Annual Report 2018

Electronic Measurement and Diagnostic Technology

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Dear ladies and gentlemen,
dear colleagues and friends,
by tradition we would like to give you a review of last year’s events.
In this annual report you will find more details on our projects:

**Condition Monitoring, Diagnosis and Lifetime Prediction**

- Dry Clutch Control Based on Lifetime Prediction
- Condition Monitoring and Remaining Useful Lifetime Prediction of Hydrodynamic Journal Bearings Integrated in Future Planetary Gearboxes of Geared Turbofans
- Sequential Design for the Identification of a Wear Model Based on a Gaussian Process
- Condition Monitoring and Fault Diagnosis of Future Planetary Gearboxes in Aero Engines
- SiCWell - Influence of SiC Inverters on the Lifetime of Traction Batteries
- Remaining Useful Life Estimation based on Compressively Generated Health Indicators and Wiener-Process Prediction
- Development of Methods for the Failure Diagnostics and Predictive Maintenance of Electrical Machines in a Networked Vehicle System
- StreetProbe - Cooperative Cloud-Based Road Condition Monitoring
- Road Surface Reconstruction by Stereo Vision
- Full Life Cycle Optimized Control of Induction Motor based on Hybrid Intelligent Technology and MCU-Cloud Data Fusion
- USP - Universal Signal Processing

**Automotive Engine and Transmission Control**

- AI in Transmission Control – Clutch Engagement with Reinforcement Learning
- Optimizing Control Strategies of Embedded Systems Using Artificial Neural Networks
- Optimization of Iterative Online Methods for the Determination of Steady-State Data Driven Models in Terms of Combustion Engine Calibration

- Development and Optimization of Coordinated Control Strategy for Mode Transition in ECVT

and a summary of our teaching activities and the news from our workshops.

In the coming year, the School of Education (SETUB) will counteract the shortage of teachers, especially at vocational schools, with the further introduction of Q-Master programs (Master’s programs as a cross entry with a Bachelor’s degree). After the Q-Masters for the subject combination Electrical Engineering / Information Technology were successfully launched in 2016, there will be numerous additional offers in combination with the second subject Mathematics in 2019. This allows many students to study both the first and second subject at the TU Berlin.

There are also positive things to report from the Master’s program Automotive Systems. After the new study and examination regulations StuPO 2017 were started in 2017, the number of applicants and newcomers is developing very well. Thus, a total of 76 students were admitted for the winter and summer semester.

Unfortunately, all the gratifying developments were overshadowed by the tragic death of our colleague, Prof. Roland Baar. We have lost an outstanding researcher and university teacher who has extraordinarily pushed the interdisciplinary cooperation of the Faculty IV with the Faculty V of Mechanical Engineering and Transport Systems.

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
The project KFZ-Reibkupplung started in 2015 in cooperation with IAV GmbH. The project focused on research of new methods for predicting dry clutch wear. The resulting model is supposed to be capable of estimating friction lining abrasion and to predict future wear. As a result, the predicted wear values shall be integrated into the clutch control to control the dry clutch lifetime.

In the first half of 2018, a concept for lifetime prediction by using a moving average was developed and tested on real-time operating hardware similar to common transmission control units. The lifetime prediction extrapolates the trend of estimated dry clutch wear. A model was used or wear estimation, which was identified in 2017. Hence, the expected remaining useful lifetime can be predicted during operation.

As the next step, a control concept for guaranteeing a required lifetime was developed, which is called reliability-aware control. This control concept consists of two controllers. The first controller is called strategy-controller and controls the lifetime by setting the desired system behavior. In order to control the system lifetime, target trends for health index and predicted remaining useful lifetime were defined. To keep these target trends, a fuzzy-logic based controller was developed, which sets the optimization target for the underlying second control. The second controller is called behavior-controller. The behavior-controller controls the system behavior according to the demanded optimization target, which can change between comfort and wear minimization of an engagement. For this task, a model-predictive controller was designed.

