Department of Automation Technology and Learning Systems
Faculty of Electrical Engineering
FH Südwestfalen - Soest

Prof. Dr.-Ing.
Andreas Schwung
Facts

- Head: Prof. Dr.-Ing. Andreas Schwung
- 10 Assistants (MSc.) – PhD-candidates
- 2 external PhD-candidates (MSc.)
- approx. 40 BA/MA in Lab during 2020

- Laboratory equipment:
  - Industrial robots (SCARA + 6-DOF-Robot)
  - Plant for bulk goods with transportation and dosing technology
  - Prototype for peristaltic singulation and sortation machines
  - High Bay Storage System
  - Mobile Robot
  - Collaborative robots
Research activities

Research is devoted to the following core points:

- Self learning automation systems and control
- Intelligent data analytics and machine learning
- Mechatronic system design / discrete element method
Research activities
Self-learning Automation Systems

➢ Self configuration and reconfiguration of control systems
➢ Self learning/self optimization in distributed production systems
➢ Self-Planning in Manufacturing Scheduling
➢ Development of PLC-function blocks for self-learning systems / advanced control methods
➢ PhD-Topics:
  ➢ Energy management in distributed production systems via a combination of Reinforcement Learning and Game Theory
  ➢ Reactive Distributed Job Shop Scheduling in Manufacturing Processes
  ➢ Self-Learning Control Systems for 3D Printed Individualized Robots
  ➢ Peristaltic Transport of Bulk and Packaged Goods
Objective:
➢ Distributed autoadaptive system for industrial energy optimization using deep reinforcement learning and game theory

Challenges:
➢ Energy flow modeling and simulation in complex industrial systems using Simulink
➢ Distributed, self-optimizing system design
➢ Reinforcement learning of optimal energy profiles
➢ Game theoretic approaches for distributed optimization
➢ Simulation-based training of data-based control algorithms
➢ PLC-ready implementation
PLC-informed Reinforcement Learning
Research, Development and Prototyping

Objectives:
➢ Self-Learning Control of industrial plants, machines and equipment by making PLC code learnable

Challenges:
➢ Making PLC code adaptive, self-learning and self-optimizing
➢ Learning optimal control parameters, control sequences and operation mode changes using RL
➢ Distilling hardcoded PLC-programs into neural networks to make it learnable
➢ PLC-ready implementation
Objective:
➢ Reactive Distributed Production Scheduling using deep reinforcement learning

Challenges:
➢ Reactive Production Scheduling
➢ Distributed, self-optimizing system design using graph networks
➢ Scalability to high dimensional production environments
➢ Incorporation of data analytics (e.g. predictive maintenance, future sales prediction etc.)
➢ MES-ready implementation
Gentle Singulator for 3D bulk of piece of goods 
Research, Development and Prototyping

**Objective:**
- Prototype which is able to singulate gently piece of goods by using peristaltic wave movements

**Challenges:**
- DEM Simulations (C++ Programming)
- Mechanical design and actuation
- Sensors (Camera Tracking)
- Data based control using reinforcement learning
- Policy learning for transportation, singulation and sortation
- Curriculum learning using combined Matlab/Simulink and DEM simulation
- PLC-ready implementation
Self-Learning Control of 3D-Printed Robots
Research, Development and Prototyping

Objectives:
➢ Self-Learning Control of individually configured industrial Robots for individual applications areas

Challenges:
➢ Training of optimal Movement profiles using Simulations
➢ Working with different sensor equipment (Force-Moment vs. Camera)
➢ Working with different actuation equipment (Gripper, Tool)
➢ Fulfillment of individually defined tasks
➢ No programming required!

