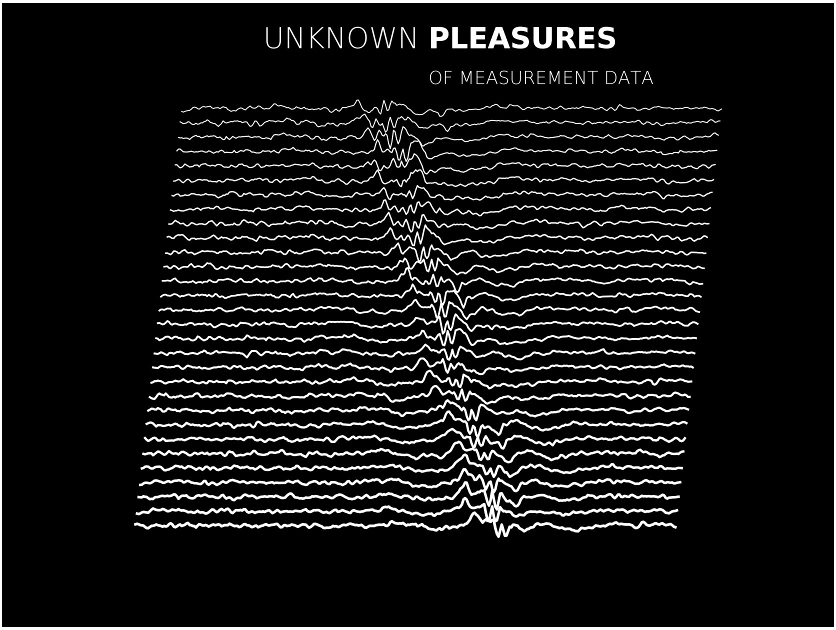
Technische Universität Berlin



Annual Report 2021

Electronic Measurement and Diagnostic Technology

Dear ladies and gentlemen,
dear colleagues and friends,

even if we feel like running a marathon unprepared and after the 35th kilometer the course length is increased to an indefinite length, we have still been able to research and teach with pleasure and success in this Corona year. By tradition, we would like to give you an overview of last year's events and projects.

Research Projects

- Journal Bearing Wear Prediction using Neuronal Networks
- Fault Diagnosis and RUL Prediction for Ball Bearing
- Condition Monitoring and Fault Diagnosis of Future Planetary Gearboxes in Aero Engines
- SicWell - Influence of SiC Inverters on the Lifetime of Traction Batteries
- Development of Methods for the Failure Diagnostics and Predictive Maintenance of Electrical Machines in a Networked Vehicle System
- Unsupervised Feature Extraction of Multivariate Time Series Data using Autoencoder Followed by a Classification on the Autoencoder Representation from an Automotive System with Sparse Error Class
- Unsupervised Domain Adaption on Time Series Data for Remaining Useful Lifetime Estimation
- Development of a Scalable Model- and Data-Based Diagnostic Concept using Vehicle Measurement Data
- Building a Hybrid Model with an Autoencoder Based Selection Strategy
- Optimisation of Adaptive Test Design Methods for the Determination of Steady-State Data-Driven Models in Terms of Combustion Engine Calibration
- AI in Transmission Control – Clutch Engagement with Reinforcement Learning

In addition, our annual report contains a summary of our teaching activities and the news from our workshops.

Finally, I would like to thank all partners and the whole MDT-Team. I hope you will enjoy our annual report. Please contact us if you have any questions or comments.

I wish you and your families a

blessed Christmas and a Happy New Year,

Clemens Gühmann

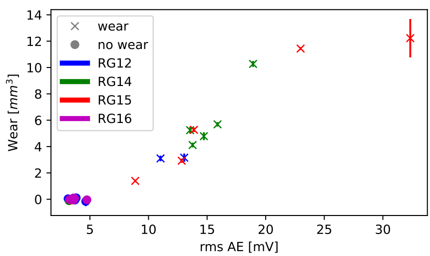
Research Projects

Journal Bearing Wear Prediction using Neuronal Networks

José-Luis Bote-Garcia (Publication 2021: [1])

After an evaluation of the 2020 tests, we analyzed the procedure for determining the wear volume on a journal bearing in detail. This led to a better understanding and experimental design. Finally, we carried out another series of experiments in the spring. Here, the individual experiments lasted 16 hours to achiev higher wear volumes.