Afterward, in the second half of 2018, the reliability-aware controls were verified by experiments on a transmission test bench. By verification, the capability of controlling wear and lifetime of a dry clutch was proven successfully. By this verification, the project was finished at the end of November 2018.
Condition Monitoring and Remaining Useful Lifetime Prediction of High-Performance Hydrodynamic Journal Bearings based on Acoustic Emission Analysis

Noushin Mokhtari (Publications 2018: [9], [10])

This research project is conducted on behalf of Rolls-Royce Deutschland Ltd & Co KG. It started in 2015 with the purpose of developing monitoring possibilities for future planetary gearboxes integrated in geared turbofans. This part of the project deals with the condition monitoring and remaining useful lifetime prediction (RUL) of high-performance hydrodynamic journal bearings (HJB) which are integrated in the planetary gearbox.

HJB wear as a result of mixed or boundary friction is the most essential damaging mechanism. To detect these friction conditions we placed our focus on the acoustic emission (AE) analysis in the past few years. The reason for this is the high sensitivity and the applicability of this method in real applications.

This year we were able to validate and improve our friction detection methods at the TU Clausthal HJB test bench which uses the potential oil and bearing material. One of the results was the good correlation between the friction torque and the AE features. With this information it can be assumed that it is possible to determine the friction torque from AE features. To validate this assumption further tests at our test bench are needed.

Previous tests at our HJB test bench only examined rotational speed and load variations while the oil temperature was constant. The oil temperature variation plays a significant role in the generation of mixed friction events and wear due to oil viscosity changes. So we decided to realize a temperature control. At this new temperature controlled test bench not only friction tests are going to be done. To make a statement about the RUL not only the detection of friction states is needed but also the actual wear height. Wear changes the sliding surface geometry so that the HJB loses its functionality above a certain wear height. For the next year it is planned to answer the question whether it is possible to determine the actual wear height of hydrodynamic journal bearings based on AE analysis. For this it is also planned to do long-term-tests and to measure the roughness and roundness with tactile measurement devices. It is also planned to validate and improve the developed methods at other test benches.
Sequential Design for the Identification of a Wear Model Based on a Gaussian Process  
José-Luis Bote-Garcia

The goal of this research project is to obtain an heuristic approach to identify a wear model for the prognosis of the wear. The approach is going to be tested on journal bearings with the new test rig.

The approach is based on Gaussian Process (GP) which can make predictions by estimating a posterior mean as well as a posterior variance for a given point. A GP is defined by a kernel function with hyperparameters and the training data. Those data points have to be collected from experiments.

A crucial part for every identification process is to collect enough and informative data. The estimation of the posterior variance by a GP is useful because it gives us a measure of uncertainty about a prediction. This feature is used under different names – Sequential Design, Near Optimal Sensor-Placement, Bayesian Optimization – for many applications with different objectives. All have in common that they use some kind of acquisition function which uses the estimated posterior variance of a GP upon other terms to determine the next spot to be evaluated by an experiment or a spot where a sensor should be placed. This acquisition function uses all data collected so far.

In the case of journal bearings we want to estimate the wear/ the abrasion. The input values of the wear model are the oil temperature, the load, the speed and the actual wear. The wear is going to be measured by dismounting the bearing and using a roundness measurement device.

Standard Design of Experiment approaches, where all points to be measured are fixed at the beginning, fail since we cannot tune the wear of a bearing in a natural way. For the Sequential Design it is not as important because it uses the data points collected so far to determine the next point to be evaluated.

In the first round the initial wear of the bearings under test will be measured. The first combination of load, temperature and speed to be applied will be chosen normally distributed. At the end the wear will be measured again. By means of the acquisition function and the collected data a new combination for the next round is determined for each bearing.
Condition Monitoring and Fault Diagnosis of Future Planetary Gearboxes in Aero Engines
Mateusz Grzeszkowski (Publication 2018: [3])

The co-operation partner within this project is Rolls-Royce Deutschland Ltd & Co KG. This project deals with the development of a condition monitoring system for Rolls-Royce’s trendsetting geared turbofan for civil aviation. This part of the project covers the monitoring of gear teeth damages like wear, pitting and tooth root cracks using primarily acceleration and acoustic emission sensors.

