of »Autonomous Driving – Standardized Virtual Development as a Key to Future Mobility« came together at the **ASAM International Conference** in the Dresden Congress Center.

TRADE FAIRS

Internationale Schwerlasttage IST 2019, Hohenroda
September 13-14, 2019
Presentation of TruckTrix® as a component of the HeavyGoods app for heavy duty transport planning, jointly with CodeSquare

18th FLORIAN – Trade fair for Fire Brigades, Civil Protection and Disaster Control 2019, Dresden
October 10-12, 2019
Demonstration of the modular MobiKat system for firefighting

Bus World Europe, Brussels (Belgium)
October 18-23, 2019
Presentation of a steering system for extra long buses (booth of Hübner GmbH & Co. KG), Heat2Go project presentation (booth of KOVEKTA AG)

iHub Roadshow, Berlin
October 22, 2019
Presentation of the BMWi-funded iHub project at the international supply chain conference

9th Dresden Commercial Vehicle Day at HTW, Dresden
October 25, 2019
Exhibition of the FRAMO electric truck

AGRITECHNICA, Hanover
November 10-16, 2019
Presentation of the BMBF-funded Feldschwarm® project – autonomous field modules for resource-friendly farming

ASAM International Conference 2019, Dresden
December 10-11, 2019
Demonstration of the automated fast charging system and latest developments for cooperative driving

10th VDV-Konferenz Elektrobusse – Markt der Zukunft!, Berlin
February 5-6, 2019
Exhibition of the innovation platform ColumBus with partners of the eBus cluster project

3rd International VDI Conference »Autonomous Trucks«, Munich
March 27-28, 2019
Presentation of the BMWi-funded AutoTruck project

transport logistic 2019, Munich
June 4-7, 2019
Presentation of the BMVI-funded SiGMa project for traffic security in municipalities (ministry booth)

DAK

DRESDEN COLLOQUIA ON AUTOMATION TECHNOLOGY

Supported by the Fraunhofer IVI and several institutes of the Faculty of Electrical and Computer Engineering at TU Dresden, the Dresden Colloquia on Automation Technology (Dresdner Automatisierungstechnische Kolloquien – DAK) has established itself as a high-profile event series with an over 40-year tradition.

The wide range of topics offered covers the entire field of engineering and includes talks on fundamental control and systems theory, applied automation engineering, mechatronics, sensor development, microelectronics and interesting reports from practice-oriented projects.

Talks of renowned experts in the field are the main attraction of the regular events. They are usually accompanied by contributions from the organizing institutes, which underlines the importance of DAK as a specialist communication platform for university institutes, higher education institutions and vocational colleges, non-university research institutes, as well as engineering firms and regional industry.

Altstraßen in Sachsen
February 4, 2019
Dr.-Ing. Bernd Hofmann, Landesverein Sächsischer Heimatschutz e. V.

Hierarchische Trajektorienplanung für kooperative autonome Fahrzeuge
May 13, 2019
Jan Eilbrecht, M. Sc., Universität Kassel

Hierarchische modellprädiktive Regelung eines stationären Wasserstoff-Batterie-Hybridsystems
June 3, 2019
Verena Neisen, M. Sc., RWTH Aachen

Kooperative Trajektorienfolgeregelung in vernetzten ereignisdiskreten Systemen
October 21, 2019
Markus Zgorzelski, M. Sc., Ruhr-Universität Bochum

LIFE AT WORK AND BEYOND

In the light of future technological and societal changes, the institute devotes special attention to topics of security and safety. This is not only reflected in its research projects, but it is a constant concern in the staff's everyday life. The annual health day, therefore, focused on bicycle safety, offering workshops on fall prevention and stability training. The event also included a delight for all »techies«, who were invited to travel through the human body using VR glasses.

Apart from their own physical health, family life is, without a doubt, the most valuable good for all employees. Reconciling it with work life has been an important priority of the Fraunhofer IVI for many years. Support is provided in the form of day care options and a parent-child office, but also by incorporating consulting and coaching in family and diversity matters. These offers are gaining importance for the institute in distinguishing itself from its competitors in the hunt for highly qualified staff.

Digitalization is omnipresent in all areas of life these days. That is just why the opportunities for coming together in the analog world beyond the daily research work are so highly appreciated at the Fraunhofer IVI. For the annual staff outing, the colleagues embarked on a relaxed hike and descended into a mining adit to learn about work underground. Celebrating the Christmas season is also a long-standing tradition at the Fraunhofer IVI, bringing crafts and presents for the little ones as well as mulled wine and a theater performance for the adults. At the same time, the staff not only rejoiced in the celebration of the year's end, but they also gave cheers for their Fraunhofer IVI, which was founded as a transport research institute 20 years ago.

