

# Seminar machine learning

## Summer Semester 2015

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- Time and place - Wednesdays, 17:10 - 18:50, Room E202
  - First presentation – May 13<sup>th</sup>
  - Last presentation – July 8<sup>th</sup>
  
  - The students are expected to give a 30 minute talk on the material they are assigned, followed by 15 minutes of questions.
  - The talk and the slides are allowed to be both English or German, but we strongly encourage the students to give the talk in English.
  - It is expected of the students to participate in the discussions.
  - **Important!** The content of the talk should exceed the scope of the paper, and demonstrate that a thorough understanding of the material was achieved.
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# Predictive Maintenance

- Methods and technologies helping to estimate the future condition of a system that is subject to degradation caused by normal operation.
- Minimize the long-term cost of maintenance activities while guaranteeing certain quality constraints.
- Condition-based Maintenance
  - Condition monitoring is used to provide continuous information on the status of the system
  - Repairs are performed to optimize long-term cost of use
- Prognostics and Health-Management
  - Continuous information collection to estimate a lifetime of a system
  - Eliminate or reduce factors affecting lifetime

# 1. Current status of machine prognostics in condition-based maintenance: a review

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- Gives an overview of the (2010) state of predictive maintenance.
  - Shows various types of prognostic models, summarizes trends
  - Type of observed systems: Mechanical
  - Presentation type: review
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## 2. Prognostics and Health Management of Electronics

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- Different approaches to enable and perform prognostics and health monitoring of electronic devices, with emphasis on specifics of electronic systems.
  - Type of observed systems: Electronics
  - Presentation type: review
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### 3. Multi component fault diagnosis of rotational mechanical system based on decision tree and support vector machine

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- Prediction of faults in bearings/shafts of rotating machinery, indicated by vibration.
  - Decision Trees are used for feature selection.
  - Extensive evaluation with the two SVM methods and four different kernels.
  
  - Type of observed system: Mechanical
  - Presentation type: paper presentation / intro to SVM
  - Problem type: Classification
  - Methods used: c-SVM and  $\mu$ -SVM, Decision Tree
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## 4. Application of support vector machine for equipment reliability forecasting



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- Prediction of reliability in CNC machines via Regression.
- Type of observed systems: Mechanical
- Presentation type: paper presentation
- Problem type: Classification
- Methods used: SVM

## 5. Development of smart sensors system for machine fault diagnosis

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- Smart sensors system including vibration, current and flux sensors are used for fault diagnosis of motors.
  - Equal performance to traditional sensors is shown.
  
  - Type of observed systems: Mechanical
  - Presentation type: paper presentation
  - Problem type: Classification
  - Methods used: SVM, LDA, KNN, RF – random forest
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## 6. Bearing fault prognosis based on health state probability estimation

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- Assess remaining life of bearings from gas pumps via SVM classification.
  - Health-state probabilities are used.
  
  - Type of observed systems: Mechanical
  - Presentation type: paper presentation
  - Problem type: Classification
  - Methods used: SVM
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## 7. One-class support vector machines—an application in machine fault detection and classification

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- Machine fault detection of electro-mechanical machinery based on vibration measurements using new 1-class SVM technique.
  - Type of observed system: Mechanical
  - Presentation type: paper presentation / 1-class SVM
  - Problem type: Classification
  - Methods used: 1-class SVM, MLP – multi-label perceptron
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## 8. Fault detection and diagnosis in process data using one-class support

- A one-class SVM is used to determine a non-linear distance metric comparable to Principal Component analysis (PCA) and dynamic PCA.
- A feature selection based on a SVM method is conducted and the evaluation is done on a benchmark dataset as well as a real world dataset.
  
- Type of observed system: Electronics, chemical
- Presentation type: paper presentation
- Problem type: Classification
- Methods used: 1-class SVM, PCA

## 9. Power Wind Mill Fault Detection via one-class ny-SVM Vibration

- Uses simulated as well as real-world data to built a prediction mechanism based on vibration measurements.
- Type of observed system: Mechanical
- Presentation type: paper presentation
- Problem type: Classification
- Methods used: 1-class SVM, ANN

# 10. Improving Rail network velocity: A machine learning approach to predictive maintenance

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- Historical detector and failure data as well as weather data and maintenance information is used to build failure prediction models with the goal to increase network velocity.
  - Type of observed system: Mechanical
  - Presentation type: paper presentation
  - Problem type: Classification
  - Methods used: Rules
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# 11. Towards a Machine Learning Algorithm for Predicting Truck Compressor Failures Using logged vehicle data

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- A new rule induction method is introduced with the goal to better capture important dependencies in time-ordered sequences of truck vehicle information.
  - Type of observed system: Mechanical
  - Presentation type: paper presentation
  - Problem type: Classification
  - Methods used: Rule induction
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## 12. Online monitoring and fault identification of mean shifts in bivariate processes using decision tree learning techniques