This year a pitting diagnosis system was developed to allow a differentiation between undamaged gears and gears with progressive pitting damage. The investigations showed that the diagnostic methods are robust against gear geometry deviations regarding the pitting detection capability. In the next step further pitting investigation tests will be performed accompanied by defined visual tooth flank inspections, to gain a reliable statement about the tooth surface condition to evaluate the monitoring methods.

Additionally a model-based estimation algorithm was developed to extract dynamic speed curves of a gearbox directly from acceleration sensor data. This algorithm will be applied next year on planetary gearbox test data to support vibration resampling methods. Furthermore in 2019 the vibration behaviour of potential planetary gearbox failures like misaligned planet gears will be examined on a planetary gearbox test bench and the developed monitoring functions will be evaluated regarding the robustness and failure separation capabilities.
Remaining Useful Life Estimation based on Compressively Generated Health Indicators and Wiener-Process Prediction

Christian Knöbel

To accurately and reliably predict component lifetime, it is crucial to find features that reflect the current health state of the system. Feature generation usually is based on time-, time-frequency- or frequency-domain methods, operating on data sampled at rates far exceeding the Nyquist-rate. However, due to high redundancy most of the computed features are discarded in a subsequent dimensionality reduction and feature selection step, making the whole process computationally inefficient and costly.

To overcome the aforementioned problem, Compressed Sensing (CS) is proposed as a feature generator that does not rely on Nyquist-sampled data, but works as an analogue to information converter. One key enabler for CS is signal sparsity, allowing fast and efficient sampling directly to a compressed space. As most artificial and natural signals are sparse or at least compressible in some domain, a considerable dimensionality reduction can be performed by taking only few linear non-adaptive measurements of the original signal using a suitable sampling system.

The prognostic approach itself is based on mathematical properties of CS stating a conservation of distinct signal characteristics during the compression step. I. e., it is assumed that failure and wear specific information can be retrieved from the compressively sampled data without the need for signal reconstruction (which would be the original purpose of CS). For generating a health indicator depicting the underlying component state, the highly condensed information in the CS coefficients is fused into a single value between 0 and 1 (not healthy, healthy) employing a Logistic Regression approach (red curve in the upper plot of the figure). To reflect the stochastic properties of the constructed health indicator, the remaining useful life (RUL) estimation is based on a Wiener-process. The model is parametrized at desired monitoring intervals using new degradation information as well as a combination of state-estimation and Expectation-Maximization (blue curve in the upper plot). Based on said parameter updating scheme, the RUL probability density function is recomputed leading to a quick convergence of the remaining life estimates (red curve in the lower plot of the figure, green is the true RUL).
Future work will deal with improving the whole process in terms of robustness and flexibility as well as quantifying compression (i.e. feature generation) influences on prognostic performance.

This project is in cooperation with Hochschule Konstanz für Technik, Wirtschaft und Gestaltung, Prof. Reuter.

**StreetProbe - Cooperative Cloud-Based Road Condition Monitoring**

**Daniel Weber, Daniel Adam**

The central idea behind the project StreetProbe is to develop a cloud-based system to detect road deterioration and its development over time. StreetProbe is sponsored by the Federal Ministry of Economics and Energy in the area of Smart Service World.

Modern vehicles already have several sensors on board, which are able to detect the road condition as well as the pavement surface distresses. After preprocessing and preclassification this data will be transmitted to a cloud platform. Based on this cloud data, damaged roads will be detected at an early stage.

To perform the measurements, a development vehicle provided by Daimler AG was equipped with sensors and extensive measurement devices. Utilizing the acquired sensor data, we have developed a real-
time classifier based on a support vector machine. We tested this real-time classifier with a Rapid Prototyping Hardware in real world driving scenarios. With this preclassification we are able to distinguish conspicuous and inconspicuous roads.

After the preclassification step we classified the conspicuous road sections in more differentiated classes like manhole cover, cobblestone, sleeping policeman.

The next step will be the classification of the damage type within the cloud. Since we do not have the possibility to do measurements with many different vehicles, we simulate them. Therefor we would like to thank the company IPG, which has provided us with the simulation software CarMaker. For the simulation we generated synthetic types of road surfaces and road damages, which we simulated with different kinds of vehicle classes. For the classification we used recurrent neural networks. Soon, with the help of our project partners DRC, BASt and 3D Mapping, we will expand our simulation to include real road 3D Models.

Supported by:

on the basis of a decision by the German Bundestag
Full Life Cycle Optimized Control of Induction Motor based on Hybrid Intelligent Technology and MCU-Cloud Data Fusion

Diwang Ruan

Owing to such numerous advantages as high reliability, high performance and simple design, induction motors have been widely used in many critical applications. Therefore, it is of significant economic value to achieve a remarkable improvement in the service life of the motor by accepting a small reduction in its dynamic performance. Based on the trade-off between above two factors, this project focuses on full life cycle optimized control of induction motors and it started in October this year. To realize aforementioned objective, three main problems will be investigated in detail.

1. On-line fault diagnosis based on hybrid intelligent technology.
   In recent years, intelligent methods like ANN, fuzzy logic and so on have been widely used in motor diagnosis, however, the diagnosis accuracy of a single intelligent technique is not high enough and the generalization ability is weak. In this project, different intelligent techniques will be synthesized and integrated according to the diversity and complementarity between them to improve the accuracy of on-line diagnosis.

2. Lifetime prediction modeling based on MCU and cloud data fusion.
   Fault prognosis and the remaining useful lifetime have much to do with a motor’s future working condition besides its present health state. Therefore, in this project, the motor’s future working condition will be predicted by characteristic parameter extraction from history data stored in the cloud. Meanwhile, with the MCU’s limited resources taken into consideration, complex models for life prediction will be also run in the cloud and simplified processed results will be sent back to the MCU.

3. Full life cycle optimized control based on MPC.
   Once the on-line fault diagnosis and lifetime prediction models have been finished and validated, MPC will be used to generate the control input to achieve the multi-objective optimization with respect to life prolongation and dynamic response.

   In autumn, a preliminary study and some simple modeling work have been conducted. Next year, the main focus will be on the first problem: fault diagnosis based on hybrid intelligent technology.
SicWell - Influence of SiC Inverters on the Lifetime of Traction Batteries

Daniel Weber

With an ever-increasing demand of electric vehicles the lifetime maximization of the most expensive part, the traction battery, is of great importance. With the emergence of silicon carbide inverters, a potential vehicle range increase of 5% could be achieved. For the battery lifetime 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 have to be extensively analyzed. The project SiCWell in cooperation with Daimler AG and Solfas Technologie GmbH aims to do just that.

Vehicle grade lithium-ion cells will undergo ageing tests in our battery laboratory. For this Solfas Technologie GmbH develops a battery tester that is able to load batteries with sine shaped and later representative noise currents. The results will be utilized in order to identify ageing mechanisms and design ageing models. Together with Daimler AG the design implications for vehicles electrical systems will be identified.

The aim of MDT lies in battery state of health diagnosis and remaining useful lifetime prognosis utilizing the current noise information. The developed algorithms will be integrated in an embedded system in order to demonstrate the applicability in electrical vehicles.

Development of Methods for the Failure Diagnostics and Predictive Maintenance of Electrical Machines in a Networked Vehicle System

Russell Sabir (Publication 2018: [11])

The focus of the PhD project is to do condition based monitoring (CBM) or predictive maintenance of the electrical machines used
as alternators in vehicles. CBM is carried out for the machine by monitoring its electrical signals e.g. current, voltage etc. to detect electrical short or open circuits, and by doing the lubricant or vibration analysis to detect the mechanical faults occurring in the machine bearing. Using this data, diagnostic functions can be developed and mounted on board in the electrical machine. The advantage of having these functions in the machine is that the machine condition can be evaluated at all times even during the machine operation. Secondly, the economic losses can be reduced that result from downtimes of the vehicles by planning the maintenance of the machine in advance. The approach that is being developed for the machine fault diagnosis is to collect large amounts of data from a healthy and faulty machine. The data consists of electrical signals from the machine’s sensors and vibration signal from the machine’s accelerometer. Then, Deep Learning algorithms are applied to extract the important features from the data to distinguish between a faulty and healthy electrical machine. The purpose of the Deep Learning algorithm is not only to detect the machine faults but also to localize it and determine the fault severity. Then based on the output of the fault detection algorithm the appropriate reaction is taken for scheduling machine maintenance.

