Robot Cognition in Disassembly-
Advanced Information Processing for an Adaptive Dismantling Ecosystem

ADAPTIVE 2020 – ESES Track

Hendrik Poschman, M. Eng.
Ostfalia University of Applied Sciences
Faculty of Mechanical Engineering
Institute of Production Technologies (IPT)

Brief self-introduction

- Born 18.06.1992, in Brunswick, Germany

- Bachelor of Engineering (B. Eng.) Industrial Engineering, 2015
- Master of Engineering (M. Eng.) Automotive Production, 2018
- PhD-Student TU Clausthal since 2018 at the Institute of Mineral and Waste Processing, Waste Disposal and Geomechanics, Prof. Dr.-Ing. D. Goldmann

- Project Manager Engineering Changes at Volkswagen AG, 2015 to 2018
- Engineering Consultant since 2018
- Research Associate at Ostfalia University since 2018

- Expertise: industrial robotics, perception technologies and AI, automotive software systems, automotive production, certified scrum master

Content

Recycling 4.0

- Building a better World – the Motivation for Recycling
- Recycling 4.0 Environment
- Current Problems
- System Approach
  - Architecture
  - Modules and pilot system
  - Communication and information concept
  - Decision Making
- Conclusions

Building a better World – Motivation for Recycling

Recycling 4.0

[https://www.pexels.com/de-de/foto/person-arbeiten-funken-schweissen-73833/]

Transformation necessary!

Recycling 4.0 Environment

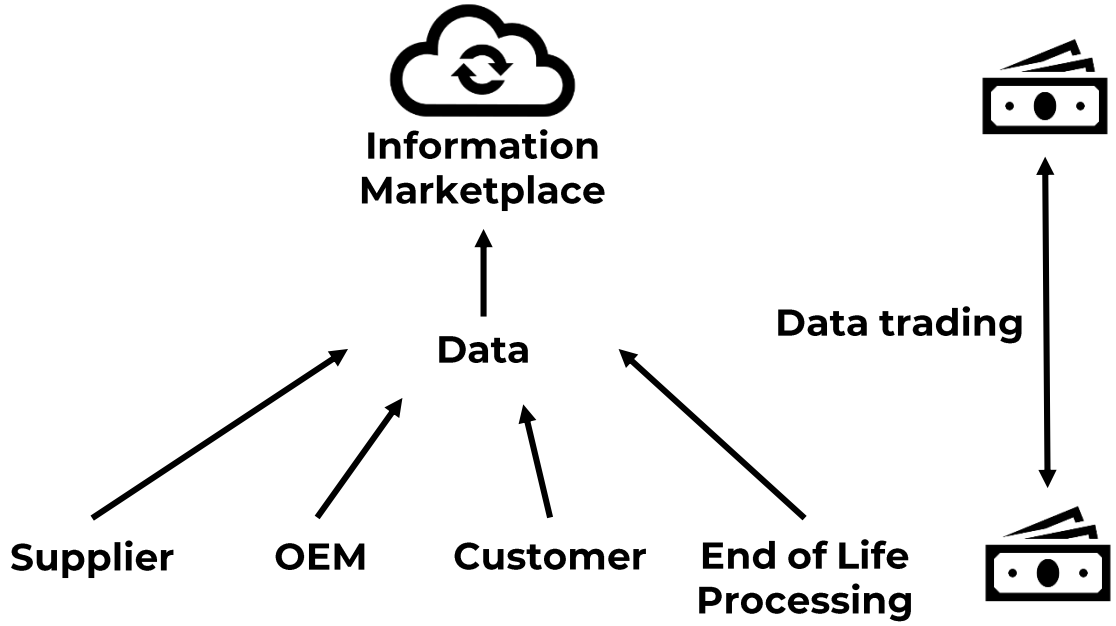
Recycling 4.0

TU Clausthal | Ostfalia Hochschule für angewandte Wissenschaften | Technische Universität Braunschweig