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- A decision tree learning model is proposed for the use in process monitoring and fault detection, while also giving information about the underlying subset of variables that imply the faults.
  - Type of observed system: Mechanical
  - Presentation type: paper presentation
  - Problem type: Classification
  - Methods used: Decision tree
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# 13. Developing Data Mining Based Prognostic Models for CF-18 Aircraft



- Based on sensor and maintenance data of the CF-18 Aircraft, a generic prognostic model is built, and the steps included are shown.
- Type of observed system: Mechanical
- Presentation type: paper presentation
- Problem type: Classification

# 14. A Data-Driven Approach for Monitoring Blade Pitch Faults in Wind Turbines



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- Blade failures are predicted by implementing a genetic programming approach and testing it against different scenarios.
- Type of observed system: Mechanical
- Presentation type: paper presentation
- Problem type: Classification



# 15. Diagnostics and Prognostics Method for Analog Electronic Circuits

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- Failed electronic circuits are used to build a model of how components respond to a test signal.
  - Filters are used to estimate remaining useful performance.
  
  - Type of observed system: Electronics
  - Presentation type: paper presentation
  - Problem type: Classification, prediction
  - Methods used: SVM, filters
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# 16. Machine Learning for Predictive Maintenance a Multiple Classifiers Approach

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- Multiple classifiers are trained with different prediction horizons.
  - This information is used to minimize expected costs of an operating cost based maintenance decision system.
  
  - Type of observed system: Electronics
  - Presentation type: paper presentation
  - Problem type: Classification, prediction
  - Methods used: SVM, KNN
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# 17. Fault diagnosis and prognosis using wavelet packet decomposition, Fourier transform and artificial neural network

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- Proposes a method to predict faults and degradation of mechanical components based on vibration signals, which are decomposed via wavelet packet decomposition and then used to train an artificial neural network.
  - Type of observed system: Mechanical
  - Presentation type: paper presentation
  - Problem type: Estimation
  - Methods used: ANN
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## 18. Hidden semi-Markov model-based methodology for multi-sensor equipment health diagnosis and prognosis

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- A Hidden semi-Markov model is used to identify the health-state of a component. The method is tested on real-world data from hydraulic pumps.
  - Type of observed system: Mechanical
  - Presentation type: paper presentation / explain HMM
  - Problem type: Estimation
  - Methods used: HMM
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# 19. Remaining Useful Life Estimation of Critical Components With Application to Bearings

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- A data-driven prognostics method is used to predict the RUL of a physical system. Hidden Markov Models and Dynamic Bayesian Networks are used for modeling. The method is tested on real-world data.
  - Type of observed system: Mechanical
  - Presentation type: paper presentation
  - Problem type: Estimation
  - Methods used: DBN – Dynamic Bayesian Networks
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## 20. Comparison of prognostic algorithms for estimating remaining useful life of batteries

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- Different, simple and complex approaches are described and compared in application to estimation of lifetime of batteries. Also, the model of battery degradation is described.
  - Type of observed system: Battery
  - Presentation type: paper presentation
  - Problem type: Estimation
  - Methods used: RVM – Relevance Vector Machine, filters
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# 21. Continuous-Time Predictive-Maintenance Scheduling for a Deteriorating System

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- Describes how optimal inspection and replacement policy can be achieved given a specific stochastic deterioration process.
  - Type of observed system: Mechanical
  - Presentation type: paper presentation
  - Problem type: Decision
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## 22. Optimal replacement under partial observations

- Derivation of optimal replacement policy for a system described by three states: normal, warning and failed. The system can only be observed using indirect measurements.
- Type of observed system: Any
- Presentation type: paper presentation
- Problem type: Decision
- Methods used: HMM



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## 23. An adaptive machine learning decision system for flexible predictive maintenance

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- An adaptive PM approach is presented based on opportunity and risk costs by using PCA & regularized regression where the application is semiconductor manufacturing.
  - Type of observed system: Electronics
  - Presentation type: paper presentation
  - Problem type: Decision
  - Methods used: PCA, regression
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## 24. Multi-sensor data fusion using support vector machines for motor fault detection

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- Treating each single sensor of a multiple sensor system as evidence for motor faults, a hybrid model using SVMs as well as Short Term Fourier Transform techniques is built.
  - Type of observed system: Mechanical
  - Presentation type: paper presentation
  - Problem type: Classification
  - Methods used: Hybrid
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## 25. Learning to predict train wheel failures



- To predict train wheel failures different ML methods are employed such as automatic labeling, feature extraction, model building and fusion as well as evaluation.
- Type of observed system: Mechanical
- Presentation type: paper presentation
- Problem type: Classification

## 26. Data fusion data mining-based architecture for condition-based maintenance

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- A generic condition-based maintenance solution is presented which is relevant across different domains.
  - To do so, a combined data fusion/data mining approach using machine learning at several steps is employed.
  
  - Type of observed system: Any
  - Presentation type: paper presentation
  - Problem type: Architecture
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