HOW TO REACH US

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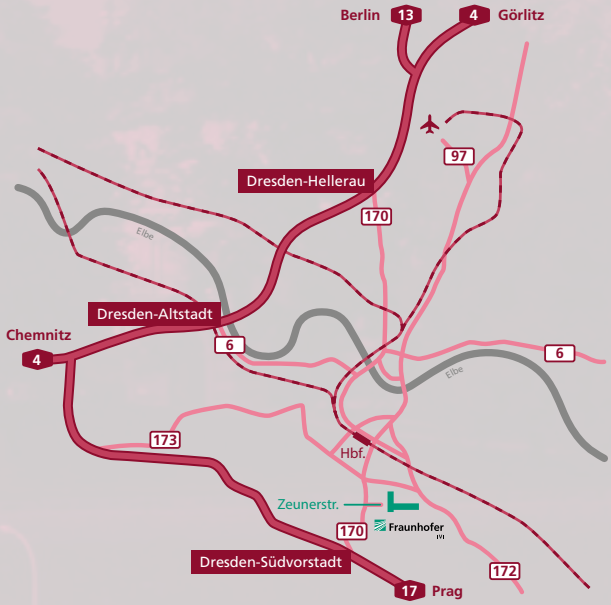

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ACADEMIC OUTPUT

PUBLICATIONS

ARTICLES AND PRESENTATIONS

Abuaisha, T.; Kertzscher, J.: **Fractional-order Modelling and Parameter Identification of Electrical Coils.**
In: Fractional Calculus and Applied Analysis, vol. 22, 2019, issue 1, Berlin, de Gruyter, p. 193-216, ISSN 1314-2224, DOI: 10.1515/fca-2019-0013

Abuaisha, T.; Kertzscher, J.: **Ein Beitrag zur Hysterese-Modellierung mit Hilfe des fraktionalen Ansatzes.** 2. Freiberger Kolloquium Elektrische Antriebstechnik FKEA, Freiberg, Germany, June 6-7, 2019
In: Conference Proceedings. Kertzscher, J. (ed.), Freiberg, Technische Universität Bergakademie Freiberg, 2019, Freiberger Forschungshefte A932 Elektrische Antriebstechnik, p. 7-20, ISBN 978-3-86012-610-3

Auerswald, R.: **OpenSCENARIO Beyond Simulation – Application Methods for Field Testing.** ASAM International Conference 2019, Dresden, Germany, December 10-11, 2019

Auerswald, R.; Busse, R.; Dod, M. et al.: **Cooperative Driving in Mixed Traffic with Heterogeneous Communications and Cloud Infrastructure.** 5th International Conference on Vehicle Technology and Intelligent Transport Systems VEHITS19, Heraklion, Greece, May 3-5, 2019, presentation: R. Fritzsche
In: Conference Proceedings. Gusikin, O.; Helfert, M. (eds.), Setúbal, SciTePress, 2019, p. 95-105, ISBN 978-989-758-374-2, DOI: 10.5220/0007682900950105

Bartholomäus, R.; Wittig, H.: **Modellierung und Ladezustandsdiagnose von Lithium-Ionen-Zellen.** 2. Freiberger Kolloquium Elektrische Antriebstechnik FKEA, Freiberg, Germany, June 6-7, 2019, presentation: R. Bartholomäus
In: Conference Proceedings. Kertzscher, J. (ed.), Freiberg, Technische Universität Bergakademie Freiberg, 2019, Freiberger Forschungshefte A932 Elektrische Antriebstechnik, p. 166-178, ISBN 978-3-86012-610-3

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In: Conference Proceedings. Piscataway, NJ, IEEE, 2019, 8 pp., ISBN 978-0-9568086-6-0, DOI: 10.23919/EMPC44848.2019.8951887

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Pretzsch, S.: **Mobility Data Space – Vernetzen, Veredeln und Verwerten von Mobilitätsdaten.** mFUND – Konferenz 2019 »Datenimpulse für smarte Mobilität«, Berlin, Germany, September 26-27, 2019

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Pretzsch, S.: **Fraunhofer Lighthouse Project: Cognitive Agriculture: COGNAC-Platform & Agricultural Data space.** 5G & Digital Farming at the IEEE 5G Summit, Dresden, Germany, October 2, 2019

Rauschert, A.: **Einführung in die KI mittels Big Data im Maschinenbau.** Verein Deutscher Maschinen- und Anlagenbau VDMA, Arbeitskreis Antriebstechnik, Frankfurt/Main, Germany, February 19, 2019