This project is in cooperation with SEG-Automotive SG/EAT2

Road Surface Reconstruction by Stereo Vision
Hauke Brunken

For road maintenance it is important to possess current information about road conditions. This work focusses on gathering this information with the help of cameras, which are mounted behind the windshield of a vehicle. Since surface deformations cannot be detected on 2D images, stereoscopic cameras are utilized and depth information is acquired.

Last year the method of road surface reconstruction by stereo vision has been refined. The new method uses a single neural network, that retrieves the left and right camera images as input and creates a depth map as output in a single step. An example is shown in the Figure below.

The depth map is further processed in another neural network, where it is segmented and classified into different kinds of pavement distres-
The image of a stereo camera is processed into a depth map ses. This procedure makes it possible to capture large parts of road networks quickly and to automatically find the sections that need to be revised most urgently.

**USP - Universal Signal Processing**

Daniel Weber, Daniel Adam

Universal Signal Processing (USP) is a tool developed for and by the chair of electronic measurement and diagnostic technology. It offers an efficient way to filter and extract features from time signals. The filter and feature extraction methods, in the following simply referred to as filters, have a modular design, so they can be shared and stored in a central filter library. Every filter may have an arbitrary amount of parameters and may combine signals as needed. The output signals of filters may be used for other filters, enabling you to create complete feature extraction pipelines. The description of the way these filters will be applied to the time signals is stored in recipes as XML files. The time signals are stored in a standardized data structure specifically designed for USP.

In order to maximize performance and convenience USP is made of
a separate frontend and backend. The frontend lets you edit recipes by adding and parametrizing filters and choosing the corresponding signals. It can also visualize the filter and signal dependencies in a flow chart for understanding and documentation purposes.

The backend is the execution engine which applies a given recipe on a time signal file, saving the results in a new time signal file. Both, the frontend and the backend are written in python and are therefore platform independent. The backend provides a python script as well as a function for recipe execution, enabling you to integrate it seamlessly in your individual workflow. USP will have a great amplifying effect on our research. It provides us with an efficient way of sharing knowledge by exchanging recipes and filters we developed. Methods and data of research results over generations of research associates will be capitalized on more easily, reducing the initial learning time for new research associates.
Automotive Engine and Transmission Control

AI in Transmission Control – Clutch Engagement with Reinforcement Learning
Alexander Lampe

The vast progress in the fields of machine learning and artificial intelligence as well as the increase of computational power make AI methodologies also attractive to automotive applications. While the classical control theory is widely used in transmission control tasks, AI based control approaches like Reinforcement Learning (RL) can have several advantages in solving complex problems.

This project investigates the application of Reinforcement Learning to control the clutch engagement in transmissions like DCTs and AMTs, in which the friction clutch is used as the start-up element. The clutch engagement in a vehicle drive-off scenario is a challenging control task due to multiple criteria like comfort, spontaneity and friction wear, which have to be all considered in the control strategy. To fulfill those multiple requirements, it is common practice to develop a control strategy with heuristic methods in a simulation environment and then to adapt it to the real vehicle by manual calibration, where both, software development and software calibration, are iterating and time consuming tasks. There exist other control approaches like Model Predictive Control (MPC), which take multiple criteria into account by the use of a loss function. The loss function is then minimized on the embedded controller per time step to compute the control variable. While the optimization per time step has high computational costs and also requires a physical model of the real system, the Reinforcement Learning approach overcomes these disadvantages since the optimization and the physical representation of the system can be replaced by experience, which is gathered during execution and stored in an artificial neural networks. To gain initial experience, the RL controller is trained in simulation at first and then applied to the real vehicle where it adapts to the new environment by updating its initially gained experience.