A total of four bearings were used. All bearings were partially worn in, as they originated from last year's experiments. The speed and oil temperature were kept constant during all of the experiments. The 2020 experiments showed that the acoustic emission behaved quite stably over a brief period of time. Thus, the acoustic emission (AE) was measured every 5 minutes for 20 seconds. The load, as a variable parameter, was changed across experiments. The load was set at 20, 40, 60, and 80 bar, with the experiments at 60 bar performed three times to determine behavioral change across experiments.



Thus, a total of 24 experiments were performed. These show a strong correlation between the RMS value of the AE and the estimated wear volume. A linear regression reaches an RMSE value smaller then $1\,mm^3$ and an R^2 value higher then $80\,\%$. This simple regression model serves as a basis for better regression techniques such as random forest regression and various forms of neural networks.

Data-driven Modeling, Fault Diagnosis and Remaining Useful Life Prediction for Ball Bearing

Diwang Ruan (Publication 2021: [3, 4, 5, 6])

This PhD thesis focuses on data-driven dynamics modeling, fault diagnosis, and remaining useful life (RUL) prediction for ball bearing, which has lasted for three years since its initiation in September 2019.

Over the past three years, the following issues have been addressed in this project. 1) Bearing dynamic modeling, especially the modeling for defect bearing, including fault position, fault size and shape, and multiple faults [4]. 2) Fault classification based on Convolutional Neural Network (CNN) and improvement for its performance from manual feature extraction, hyperparameters optimization, and fully connected layer replacement. Meanwhile, four metrics like accuracy, efficiency, stability, and robustness were proposed to overall evaluate CNN [6]. 3) Some practical problems when CNN is deployed for industry applications have also been considered. For example, three kinds of uncertainties from training data, training CNN, and bearing operating load were defined as data uncertainty, algorithm uncertainty, and working condition uncertainty respectively, and then quantitated by Gaussian process [3]. Additionally, to guarantee CNN's fault diagnosis performance under imbalanced datasets, a collaborative optimized structure of CNN_GAN was proposed and verified, which takes the envelope spectrum error and CNN's classification result as two modification terms in the default GAN generator's loss function [5].

This year, this project continues on exploring the data-driven methodology for bearing fault modeling, diagnosis, and prognosis. Firstly, a Hammerstein-Wiener-based virtual state-space model was employed to identify the bearing fault dynamics, and further, the state transition matrix was used for fault diagnosis. Secondly, a new health index based on the occurrence probability of fault characteristic frequency was proposed and applied for bearing RUL prediction. Thirdly, a lightweight CNN was obtained based on neural network search (NAS) technology and weight-based pruning. Lastly, on the basis of the GAN in [5], a new physics-driven GAN was designed and trained, which will be further used for fault classification and RUL prediction under imbalanced and small datasets.

As to the plan for next year, on the one hand, the publication of the results obtained this year will be the key task; on the other hand, the documentation of my PhD thesis will be another important issue.

SicWell - Influence of SiC Inverters on the Lifetime of Traction Batteries

Daniel Weber (Publication 2021: [7, 8, 9])

With an increasing demand for electric vehicles, the lifetime maximization of the traction battery is of great importance. With the emergence of silicon carbide inverters, a vehicle range increase of 5% could be achieved. For the battery life, a lot of influencing factors like operating temperature and current have been identified, but the influence of high-frequency noise that silicon carbide inverters emit still has to be analyzed. The project SiCWell in cooperation with Daimler AG and Solfas Technologie GmbH aims to do just that.

This year, the cycling of battery cells with varying amplitudes and frequencies of superimposed sinus currents has been finished, and the cycling with realistic driving cycles with superimposed current ripples has been started. The battery aging data combined with the evaluation of current ripples have been combined to a dataset, which is suitable for the design of future current ripple aging studies and the development and validation of aging models and methods for battery diagnosis. The dataset has been made publicly available [7]. Together with Daimler AG, the results will be used to identify the design implications for vehicle electrical systems.

