Chair of Carbon Composites
TUM School of Engineering and Design
Technical University of Munich

AI, Digitalisation and Online Process Monitoring

Creating value for fibre composite applications through improved data generation, data management and data processing

The Motivation

The design, production and utilisation of fibre-reinforced parts requires a wide range of data to ensure a high-quality and cost-efficient end product. Modern digitalisation methods can be used to efficiently gather more data and find correlations that were previously unknown. This includes to:

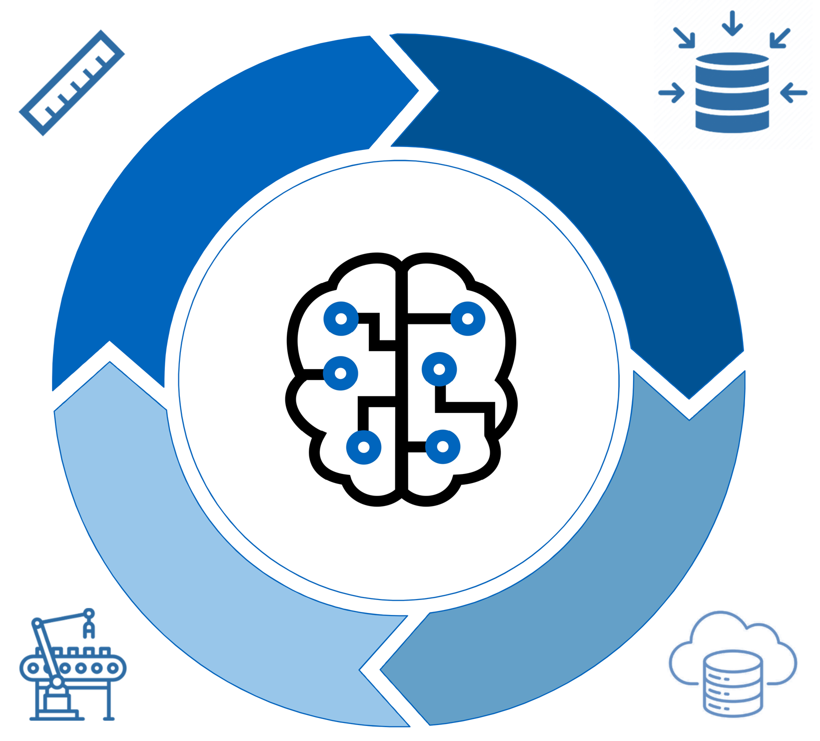
- bundle all available data,
- determine new sources of data,
- generate synthetic data,
- structure and store the data,
- interpret the data and
- make the data available.

Innovative Measuring Methods:

- high precision measuring techniques
- online monitoring of manufacturing processes
- quality assurance of components

Data Acquisition:

- implementation of sensors
- development of interfaces
- data preparation
- generation of synthetic data



Process, Material and Structural Optimisation:

- sensor-integrated structures
- digital product development
- identification and generation of digital twins

Data Processing and Storage:

- data-based modelling
- efficient data routes
- selection and setup of databases
- efficient data storage and big data

Fig. 1: Strategic fields of operation of the topic field AI, Digitalisation and OPM.

This information can be used to set up a digital twin – a virtual representation of the real process or part. Simulations using the digital twin can save cost- and time-intensive real-world investigations. This can generate an extended knowledge and identify potential areas for optimisation of the real process or part.

The Basics

Artificial Intelligence (AI)