+ Industry

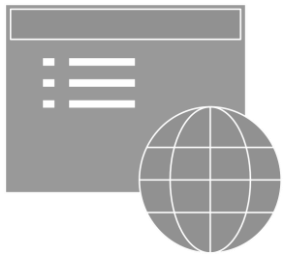
Example: Innovative Vehicle Systems (Traction battery)

[© Volkswagen AG, 2019]



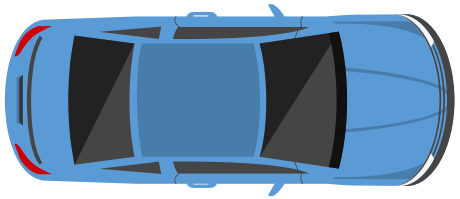
Current Problems

Recycling 4.0



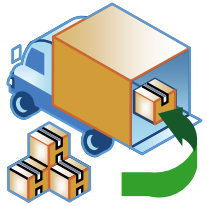
Information:
- Requirements
- Part history
- Components
- Location of valuable parts missing

Product:
- High number of variants
- Variety of product conditions
- Material diversity
- Damage risk
- Variety of connectors



Process:
- Flexibility
- High planning costs
- Low level of technology
- No optimisation
- Low average utilization

Workforce:
- High cost
- High fluctuation
- Low qualification level



Logistics:
- Transparency
- Cost
- Core-Availability
- Hazmat

System Approach

Recycling 4.0

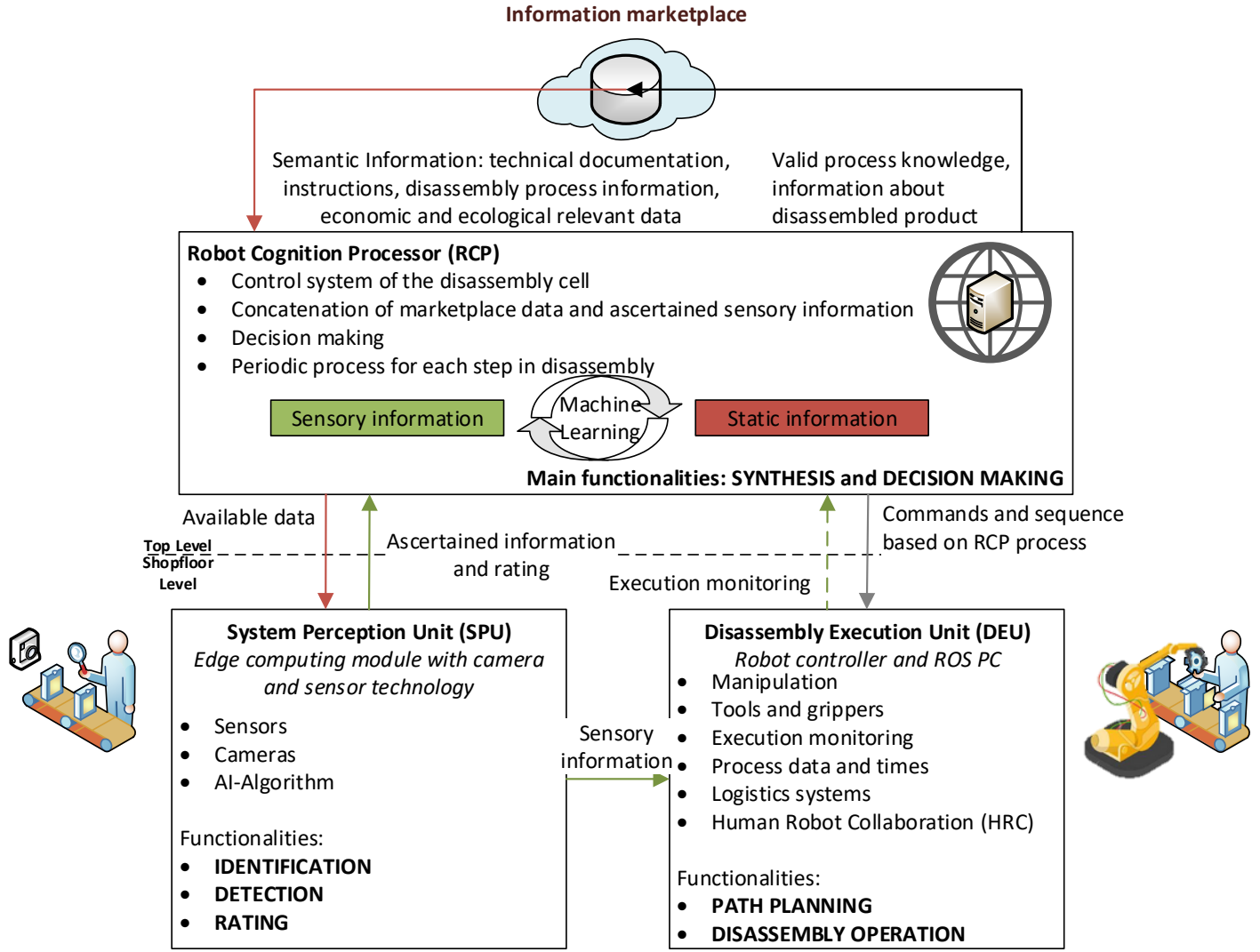
- Based on the various challenges in the recycling processes, a **lack of information** was identified as the root cause of the majority of inefficiencies and problems