In 2021 the focus of MDT was on optimizing the system identification component of the virtual test approach that has been developed for battery state of health diagnosis without reference measurements. The developed recurrent neural network-based method has been optimized and compared to state-of-the-art system identification methods on publicly available datasets [8]. Additionally, the developed method has been applied to a practical attitude estimation task and has been compared to state-of-the-art domain-specific methods [9]. The results show that the developed method outperforms all other black-box system identification methods and even outperforms state-of-the-art domain-specific methods in the attitude estimation task.

To demonstrate the viability of these methods to in-vehicle applications, the virtual tests method has been implemented on an embedded system. In 2022 the developed methods and the embedded system will be validated with the acquired aging data of the battery ripple tests.

GEFÖRDERT VOM
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für Bildung
und Forschung

BerDiBa - Digitalization of Rail Transport for Automatic Train Operation

Daniel Thomanek, Daniel Adam

The key to sustainable and environmentally friendly mobility is the digitalization of rail transport. BerDiBa ("Berliner Digitaler Bahnbetrieb") is an innovative research project that was launched at the beginning of the year to address this issue. The project includes 12 project partners and is funded by the innovation support program ProFIT.

The main focus of the project is the research and testing of technologies for automated driving on a rail. One main topic of autonomous trains is the ability to monitor its own health state and likewise of its environment. Furthermore, these health states need to be predicted into the future to ensure safe and optimal operating conditions.

The Department of Electronic Measurement and Diagnostic Technology is working on several topics.

Together with our project partners, an algorithm for the train schedule is being developed. Our department is developing wear models of various mechanical components to predict their failure as precisely as possible. This offers the possibility to optimize maintenance and hence the working timetable. For example, door openings are simulated and different stations, routes and passengers are taken into account.

Another topic is the monitoring of the railroad infrastructure. Herewith different sensors the condition of the railroad tracks is to be examined. Thus, with the help of Deep Learning, it should be possible to detect, for example, a lowering of the railroad tracks just by an over rolling train.

Not only the track will be monitored, but also the so-called structure gauge. It should not only be recognized whether e.g. branches hang in the track but the vegetation should be predicted. For this purpose, data from train cameras will be processed by neural networks. This should enable the prediction of when and where the structure gauge has to be cut free.

This research project should make rail traffic safer and increase the punctuality of trains, thus creating sustainable and environmentally friendly mobility.

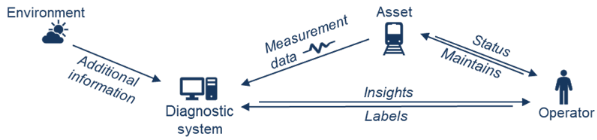
Practical solutions for transparent fault diagnostics concerning complex technical assets of the railway infrastructure

Susanne Reetz

The goal of this PhD thesis is to explore the development of transparent, interpretable fault diagnosis systems for complex assets of the railway infrastructure, given unlabeled data, multiple information sources, and expert knowledge. The research is carried out at the Asset Monitoring and Management (AMM) research group of the Institute of Transportation Systems at the German Aerospace Center (DLR).

Due to increasing demand for capacity and availability of railway networks and the need to minimize maintenance cost, new (often data-driven) approaches in prognostics and health management gain in popularity. This thesis focuses on diagnostic systems for complex technical assets of the railway infrastructure. Typically, there are large amounts of unlabeled sensor data from multiple sources getting available, as well as additional information on other influencing factors such as environmental conditions and utilization of the assets. Strict safety-regulation calls for traceable algorithms and the applications require interpretability of the results. Due to few labeled data samples, the combination of feature engineering or unsupervised learning and available expert knowledge (i.e. knowledge-based methods) seems to be a promising approach. Therefore, the thesis demonstrates a holistic approach to fault diagnosis on the example of railway switches.