Rauschert, A.: **Maschinelles Lernen & Big Data – wer sich alle Türen offen lässt, wird sein Leben auf dem Flur verbringen.** Verein Deutscher Maschinen- und Anlagenbau VDMA, Arbeitskreis Maschinelles Lernen, Frankfurt/Main, Germany, June 3, 2019

Rosner, M.; Holfeld, D.: **Machine Learning in Additive Manufacturing and Certification Processes in Aviation.** Operations Research 2019, Dresden, Germany, September 3-6, 2019

Schmid, M.; Hanss, A.; Elger, G.: **Automatic Transient Thermal Impedance Tester for Quality Inspection of Soldered and Sintered Power Electronic Devices on Panel and Tile Level.** IEEE 69th Electronic Components and Technology Conference (ECTC), San Diego, USA, May 28-31, 2019
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Urban, M.; Spitzhüttel, F.: **Traffic and Accident Scenarios Merged in the Harmonized PCMv5 Standard.** ASAM International Conference 2019, Dresden, Germany, December 10-11, 2019

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TEACHING ENGAGEMENTS

Bartholomäus, Ralf
Optimale Steuerung kontinuierlicher Prozesse. TU Dresden, Faculty of Electrical and Computer Engineering, Institute of Control Theory, SS 2019

Robuste Regelung. TU Dresden, Faculty of Electrical and Computer Engineering, Institute of Control Theory, SS 2019

Elger, Gordon
Elektronische Bauelemente. TH Ingolstadt, Faculty of Electrical Engineering and Information Technology, Bachelor Program »Elektromobilität«, WS 2019/20

Computer Aided Engineering. TH Ingolstadt, Faculty of Electrical Engineering and Information Technology, Master Program »International Automotive Engineering«, SS 2019

Produktion und Prozesse. TH Ingolstadt, Faculty of Electrical Engineering and Information Technology, Bachelor Program »Mechatronik«, WS 2019/20

Digitale Signalverarbeitung (Praktikum). TH Ingolstadt, Faculty of Electrical Engineering and Information Technology, Bachelor Program »Mechatronik«, SS 2019

Festag, Andreas
Einführung in die Car2X Kommunikation. TH Ingolstadt, Faculty of Electrical Engineering and Information Technology, SS 2019

Projektmanagement. TH Ingolstadt, Faculty of Electrical Engineering and Information Technology, SS 2019

Car2X Kommunikation. TH Ingolstadt, Faculty of Electrical Engineering and Information Technology, WS 2018/19, WS 2019/20

Software-Entwicklung für sicherheitskritische Systeme. TH Ingolstadt, Faculty of Electrical Engineering and Information Technology, WS 2018/19, WS 2019/20

Group project (Master Automatisiertes Fahren). TH Ingolstadt, Faculty of Electrical Engineering and Information Technology, WS 2018/19, SS 2019, WS 2019/20

Kertzscher, Jana
Berechnung elektrischer Maschinen. TU Bergakademie Freiberg, Faculty of Mechanical, Process and Energy Engineering, Institute of Electrical Engineering, SS 2019

Einführung in die Elektrotechnik. TU Bergakademie Freiberg, Faculty of Mechanical, Process and Energy Engineering, Institute of Electrical Engineering, WS 2018/19, WS 2019/20

Elektrische Energiewandler. TU Bergakademie Freiberg, Faculty of Mechanical, Process and Energy Engineering, Institute of Electrical Engineering, SS 2019

Elektrische Maschinen und Antriebe. TU Bergakademie Freiberg, Faculty of Mechanical, Process and Energy Engineering, Institute of Electrical Engineering, WS 2018/19, WS 2019/20

Einführung in die Elektromobilität. TU Bergakademie Freiberg, Faculty of Mechanical, Process and Energy Engineering, Institute of Electrical Engineering, WS 2018/19, WS 2019/20

Energietechnik (lecture series). TU Bergakademie Freiberg, Faculty of Mechanical, Process and Energy Engineering, Institute of Electrical Engineering, WS 2018/19, WS 2019/20

Grundlagen der Elektrotechnik. TU Bergakademie Freiberg, Faculty of Mechanical, Process and Energy Engineering, Institute of Electrical Engineering, SS 2019

Regelung elektrischer Antriebe I. TU Bergakademie Freiberg, Faculty of Mechanical, Process and Energy Engineering, Institute of Electrical Engineering, SS 2019

Regelung elektrischer Antriebe II. TU Bergakademie Freiberg, Faculty of Mechanical, Process and Energy Engineering, Institute of Electrical Engineering, WS 2018/19, WS 2019/20