This project is in cooperation with IAV GmbH.
The goal of this PhD thesis is to derive an optimal control strategy for an Exhaust Gas Aftertreatment system by defining engineering targets only. The technological advance within the automotive industry is progressing towards increasingly complex physical systems. Therefore, the process of building a good control strategy is becoming more resource intensive. To encounter those challenges, trained data driven models are becoming more popular. This is also due to the increase in computational resources and the simplification and optimization of machine learning frameworks.

This project will use a reinforced learning approach, trading the need for labelled data for a broader data pool and tests. Since these tests would be very expensive in the real world, the initial training will be done in a model environment. Using the method of transfer learning, the control strategy will then be fitted to the real world problem, decreasing the number of training iterations significantly.

In future automotive developing processes, this method could decrease the time needed for calibration. In combination with cloud services, online recalibration could become reality, ensuring an always optimal strategy with respect to certain objectives. By taking the step from calibration to training, different and more complex input data, such as weather forecasts, as well as traffic and route prediction data can be used to increase the system’s performance. The limited computational performance of embedded systems will be a challenge. In the still open field of transfer learning for time series, minimizing the number of real world tests is going to be a key task. Finally, securing the stability of the control strategy becomes much harder when using...
a trained, data driven approach. The work on the project has just started. The current focus is the creation of a fast computing and realistic model environment for initial training purposes. This project is in cooperation with IAV GmbH.

**Optimization of Iterative Online Methods for the Determination of Steady-State Data Driven Models in Terms of Combustion Engine Calibration**

Nino Pascal Sandmeier

The model based calibration process is a state of the art process for combustion engine calibration. Based on the Design of Experiments (DoE) methodology, the test design is created and measured at an engine test bench. To evaluate the engine behavior and create optimized calibration maps, data driven models such as the Gaussian Process Model (GPM) are trained on the data and subsequently used to identify optimized engine input positions related to e.g. the fuel consumption and the emission legislation.

Online methods are utilized to optimize the test design at the engine test bench and therefore improve the measurement information content. Two different areas of test design optimization are widely used for calibration purpose. Considering engine boundary information has a significant impact on the test plan quality. Furthermore, the test design can be improved by including the input relevance.

![Diagram showing non-convex exclusion area and validation RMSE over number of training points](image)

Regarding engine boundary information, this research focuses on a
geometric representation of engine boundaries by the convex set of the measurements. The furthermore non-convex area is excluded adaptively during the measurement to predict non-drivable operating areas. The model quality is improved iteratively by means of the input relevance information derived from the Gaussian Process training. More relevant inputs get a higher weight during a space filling test point selection. A test design focusing the main impacting actuators on the process outputs is the outcome.

This project is in cooperation with IAV GmbH.

**Development and Optimization of Coordinated Control Strategy for Mode Transition in ECVT**

Dengfeng Shen (Publications 2018: [12],[13])

The project “Support of the Development of HT2800 on Model and Advanced Algorithms” started in the beginning of 2017 in cooperation with Corun CHS Technology Co., Ltd.. The goal of this project is to improve the riding comfort and to address the oscillation during the mode transition from the electric driving mode to hybrid driving mode by developing and optimizing a new coordinated control strategy for a novel compound power-split hybrid electric transmission (CPSHET).

In the first half of 2018 a basic coordinated control system architecture as shown in above figure was built. It is composed of four
main parts: 1) driver demands interpretation; 2) engine demands calculation; 3) motor demands calculation; and 4) clutch demands calculation. The function of the driver demands interpretation block is to interpret the driver demand and produce a limited target wheel torque. The previously proposed Kalman filter (KF) based clutch torque estimator is also integrated in this block. The engine demands calculation block can realize the determination of the target engine torques during the different engine starting processes and the engine injection order. The motor demands calculation block is to determine the target motor torque by considering the limited target wheel torque from the driver demand and the target carrier angular acceleration during the different engine starting processes. The clutch demands calculation block is to achieve the target clutch torques by manipulating the solenoid valve during the different engine starting processes. The simulation result indicated that the proposed coordinated control strategy could indeed suppress vehicle jerk and improve the riding comfort.