After the development of the algorithms and models of a diagnostic system, the next steps are the implementation in practice, performance validation, and (later on) continuous improvement. The latter two steps require a backflow of labeled data, which is often hard to come by, especially in railway infrastructure maintenance. New systems generally first disrupt well-established work processes before they add value in the mid-term and feedback collection results in additional documentation work for operators. To paint the bigger picture, the thesis secondly aims to consider the challenges of implementation design with respect to user acceptance and efficient, standardized feedback collection.

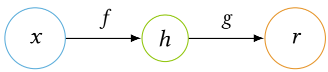


This project is in cooperation with DLR.

Unsupervised feature extraction of multivariate timeseries data using autoencoder followed by a classification on the autoencoder representation from an automotive system with sparse error class.

Jonas Köhne

Within the project „Automatic Selection of Features for the Diagnosis of Mechatronic Processes“, which started in September 2019 in cooperation with IAV GmbH, new deep learning approaches for machine diagnosis are being examined. The following research targets will be evaluated during this PhD study: classification or detection of sparse error class and deterioration effects of a mechatronic system which provides large multivariate timeseries data using a deep learning approach; also the partial automation of the necessary preprocessing and feature selection by a human expert who has a priori knowledge of the system. This should be achieved by using, amongst others, a type of artificial neural network which is called autoencoder. The resulting compressed representation of the system together with the reconstruction error should be used to classify, identify a sequence or detect an abnormal behavior of the system and possibly determine the precise condition of the equipment. The Figure below shows the general structure of an autoencoder: the mapping of an input x to an output, which is called reconstruction r, through an internal representation h (Source: Own representation based on Goodfellow et al. 2018, pp. 503).



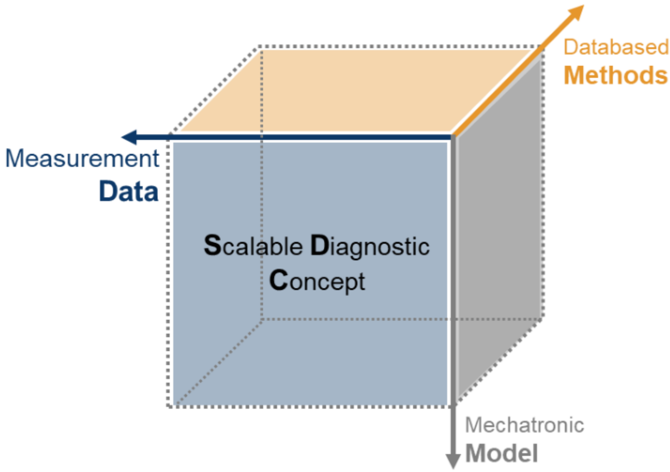
One of the main challenges in the diagnosis and predictive maintenance of a mechatronic system, particularly in the commercial vehicle sector, is the sparse amount of data from the error component or deteriorated part. The intentional destruction of the component is challenging and is especially very time-consuming with newly-used components. Other challenges are the a priori knowledge and expertise of the specific component needed for developing a robust diagnosis, not even considering a prediction of the future condition. A large dataset with multiple years of recordings from heavy-duty in field machinery has been analyzed. Also, a new approach using Autoencoder for labeling sequences of operation points in multivariate time series data is being developed.

These research questions are examined: is a representation learning approach possible to convert unsorted raw sensor data into a representation with well-separated factors of variation that describes the observed mechatronic system? If so, how feasible is it to use these separated factors as an input for a classification algorithm to diagnose the observed mechatronic systems within a possible out-of-distribution input? How well would this approach compare to a mathematical or physical modeling approach with expertise and experienced knowledge of the mechatronic system? How big is the effort of obtaining a good representation and training a classifier compared to a standard and widely accepted modeling approach?