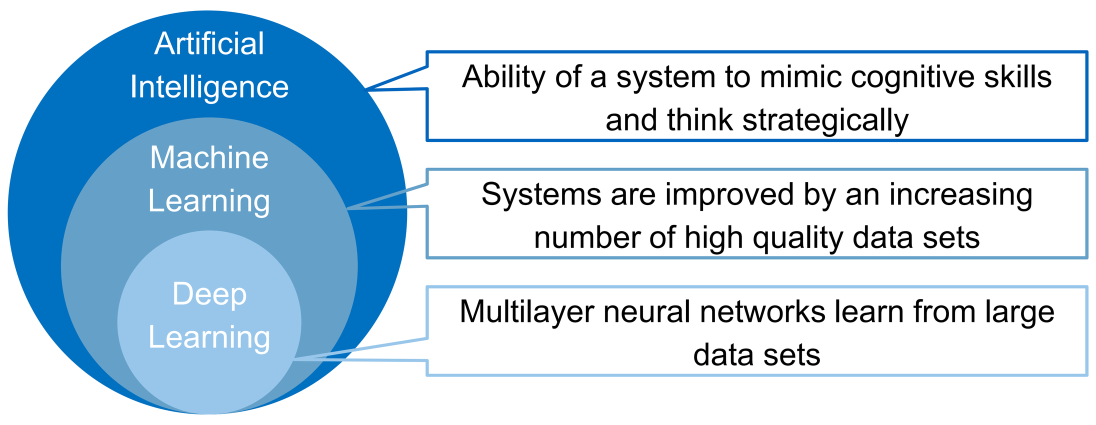


Fig. 2: Definition of AI and its sub-categories.

Digitalisation

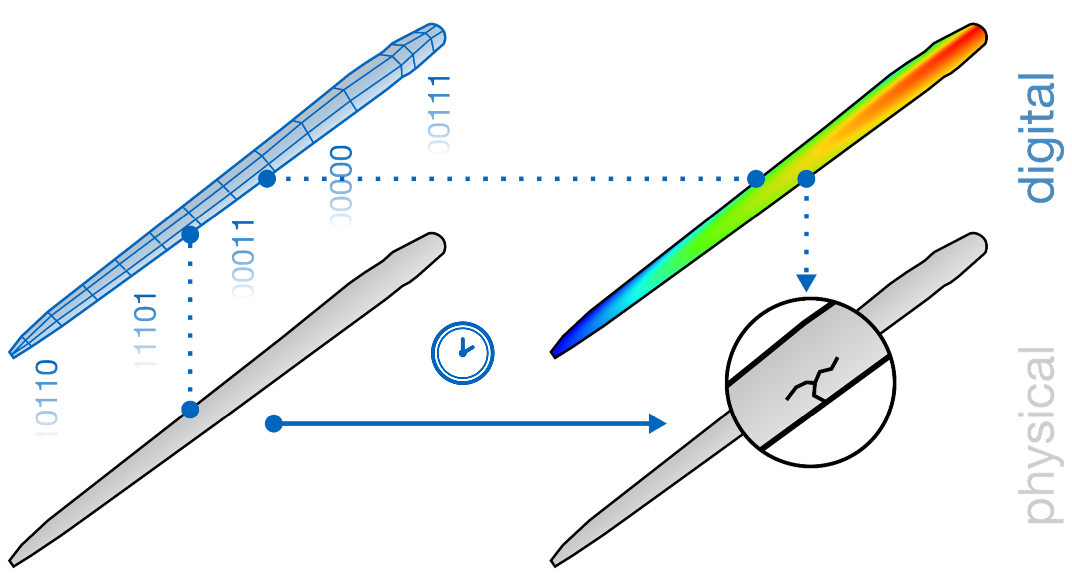


Fig. 3: Physical asset and its digital representation. Using a digital twin, the system behaviour can be predicted.

Online Process Monitoring (OPM)

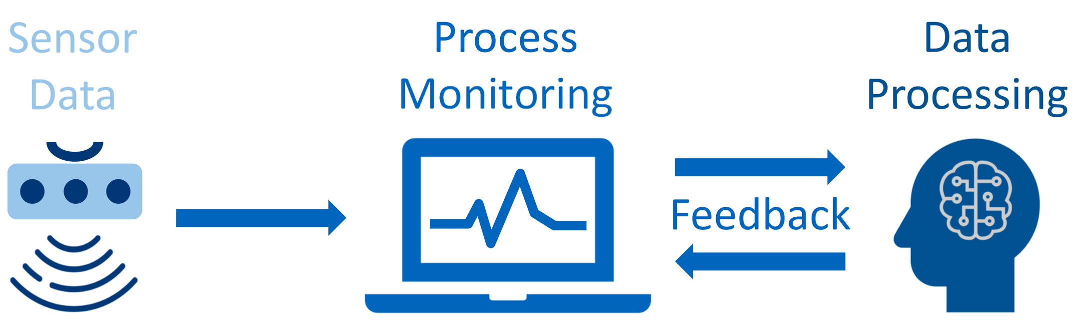


Fig. 4: Acquisition of varying sensor data during processing. This data is continuously monitored and processed (online) to allow for feedback to the monitoring system. The system can give suggestions on how to proceed with the part.