Theorie elektrischer Maschinen. TU Bergakademie Freiberg, Faculty of Mechanical, Process and Energy Engineering, Institute of Electrical Engineering, WS 2018/19, WS 2019/20

Klingner, Matthias
Elektroenergiesysteme. TU Bergakademie Freiberg, Faculty of Mechanical, Process and Energy Engineering, Institute of Electrical Engineering, SS 2019

Systemtheorie in der Anwendung (compact seminar). TU Bergakademie Freiberg, Faculty of Mechanical, Process and Energy Engineering, Institute of Electrical Engineering, WS 2018/19, WS 2019/20

Knote, Thoralf
Straßenverkehrstechnik. TU Dresden, »Friedrich List« Faculty of Transport and Traffic Sciences, Institute of Transport Planning and Road Traffic, WS 2018/19, SS 2019, WS 2019/20

Rauschert, André
Ideen-, Innovations- und Change Management. Gründungsmanagement. Mittweida University of Applied Sciences, Faculty Industrial Engineering, Faculty Media Sciences, WS 2018/19, SS 2019, WS 2019/20

Steinert, Frank
Automatisierung in der Landtechnik. TU Dresden, Faculty of Mechanical Science and Engineering, Institute of Natural Materials Technology, SS 2019

FINAL THESES

PHD STUDENTS

Kandler, Ute
Inexact Methods for the Solution of Large Scale Hermitian Eigenvalue Problems. TU Berlin

Partzsch, Ina
Ein Beitrag zur Identifikation von Bewegungszuständen mittels Inertialsensorik für die Stützung von Navigationsfunktionen im Öffentlichen Personenverkehr. TU Dresden

DIPLOMA STUDENTS

Braunisch, Nico
IoT-System-Management für Assets urbaner Verkehrsinfrastrukturen. TU Dresden

Draganov, Hristo
Entwurf eines Antriebssystems für eine Packerwalze. TU Dresden

Elschner, Toni
Entwicklung und experimentelle Untersuchung einer verlustoptimalen Laderegelung für die Betriebsführung von PV-Batteriespeichersystemen. TU Dresden

Heußer, Axel
Evaluation verzeichnungskorrigierter Trajektorien von Verkehrsteilnehmenden aus Infrarot-Videosequenzen. TU Dresden

Higert, Kevin
Erstellung eines Mehrkörpersimulationsmodells (MKS) einer gelenkten Nutzfahrzeugachse. TU Dresden

Janetzky, Bodo
Modellierung eines induktiven Ladesystems für Pedelecs. TU Freiberg

Kolb, Julius
Regelung für die Rückwärtsfahrt von Sattelzügen und Lastzügen. TU Dresden

Philipps, Norman
Pareto-Optimierung zur Planung der Prozessdatenerfassung in der additiven Fertigung. TU Dresden

Rao, Haihua
Kumulative Modellbildung einer Lithium-Ionen-Zelle. TU Dresden

Steinbock, Erwin
Entwurf und Konstruktion einer Fahrzeugachse mit Einzelradantrieben. HTW Dresden

Stief, Hubert
Abbildung von Anforderungen an Testszenarien auf bekannte Testszenarien bzw. Testszenarienfragmente. TU Dresden

Weiser, Felix
Aufbau eines gekoppelten Simulationsmodells für theoretische Untersuchungen einer Feldschwarmeinheit. TU Dresden

MASTER STUDENTS

Gidion, Fritjof
Quantitative Analyse der Komplexität von Knotenpunkten und ihr Einfluss auf die Unfallhäufigkeit. TU Dresden

Liu, Hongzhi
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Masud, Usama
System Level Testing of Automotive Cameras with the use of Monitor HIL and ADAS Algorithms. TH Ingolstadt

Qu, Zihan
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Tannenbring, Jonas
Implementierung Feldorientierte Regelung (FOR). TU Freiberg

Tellis, Sheldon
Thermal Methods to Measure the Thermal Losses of LEDs for Transient Thermal Analysis. TH Ingolstadt

Voß, Imke
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Warzok, Jonas
Vorhersage von Batterieverhalten mittels rekurrenter Neuronaler Netze. TU Dresden

BACHELOR STUDENTS

Arnold, Christian
Recherche und prototypische Umsetzung von 3D-Panoramatouren für den Innenbereich von Gebäuden. HTW Dresden

Braun, Florian
Untersuchung der Alterung des Optikmoduls MFC430. TH Ingolstadt

Deutscher, René
Automatisierte Kategorisierung von Text-Annotationen im Semantic Web. Staatliche Studienakademie Dresden (BA)