Development of a scalable model- and data-based diagnostic concept using vehicle measurement data

Andreas Schmitz

The aim of this PhD thesis is the development of a diagnostic concept, which is scalable concerning the availability of mechatronic models, measurement data, and data-based methods. The project is in cooperation with IAV GmbH. There are several ways to develop a diagnosis for an arbitrary system, most of them can be either classified in model-based or data-based methods. Also, the combination of model- and data-based methods is possible, called hybrid methods. All approaches have special advantages and disadvantages, which could be combined in a scalable inductive inference concept. Generally, the diagnosis task has three main parts: Fault Detection, Fault Identification and Fault Isolation, as can be seen in the modeling step in the figure.
The key phases of the diagnostic concept include four steps. The preprocessing for preparing the data is followed by modeling, where different model- and databased methods should fulfill the diagnostic task. The scaling step compares the different methods via specified metrics. This evaluation could be repeated, possibly with an alternative approach. Finally, a fusion strategy can be used to combine two or more approaches if needed. Beside the aim to combine different methods out of model-based and data-based approaches in a scalable way, the difference between the online- and offline-system-performance which is needed to do the diagnostic, is considered. In



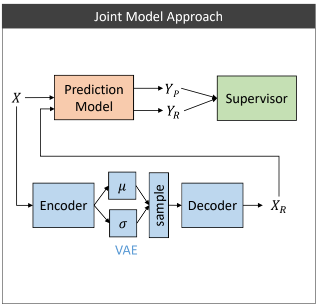
the concept it should also be reflected, that specific requirements could be given depending on the diagnostic task, e.g. maximum accuracy or maximum performance.
Currently, the development of the phases, especially the modeling part, takes place. Thereby the scalability is also in the foreground. Up next the integration of modelling and the specified metrics will be done, to answer the research question: which metrics are more suitable to different diagnostic methods and how feasible is the handling during the training and test? Is it possible, that two (or more) methods complement each other? If so, a fusion of these assessed approaches should be done.

This project is in cooperation with IAV GmbH.

Securing Deep Learning Models with an Autoencoder Based Anomaly Detection

Joana Kühne, Christian März (Publication 2021: [2])

Due to their outstanding performance, deep learning models have been introduced to many applications within recent years. However, one challenge when using deep learning models is to assure their accuracy during inference on real-world data. Especially for any safety-relevant applications this becomes crucial. The developed approach examines a novel autoencoder-based method for securing deep learning prediction models. The goal is to ensure that the input is from the same distribution as the training data, since only then a safe prediction can be conducted. The idea is to build a joint model consisting of an autoencoder and the prediction model that only produces predictions if it is certain that they are accurate.



Y_P	Y_R	$Y_P = Y_R$	case
correct	correct	true	true positive
correct	false	false	false negative
false	correct	false	true negative
false	false	true	false positive
false	false	false	true negative

The joint model structure is displayed graphically in the figure above. Both submodels are trained separately on the same training data. During inference the test data $\boldsymbol{X}$ is passed through the prediction model leading to the result Y_P. The Autoencoder uses the same input reconstruction $\boldsymbol{X_R}$. Since the autoencoder was trained on the same trainig data as the prediction model, the reconstruction $\boldsymbol{X_R}$ is expected to be close to the input if the input is close to the training data and differs significantly from the input otherwise. The reconstruction is then processed by the prediction model leading to two separate predictions Y_P and Y_R. For classification tasks, the prediction is labeled secure if the two lead to an identical result. Otherwise, the input is labeled insecure and for the input sample no safe prediction is possible. In the table, the possible combinations of the two predictions and their corresponding outcomes are summarized. The method was also adapted for regression tasks.

The method was applied on two types of classification tasks: image classification using the MNIST dataset as well as time series classification using the multivariate UEA time series classification dataset. The joint model was compared to using an Autoencoder as a supervisor with a threshold set to the reconstruction loss during inference. The joint model approach showed significant improvement regarding risk and coverage, especially if Gaussian distributed noise is added to the test data to simulate an anomaly.

In the next phase of this research, we aim to compare this method to other deep learning supervisors and to test its performance on other anomalies e.g. adversarial attacks. [2]

This project is in cooperation with IAV GmbH.

Electronic and Mechatronic Workshop

News from Our Workshops: Electronic Service and Mechatronic Workshop

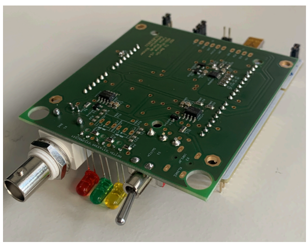
Frank Baeumer

After the Corona crisis had calmed down in spring 2021, the TU Berlin was shaken by a hacker attack on the entire IT infrastructure. Unfortunately, our chair was also very badly affected. Important data was encrypted and all department computers had to be reinstalled. So it was then the job of Electronic Service to reinstall the computers for teaching and research and gradually bring the various test stands back into operation with the newly installed computers. In cooperation with the scientific staff, the servers in our department had to be made operational again. Many test stands are now operational again and various server functions are available again. Nevertheless, further IT conversion work is pending here for the next few months so that our IT system will be more secure against attacks in the future.
Thanks to the financial support of our faculty, we were able to purchase a new bench grinder and a column drill for our Mechatronic Workshop. This acquisition was necessary because our previous devices no longer met the safety requirements.
We now hope that the 4th Corona wave will pass lightly so that we can set up exciting new test stands in the new year.

Design of a circuit for measurement data processing in home schooling

Sebastian Binder

The chair is holding a lecture about the measurement, digitalization and processing of analog signals where normally practical experiments are taking place. For this, the students are working with a circuit board including inputs, analog circuits for signal preparation and digital conversion hardware. They are using them to measure given signals and learn something about the



characteristics and problems of signal digitalization like the effects of sample rates and bit resolutions. During the last year, a general redesign using modern techniques including a STM32-Microcontroller were performed by Eva Fischerauer. A BNC-Connector enables the capability of using a functions generator as an input source. Analog signals with up to $\pm\ 7\,\mathrm{V}$ are allowed to be measured. Afterwards, analog circuits are shifting and limiting these input signals in a measurable range between $0\,\mathrm{V}$ and $3.3\,\mathrm{V}$. These signals can optionally be measured by the internal 12-Bit-ADC of the STM32F3 or an external, 16-Bit ADS8866 with SPI interface. Three discrete LED's, connected to the GPIO-Pins of the controller, making visible outputs according to the analog input signal levels possible. Everything on the board is openly programmable and accessible by the students for making various experiments. Due to covid, these experiments can't take place in the labs right now. For this reason, an audio jack for using a common PC as signal source and the capability of fully powering the PCB using USB was implemented. To fulfill the covid restrictions, every student got its own board. The Electronic Service produced 45 boards in a small series, debugged and tested them. The finished boards were placed in a plastic casing to be more robust for the common use. All boards were finished in April 2021 and were used in the summer term for education.

Project-Oriented Practical Course

Felix Piprek

The Project-Oriented Practical Course is a compulsory module in the electrical engineering course. Up to 40 students realize a joint, self-selected project in several sub-groups. In the course of the project, the ability to work in a team and project management should be learned on the basis of a practical electronic project. Here, the project development in the industry was oriented. Due to the pandemic, the number of participants had to be reduced to 4 persons per project. During the pandemic, projects such as a light organ, alarm system, alarm clock, weather station and synthesizer were implemented. The students like the module since the learned theory can be realized in a practical project. The teaching was carried out by the Mixed Signal Circuit Design chair. Our workshop enabled and supervised the technical implementation (procurement of components, production of circuit boards, housing processing, etc.).

Publications in 2021

[1] José-Luis Bote-Garcia and Clemens Gühmann. Schätzung des verschleißvolumens an gleitlagern. *tm-Technisches Messen*, 88(s1):s17–s21, 2021.

[2] Joana Kühne, Christian März, and Clemens Gühmann. Securing Deep Learning Models with Autoencoder based Anomaly Detection. In *PHM Society European Conference 6(1), p. 13.*, June 2021.

[3] Diwang Ruan, Shu Geng, Jianping Yan, and Clemens Gühmann. Bearing fault classification based on convolutional neural network and uncertainty analysis. In *2021 40th Chinese Control Conference (CCC)*, pages 4319–4326. IEEE, 2021.