- Requirements:
  - Connect the nodes of the value chain in an integrated information-driven environment
  - Make disassembly a key process step as first hands-on station
  - Increase feasibility of recycling by optimally allocating the relevant information
  - Create the possibility of knowledge acquisition and transfer

- Questions to be answered:
  - How could an advanced disassembly system look like?
  - Which sub-processes and information transfer methods are needed to run such a system feasibly?
  - How could a system decide autonomously about the end of life options on the basis of available data?

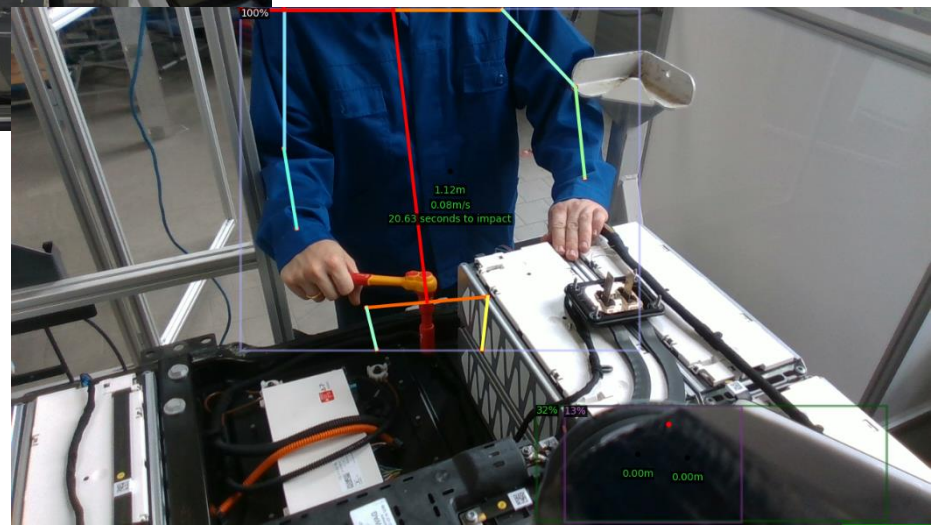
System Approach

- Disassembly system connected with superordinate data base and information marketplace
- Synthesis of individual static and sensory data to create the essential basis for decision making
- Multi agent system for each functional requirement group



System Approach

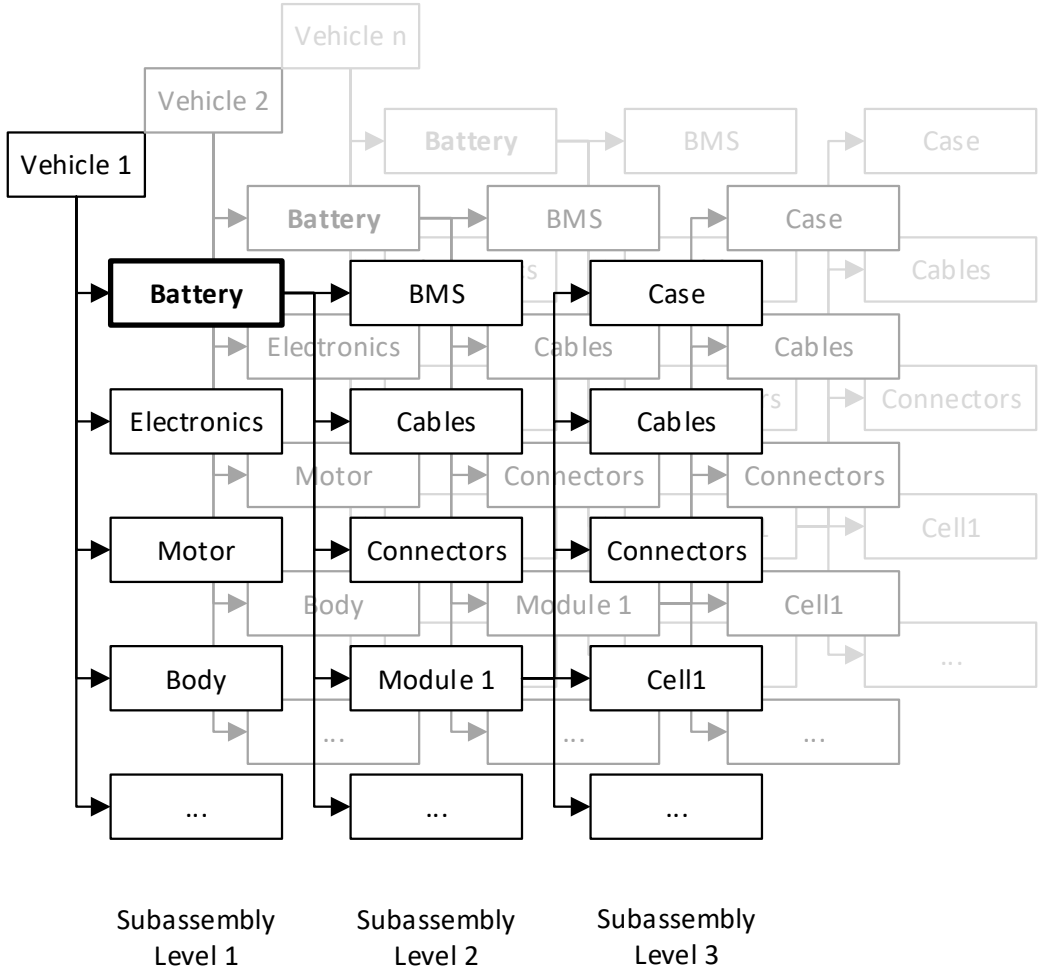
Perception Unit: **Screw Detection**



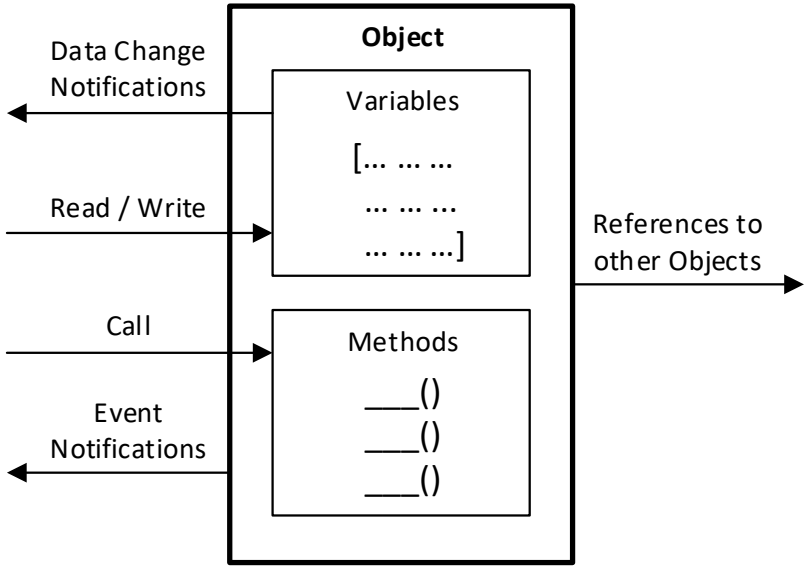
Perception Unit:

Workspace Surveillance

Product Information Model



Product Model Hierarchy in OPC UA Server

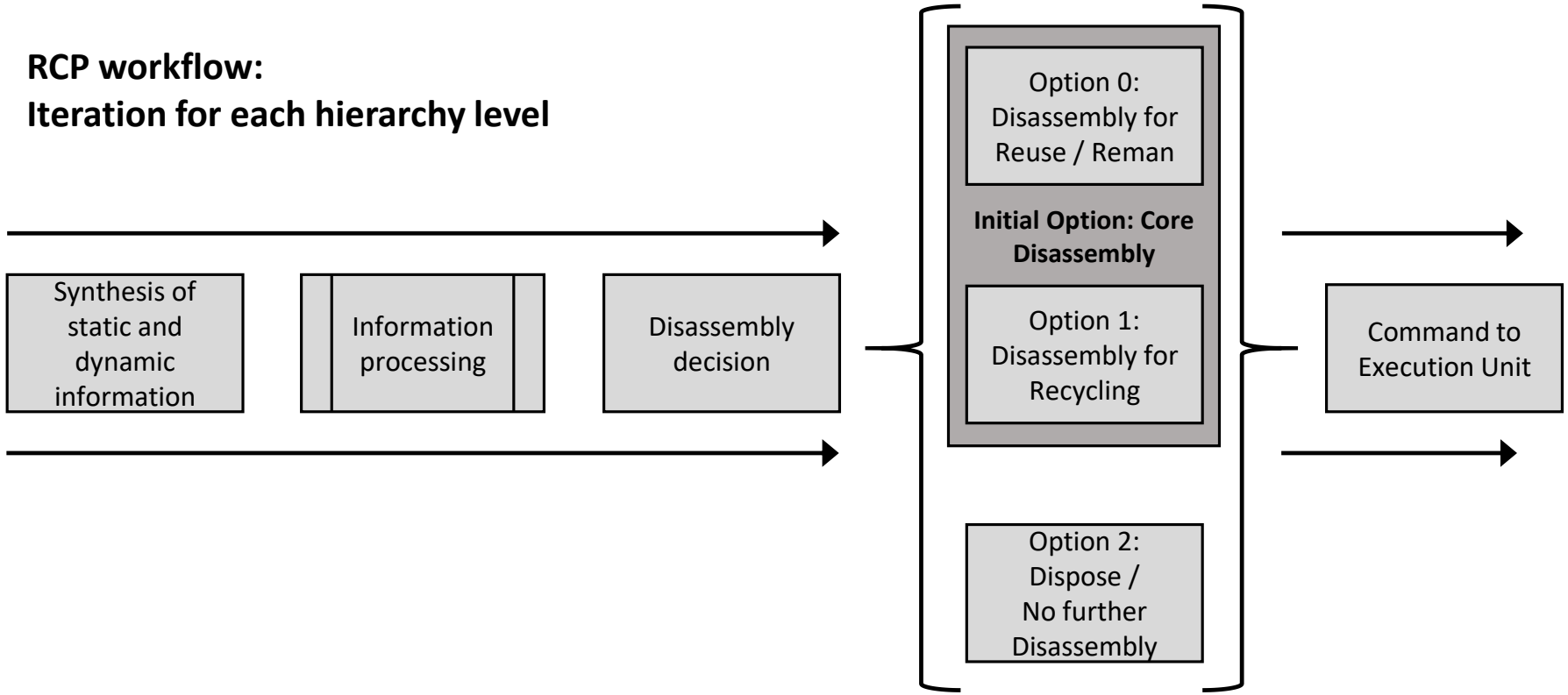


OPC UA Object Model Architecture

End of Life Decision Making

Recycling 4.0

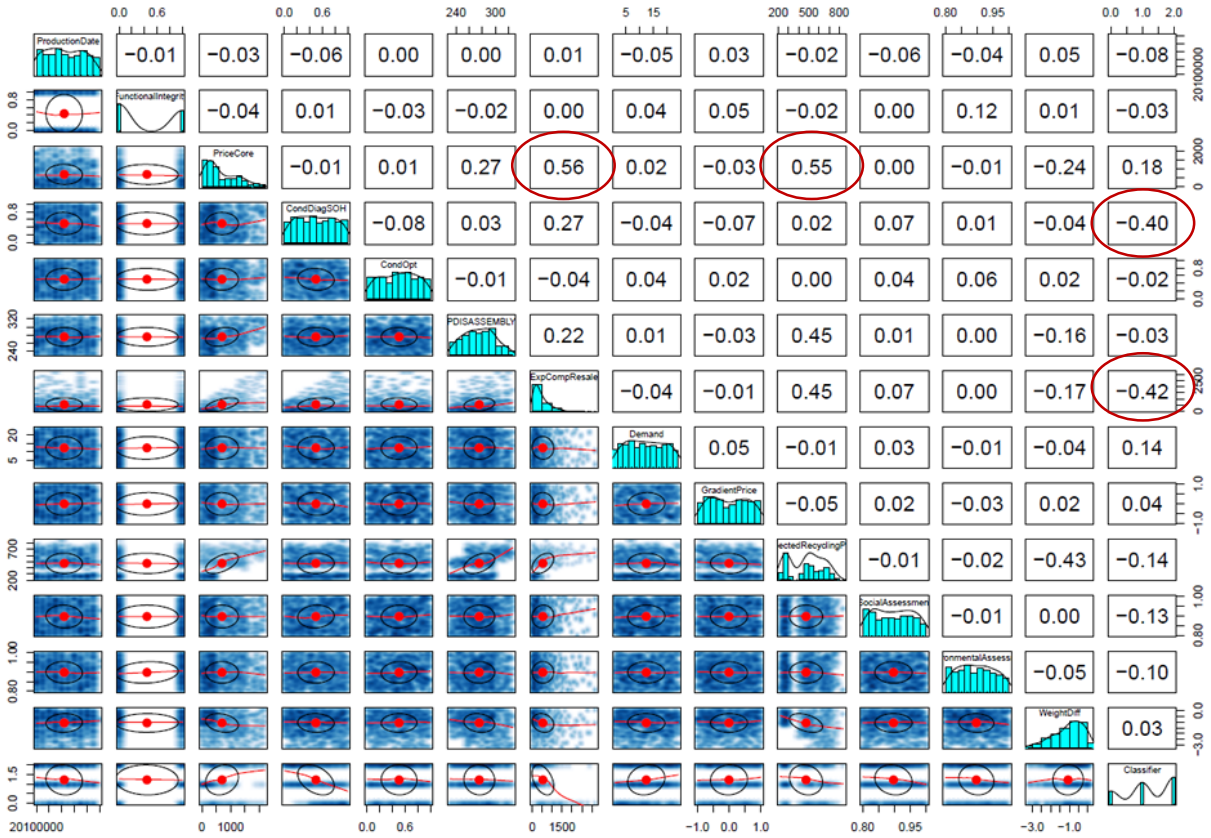
RCP workflow:
Iteration for each hierarchy level



End of Life Decision Making

Recycling 4.0

- Decision making processor for end of life option based on individual product information
- Neural network approach in order to create a flexibly weighted classifier capable of taking in high-dimensional dynamic feature maps (~5-10% advantage to gradient boosted tree models)

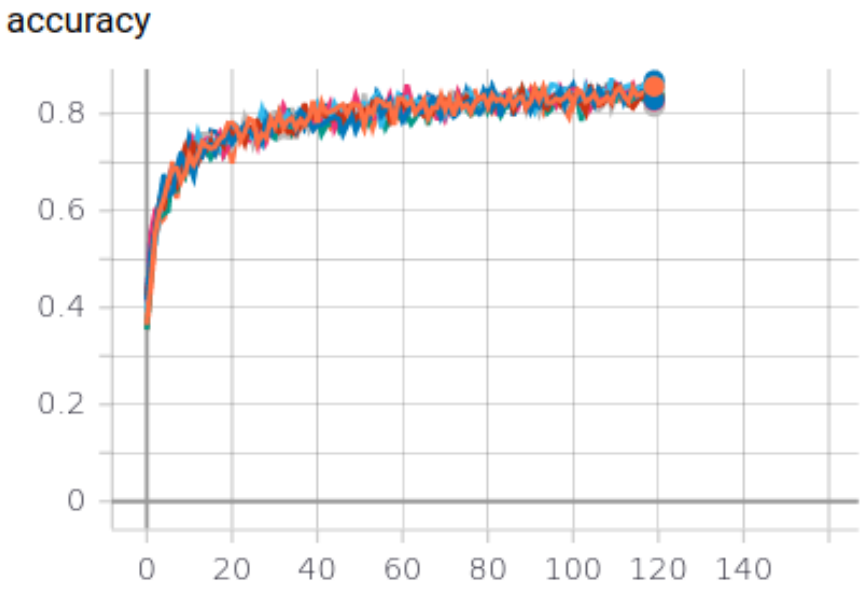


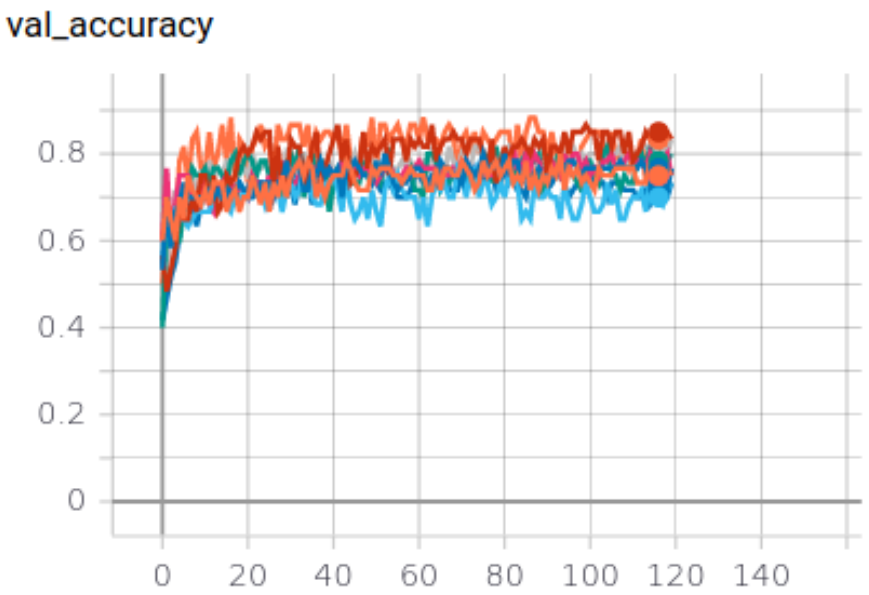
- Only few correlations in example feature set (generic batteries)
- Core price and component resale
- Core price and material recycling returns
- State of health and component resale are principal components of deterministic EoL decision

End of Life Decision Making

Recycling 4.0

- Fully connected NN
- Keras implemented, random Gaussian kernel initialization
- SGD, dropout 0.2 and 0.1, softmax classifier
- 77.96% +-3.91% on 9-fold cross valiadation, 600 samples (main problem is data acquisition!)





Conclusions

Recycling 4.0

- We presented an environment to provide the disassembly domain with an integrated solution for a connected and autonomous process management
- Multi agent system implemented for required functionalities
- The developed disassembly system is able to provide validated process knowledge, fostering the application of recycling by possible profit increase
- Hyperparameter optimization at decision module with genetic algorithms provides further improvement - current state of development at **86.4 %** accuracy
- Please follow our project on ResearchGate – new results regarding communication as well as the development of a demo-application and a holistic analysis of economic and environmental impacts of an advanced circular economy are subject of other contributions from Recycling 4.0

Thank you for listening - Any questions?

Recycling 4.0

... please feel free to contact me via e-mail: **he.poschmann@ostfalia.de**