Koch, Sebastian
Konzeption und Implementierung einer Komponente für mobile Endgeräte zur Darstellung einsatzbezogener Medien, Dokumente und Informationen. TU Dresden

Kühn, Stephan
Konzeptentwicklung eines Master-Slave-Batteriemanagementsystems mit Logik, Konfigurierbarkeit und Datenerfassung auf Zellebene. TH Ingolstadt

Mitschke, Anne
Retrofit der Isolationsüberwachungsanlage im Kraftwerk Lippendorf. TU Freiberg

Murzik, Georg Alexander
Erarbeitung und Demonstration einer Entscheidungshilfe für die Umsetzung ausgewählter Qualitätsmerkmale von automatisierten Deployments von Webanwendungen. Staatliche Studienakademie Dresden (BA)

Schnarr, Markus
Untersuchungen zu Positionierungssensornetzwerken für intelligente Verkehrssysteme. HTW Dresden

Seyffer, Norman
Antriebsschlupfregelung eines elektrischen Achsantriebes: Vergleich des dynamischen Verhaltens mit und ohne Verwendung einer externen Drehzahlgrenze. TU Freiberg

Wien, Julian
Erweiterte Prüfabdeckung für die Messung von Modulations-Transfer-Funktion und Tiefenschärfe für Optikmodule im Bereich der Fahrerassistenzsysteme. TH Ingolstadt

Yanchen, Liu
Autonome Steuerung eines schienengebundenen Transportsystems. TU Freiberg

PUBLIC BODY MEMBERSHIP AND PATENTS

PUBLIC BODY MEMBERSHIP

Brausewetter, Patrick
– JUG Saxony e. V.

Danowski, Kamen
– Section »Civil Protection«, Euroregion Elbe/Labe

Engelbrecht, Julia Maria
– IEEE Intelligent Transportation Systems Society
– IEEE Region 8: Europe, Middle East and Africa
– IEEE Vehicular Technology Society
– VDE District Dresden e. V.

Erbsmehl, Christian T.
– EVU European Association for Accident Research and Analysis e. V.
– SafeTRANS e. V.

Festag, Andreas
– 5G Automotive Associaton e. V.
– Acatech National Academy of Science and Engineering »New autoMobility«
– ETSI European Telecommunications Standards Institute

Grimm, Jan
– BASt Federal Highway Research Institute, Supervisor Group »Impact of Errors on Traffic Management Systems«
– COST Action TU1305 Social Networks and Travel Behaviour
– FGSV German Road and Transportation Research Association, Working Groups AG 3.2.9 »Video Detection in TMS (Traffic Management Systems)« and AG 3.2.10, »Quality Management of TMS«

Gründel, Torsten
– Association for Standardization of Automation and Measuring Systems (ASAM)
– CNA Center for Transportation & Logistics Neuer Adler e. V.
– ECTRI European Conference of Transport Research Institutes
– Fraunhofer Traffic and Transportation Alliance
– Kontiki Working Group in Contactless Smart Card Systems for Electronic Ticketing e. V.
– Network »SatNav Saxony«
– Silicon Saxony e. V., Applications Division, Working Group Cyber-Physical Systems
– UITP International Association of Public Transport

Hedel, Ralf
– Moderator of the ECTRI Thematic Group »Security and Risk Analysis«

Kertzscher, Jana
– VDE Association for Electrical, Electronic & Information Technologies e. V.

Knote, Thoralf
– FGSV German Road and Transportation Research Association, Working Group AG 3.10 »Theoretical Basics of Road Traffic«

Klingner, Matthias
– Agronym e. V.
– agrarWERT – Initiative for Cooperation, Digitization and Sustainability of agriculture and forestry in Saxony e. V.
– Dresden-concept e. V.
– Ingolstadt Foundation for Excellence in Science – Ignaz Kögler
– Förderverein HYPOS – Hydrogen Power Storage & Solutions East Germany e. V.
– Fraunhofer Network »Wissenschaft, Kunst und Design«
– Fraunhofer ICT Group
– Fraunhofer-Alumni e. V.
– Steering Group of the Fraunhofer Traffic and Transportation Alliance
– Network »Dresden – Stadt der Wissenschaften«

Kratzing, Richard
– Fraunhofer Battery Alliance
– Fraunhofer Energy Alliance

Rauschert, André
– Fraunhofer Big Data and Artificial Intelligence Alliance

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CERTIFICATES

DIN EN ISO 9001:2015
Sector »Development of vehicle and propulsion technology and transportation research and development«,
Certificate registration number 44 100 190788

TRADEMARKS

AutoTram®
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