[4] Diwang Ruan, Zhirou Li, and Clemens Gühmann. Modeling of a bearing test bench and analysis of defect bearing dynamics in modelica. In *Modelica Conferences*, pages 373–382, 2021.

[5] Diwang Ruan, Xinzhou Song, Clemens Gühmann, and Jianping Yan. Collaborative optimization of cnn and gan for bearing fault diagnosis under unbalanced datasets. *Lubricants*, 9(10):105, 2021.

[6] Diwang Ruan, Feifan Zhang, and Clemens Gühmann. Exploration and effect analysis of improvement in convolution neural network for bearing fault diagnosis. In *2021 IEEE International Conference on Prognostics and Health Management (ICPHM)*, pages 1–8. IEEE, 2021.

[7] Daniel Weber. SiCWell Dataset. October 2021. Publisher: IEEE Type: dataset.

[8] Daniel Weber and Clemens Gühmann. Non-Autoregressive vs Autoregressive Neural Networks for System Identification. *arXiv:2105.02027 [cs, eess]*, May 2021. arXiv: 2105.02027.

[9] Daniel Weber, Clemens Gühmann, and Thomas Seel. RIANN—A Robust Neural Network Outperforms Attitude Estimation Filters. *AI*, 2(3):444–463, September 2021. Number: 3 Publisher: Multidisciplinary Digital Publishing Institute.

Bachelor theses in 2021

[1] Gregor Kornhardt. Bearing Fault Diagnosis Based on Mechanism Modeling ans Machine Learning.

[2] Chenyi Lin. Modellierung, Simulation und Test idealer und nicht-idealer Analog-Digital-Umsetzverfahren.

[3] Lucy Viola Pagel. A dynamic emission model for a heavy-duty diesel engine with recurrent neural networks.

[4] Marcel Rüsenberg. Entwicklung eines Praktikumsversuchs zur Aufnahme und Anwendung einer Kennlinie für die Bestimmung von Temperaturen auf Basis eines Raspberry Pi Rechners.

Master theses in 2021

[1] Kemal Bagci. Steuerungskonzeptentwicklung für das schwingungsarme Wiederaufkoppeln eines Verbrennungsmotors im Anschluss an den Segelbetrieb.

[2] Kenan Bagci. Entwicklung einer adaptiven Kupplungsbefüllfunktion mit Hilfe einer Software-Bibliothek für maschinelles Online-Lernen .

[3] Julia Baldyga. Controller Development for Engine-Dynamometer System based on Model Predictive Control and Extended State Observer.

[4] Oliver Becher. Entwicklung eines vernetzten Prüfstands zur webbasierten Validierung und Parametrierung von Simulationsmodellen.

[5] Tuan Anh Bui. Entwicklung eines verteilten Informationssystems für Messgeräte zur Analyse von Power-Quality Parametern in elektrischen Energieversorgungsnetzen.

[6] He Chen. Classification of time series based on the Wigner-Ville transformation and deep neural networks.

[7] Yuxiang Chen. Application of Bearing Dynamics Model in Transfer learning for Bearing Fault Diagnosis with Convolutional Neural Networks.

[8] Khaled Diab. Konzipierung und steuergerätetaugliche Implementierung eines Trajektoriengenerators zur Erzeugung stetiger zeitlicher Führungsgrößenverläufe unter Berücksichtigung von Stellgrößenbegrenzungen.

[9] Bryan Torsten Kevin Krauß. LiDAR and Camera-Fusion: Depth Completion.

[10] Pascal Semir Lipka. Entwicklung und Implementierung eines Algorithmus zur kamerabasierten Ladungsüberwachung und -sicherung in Fahrzeuginnenräumen.

[11] Xinying Mo. The Effect of Autoencoder Pre-Training on Unsupervised Domain Adaption for RUL.

[12] Simon Pleyer. Evaluation und Implementierung einer nichtlinearen Arbeitsfluidtemperaturregelung in einem WHR System.

[13] Arne Schlowak. Entwicklung eines Testsystems für Konformitäts- und Interoperabilitätstests der Ladekommunikation zwischen Elektrofahrzeugen und Ladestationen basierend auf DIN SPEC 70121 und ISO 15118.

[14] Georg Schott. Evaluierung von verschiedenen Sensorsetups eines Kollisionswarnsystems für Schienenfahrzeuge.

[15] Mario Schwenk. Methode zur Validierung der Implementierung einer automatisierten Fahrfunktion in der Simulation.

[16] Christoph Sehmisch. Entwicklung einer Mikrocontroller-basierten Multi-Input-Multi-Output-Hardwareschnittstelle zur Steuerung eines Kraftfahrzeug-Batterieprüfstandes.

[17] Xiaofei Shang. Classification of time series based on auto-encoding and deep neural networks.

[18] Cong Shao. Remainung Useful Life Prediction for Ball Bearing of an electric motor based on Wavelet Transfer and Support Vector Machines.

[19] Xinlan Shen. Remainung Useful Life Estimation of Ball Bearing based on Extended Kalman Filter and Support Vector Machines.

[20] Xinzhou Song. Bearing Faults Simulation and Diagnosis Based on the Digital Twin.

[21] Jiaqi Wang. Classification of road damage using machine learning techniques in photos and depth images.

[22] Lu Yang. Linear Quadratic based Optimization Control of Clutch Engagement Process in Powertrain.

Courses

Despite the severe restrictions due to the Corona pandemic, we were able to offer all courses as in previous years.

Summer term 2021

Measurement Data Processing	Lecture & Lab
Control and Regulation of Automotive Powertrains	Lecture
Graduation seminar on Measurement Technique	Seminar
Measurement Data Processing	Projects
Pattern Recognition and Technical Diagnosis	Lecture & Lab
Simulation and Technical Diagnostics	Projects

Winter term 2020/2021

Basics of Electronic Measurement Techniques	Lecture & Lab
Basics of Electronic Measurement Techniques	Tutorial
Introduction to Automotive Electronics	Lecture
Modelling and Real-Time Simulation	Lecture
Modelling and ECU Optimization	Lab
Graduation seminar on Measurement Technique	Seminar
Measurement Data Processing	Projects
Simulation and Technical Diagnostics	Projects

Our Team

Head of Chair

Prof. Dr.-Ing. Clemens Gühmann

Offices

Christine Beyer	(EN 13 – MDT)
Ewa Heinze	(EN 13 – MDT)
Elisabeth Schwidtal	(EN 3 – EMSP)

Research Assistants

M.Sc.	José-Luis Bote-Garcia
M.Sc.	Mateusz Grzeszkowski (until August 2021)
Dipl.-Ing.	Jonas Köhne
M.Sc.	Tilman Krokotsch
M.Sc.	Diwang Ruan
M.Sc.	Daniel Thomanek
M.Sc.	Daniel Weber
M.Sc.	Daniel Adam (since Oktober 2021)

Doctorands

M.Sc. Joana Kühne (IAV GmbH)
M.Sc. Alexander Lampe (IAV GmbH)
M.Sc. Christian März (IAV GmbH)
M.Sc. Russell Sabir (SEG Automotive Germany GmbH)
M.Sc. Nino Pascal Sandmeier (IAV GmbH)
M.Sc. Andreas Schmitz (IAV GmbH)
M.Sc. Dengfeng Shen
M.Sc. Susanne Reetz (DLR)

Not Permanently Employed Lecturer

Dr.-Ing. Mirko Knaak	Seminar Measurement and Technical Diagnosis
Dr.-Ing. René Knoblich	Automotive Control Systems for Drivelines and Introduction in Automotive Electronics - Lab

Tutors Measurement Laboratory

Max Herzberg
Gregor Kornhardt
Lisa Lokstein
Kilian Recher
Emil Thaon de Saint André

Institute Engineers (EMSP & MDT)

Dipl.-Ing.	Frank Baeumer
B.Eng.	André Göttlicher

Electronic Service (EMSP & MDT)

B.Sc. Felix Piprek
B.Sc. Sebastian Binder

Mechatronic Workshop (EMSP & MDT)

Peter Jaeck
Patrick Schulz

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