The Application

AI and OPM for Defect Detection

While OPM allows for a continuous acquisition of relevant process data, AI can be used to efficiently interpret and correlate that data. In the field of AI and OPM, the chair addresses the integration of sensory devices in production facilities for fibre reinforced polymers. Two examples are the detection of process defects during braiding fibre preforms and Automated Fibre Placement (AFP).

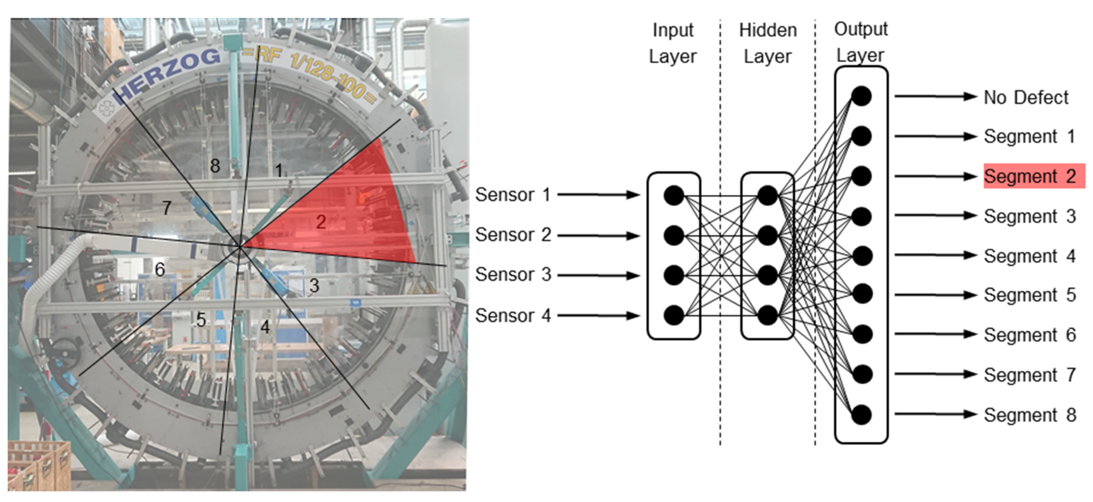


Fig. 5: Feed-Forward Neural Network (FFNN, type of AI) to determine the position of a defect in a braiding machine based on a sensor-integrated braiding ring with four pressure sensors (OPM).

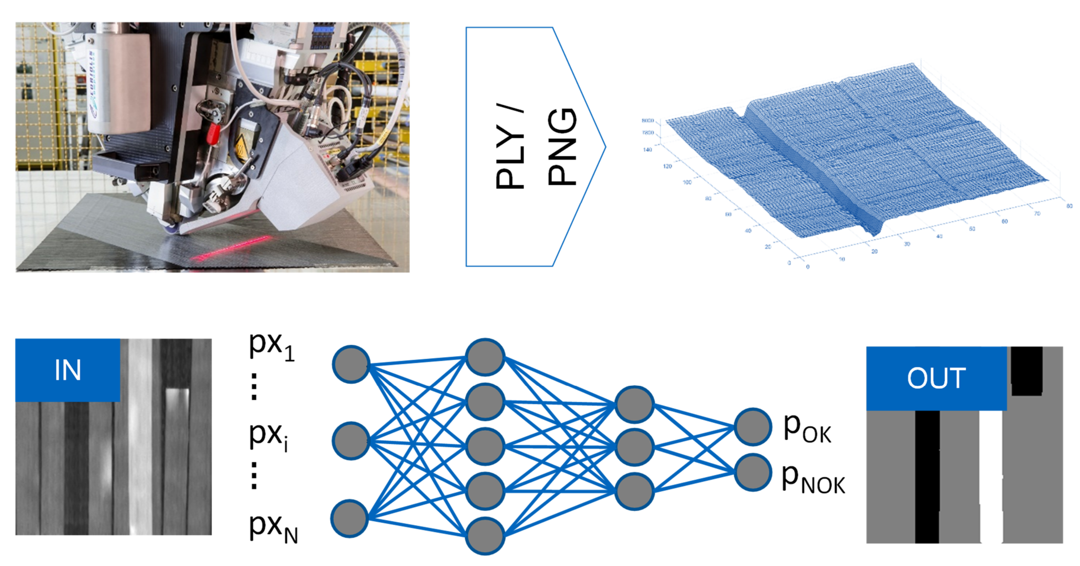


Fig. 6: Classification of OK / not-OK parts in AFP using a pre-trained Convolutional Neural Network (CNN, type of AI) based on height data from a laser line scanner (OPM).