In the second half of 2018 two second-order sliding mode controllers with super twisting algorithm were developed to replace the original PI controllers in the aforementioned basic coordinated control system so as to improve the robustness and trajectory tracing performance of engine speed and carrier speed. Meanwhile, an active damping algorithm was also integrated into the basic coordinated control system to further reduce the vehicle jerk. Afterwards, the multi-objective optimization algorithms were implemented to optimize the target engine speed and target carrier speed by considering the vehicle jerk, clutch wear and engagement time. The optimization results will be verified in the test bench or a real vehicle in the future.
News from Our Workshops: Electronic Service and Mechatronic Workshop

Frank Baeumer

In 2018 our chair made some major investments. Two new servers were ordered to improve our IT infrastructure and measurement devices for roundness and roughness to extend our measurement abilities. Our Mechatronic Workshop supported and modified our existing test benches and designed the mechanic part of our new temperature controlled journal bearing test bench. Our Electronic Workshop supported our research assistants and students in developing circuit boards, improved the electrical part of our test benches and supervised the IT infrastructure.

Temperature Controlled Journal Bearing Test Bench

This year our Journal Bearing Test Bench was extended with a control unit to regulate the temperature of the hydraulic oil in a range from 15 - 100 degrees Celsius. Therefore a new electronic cubicle was built and a mechanical carrier for the hydraulic components and the Journal Bearing unit itself was implemented. You can see the installation of these components on the image beside. The journal bearing itself, which is object of our research is located on the machine bed in the upper part of the carrier. In the lower part of the carrier you can see the new hydraulic block, which includes the heater for heating the oil, pumps to generate the required pressure, valves to control pressure and oil flow and sensors to get the corresponding actual values. At the moment the installation is still in implementing and testing phase, but it will be finished within the next weeks. Special thanks are due to the company Mechatronic System Engineering for the good cooperation.
Publications in 2018


Bachelor theses in 2018


Master and Diploma theses in 2018


Conferral of Doctorate

- On 16th of July 2018, Axel Kiffe successfully held his graduation talk with the title "Echtzeitsimulation leistungselektronischer Schaltungen für die Hardware-in-the-Loop-Simulation" in order to gain his doctorate (PhD) [7].

- On 17th of July 2018, Rudolf Lück successfully held his graduation talk with the title "Überwachung hybrider Schräggullager in Luftfahrttriebwerken" in order to gain his doctorate (PhD) [8].

Courses

Summer term 2018

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>Measurement Data Processing</td>
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<tr>
<td>Model-Based Software and Function Development</td>
<td>Lecture &amp; Laboratory</td>
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<td>Control and Regulation of Automotive Powertrains</td>
<td>Lecture</td>
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<td>Projects</td>
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<td>Lecture &amp; Laboratory</td>
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<td>Simulation and Technical Diagnostics</td>
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Winter term 2018/2019

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<td>Lecture &amp; Laboratory</td>
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<td>Tutorial</td>
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<td>Introduction to Automotive Electronics</td>
<td>Lecture</td>
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<td>Laboratory</td>
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<tr>
<td>Simulation and Technical Diagnostics</td>
<td>Projects</td>
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Awards

- Noushin Mokhtari: Best Paper Award, IEEE PHM 2018, [10]
- Noushin Mokhtari: 3rd place in the category "Publications" with the Rolls Royce Deutschland Engineering Innovation Award, [10]

Acknowledgements

We would like to thank the following partners for supporting our teaching and research activities by innovative products:

- Daimler AG - Vito E-Cell
- IPG Automotive - CarMaker
- Open Source Modelica Consortium\OpenModelica
- QTronic - Silver, Testweaver

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M.Sc. Daniel Strommenger
M.Sc. Daniel Weber
Doctorands
Dipl.-Ing. Eduard Bakhach (Daimler AG)
M.Sc. Sven Holzendorf (IAV GmbH)
M.Sc. Yi Huang
M.Sc. Christian Knöbel (Hochschule Konstanz)
M.Sc. Alexander Lampe (IAV GmbH)
M.Sc. Russell Sabir (SEG Automotive Germany GmbH)
M.Sc. Nino Pascal Sandmeier (IAV GmbH)
M.Sc. Marc Seimert

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

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