Quellen: Universal Robot
Coordination Control of Industrial Robots
Research, Development and Prototyping

Objectives:
➢ Self-Learning Coordination Control of industrial robots for individualized application areas

Challenges:
➢ Training of optimal movement profiles and movement primitives using Simulations
➢ Connection to simulations environment to be used as co-simulation
➢ Coordination among multiple robots to accomplish different tasks
➢ Optimal coordination in terms of various targets
➢ Fulfillment of individually defined tasks
➢ No programming required!
Objectives:
➢ Reduction of set-up times for digital twins using machine learning

Challenges:
➢ Setting-up as well as parameterization of digital twins in general time-consuming tasks
➢ Reduction of set-up times by automatic generation of digital twins based on previous experiences
➢ Automatic parameterization of digital twins using transfer reinforcement learning approaches
➢ Implementation in HIL-demonstrator
Research activities
Intelligent Data analytics and Machine Learning

- Big Data analytics for production data
- Implementation in PLC and IT- and data base systems

Application areas:
- Condition Monitoring
- Energiemanagement und Optimization
- Predictive maintenance
- Process- and Quality optimization
- Knowledge transfer systems

Research-Topics:
- Information fusion of heterogenous Information sources of expert knowledge and process data
- Deep Neural Networks and Deep Learning for Condition Monitoring and Predictive Maintenance
- Semi-Supervised Learning for Anomaly-Detection in Industrial Processes
Manufacturing assistance systems
Research, Development and Prototyping

Objective:
➢ Manufacturing assistance system and heterogeneous information fusion

Challenges:
➢ Interactive, scalable and modular assistance system
➢ Data processing and automation platform for world-wide services (Cloud-Platform)
➢ Heterogeneous information fusion
➢ Expertise acquisition and translation
➢ Information assistance for operators via virtual/mixed reality (Apps, Smart Glasses…)
➢ Web Application for Condition Monitoring and Fault Diagnostics
➢ Fault Diagnostic Assessment: Historical Data and Machine Learning
Objective:
➢ Application of Deep Neural Networks to Condition Monitoring and Predictive Maintenance

Challenges:
➢ Prediction of future machine damages
➢ Application of deep learning structures like autoencoders, stacking networks etc.
➢ Learning of degradation patterns using big data analytics
➢ Efficient and easy-to-use algorithms for machine learning
➢ PLC-ready implementation
Objective:
➢ Semisupervised Learning using generative Deep Neural Networks for Condition Monitoring and Predictive Maintenance

Challenges:
➢ Prediction of future machine damages
➢ Learning of degradation patterns using big data analytics
➢ Application of semi-supervised learning algorithms
➢ Approaches suitable for highly unbalanced data sets
➢ Efficient and easy-to-use algorithms for machine learning
Reference projects – Industry Transfer – Research
Department of automation technology - selection

➢ H2Energy – Center for hydrogen mobility – energy management for hydrogen drive trains using machine learning methods (project with different industrial partner, MKW NRW)

➢ Assistence and Process Monitoring System für Peeling Maschines - Development of modular ML-Functions für Maintenance-Assistance, Set-up Time Optimization and Planning Assistance (project with machine manufacturer, ZIM)

➢ Collaborative, cooperative and self-learning robot platform (project with Automation-Company, ZIM)

➢ Development of a knowledge transfer system for complex manufacturing processes (hot metal forming) (project with prod. company + IT-company, BMBF)

➢ Production planning and Anomaly Detection using RL and ML-Methods (project with MES-manufacturer, ZIM)

➢ Self-optimizing power-guided heat networks using load and energy price predictions (project with energy provider, ProgresNRW)
Reference projects – Industry Transfer – Consultance

Department of automation technology - selection

- Automation of data preprocessing for data engineering at rolling stands (project with prod. SME)
- Analysis, Revision and Extensions of a system for MDE/BDE (project with prod. SME)
- Automation and Standardization in the automation of production lines (various projects with machine- and plant manufacturers)
- Development and implementation of a semi-autonomous operation of heat networks (project with energy provider)
- Development of a system for ML-based condition monitoring in pumps (project with pump manufacturer)
Automation Technology
Any Questions?

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