Digitalisation for Material Behaviour

Combining modern simulation methods with real-world measurement data allows for an advanced insight into the material behaviour of composite parts during their entire lifecycle. The chair investigates this approach by developing a digital twin of a wind turbine blade. The data is organised in a formal material description (ontology) and the digital twin can be used to predict the history-dependent material behaviour.

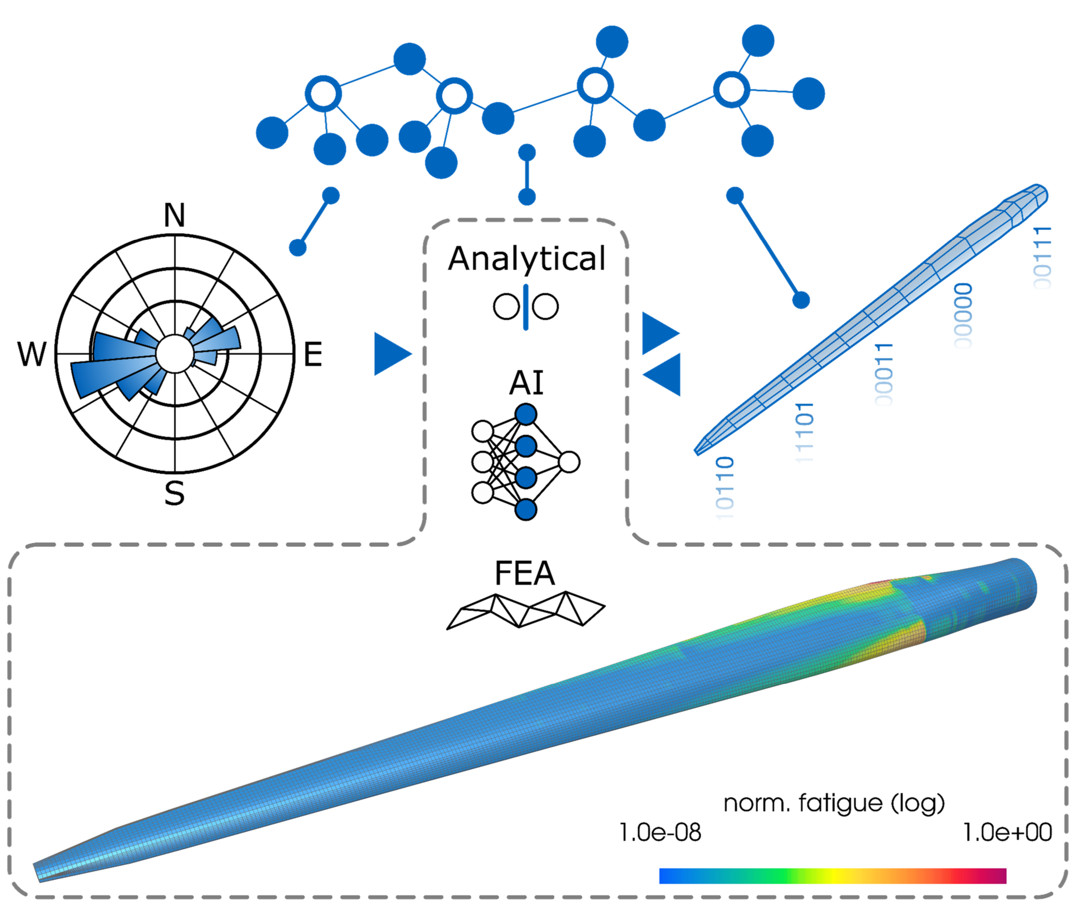


Fig. 7: Digital twin of a wind turbine blade and its augmentation with weather data. Using analytical, statistical (AI) and numerical (FEA) methods, the fatigue behaviour of the blade can be predicted.

More Information and Contacts: