MSc thesis Proposal

Edge Analytics for Real-Time Defect Detection in Laser Powder Bed Fusion

Metal additive manufacturing (3D printing) is a large and rapidly growing market. The main advantages of the technology are in creating complex geometries, consolidating assemblies into one piece, reducing weight and optimizing functional design. Machine learning (ML) algorithms as a part of artificial intelligence are actively and successfully applied in different steps of additive manufacturing especially in laser powder bed fusion technology (LPBF). The LPBF technology has more than 50 parameters that have an impact on the properties of built components. Applications of ML, such as support vector machines, decision trees, and shallow and convolutional neural networks, etc., to LPBF, have generally identified process anomalies by classifying process conditions from sensor data alone or based off post-build inspection techniques.

In this thesis, the student is expected to acquire knowledge about advanced manufacturing technology, understand neural networks performing with different data types for process flaws detection.

The main goal of the thesis is to deploy a **defect classification algorithm** together with the monitoring system for online classification of defects during the printing phase. To do so, the student is using an existing offline model and adapting it for deploying that model in an **edge platform** that is connected to the printer **machine monitoring system**. The tasks involve data processing in real-time for defect detection in Nvidia edge device or similar. Thesis work also includes checking the model for correctness and sensor faultiness as well as **drift detection**. Develop and analyse the generalizability of different algorithms. Develop the ability to solve complex tasks, manage and process large datasets. Well trained ML model will be used **in situ with the melting process** for desirable feature prediction. The most commonly used for LPBF is a **Convolutional neural network (CNN)**. This work will be performed with **connection to the material** and mechanical engineering department. Even if the performances of the different deep learning methods are quite fascinating, the quality engineering knowledge is still very relevant, especially if it is combined with suitable machine learning techniques.

<u>Possible areas of research:</u>

- Development of machine learning models for sensor-based process monitoring
- Validate models across different parts, builds, build positions and machines
- Connecting the printer to a real-time process monitoring system.

The main aim of this thesis is to develop and apply methods based on Machine learning to provide **generalizability of networks** related to the LPBF process. Demonstrate the ability of algorithms to improve the quality of the built parts or components at low cost and minimizing human interaction. Also, the realistic goal for this research is creating a flexible ML method that allows using various combinations of data from different facilities to achieve desirable properties of parts.

MSc thesis Proposal

Deep Learning-Based Sensor Fusion for Defect Classification in Laser Powder Bed Fusion

Metal additive manufacturing (3D printing) is a large and rapidly growing market. The main advantages of the technology are in creating complex geometries, consolidating assemblies into one piece, reducing weight and optimizing functional design. Machine learning (ML) algorithms as a part of artificial intelligence are actively and successfully applied in different steps of additive manufacturing especially in laser powder bed fusion technology (LPBF). The LPBF technology has more than 50 parameters that have an impact on the properties of built components. Applications of ML, such as support vector machines, decision trees, and shallow and convolutional neural networks, etc., to LPBF, have generally identified process anomalies by classifying process conditions from sensor data alone or based off post-build inspection techniques.

In this thesis, the student is expected to acquire knowledge about advanced manufacturing technology, understanding of neural networks performing with different data types for process classification. Working with large diversified data sets. Connect process variables to build part attributes using the available data set. Development of **cloud-based defect classification** algorithm. Develop and analyse the **generalizability of different algorithms**. Develop the ability to solve complex tasks, manage and process large datasets. The student is expected to develop and train a ML model that will be used **ex-situ** with the manufacturing process for defect classification, **process features extraction and analysis**. The most commonly used for LPBF is a **Convolutional neural network (CNN), k-nearest neighbours (KNN), Decision trees (DT), Support vector machines (SVM), Deep belief network (DBN)**. Perform and demonstrate multiple methods for **data fusion**. This work will be performed with connection to the material and mechanical engineering department. Even if the performances of the different deep learning methods are quite fascinating, the quality engineering knowledge is still very relevant, especially if it is combined with suitable machine learning techniques.

Possible areas of research:

- Sensor data fusion, data classification or clusterization
- Development of machine learning models for process simulation from the microstructure to the melt pool to the finished component
- Features extraction and material properties prediction.

The main aim of this thesis is to develop and apply methods based on Machine learning to provide **generalizability of networks** related to the LPBF process. Demonstrate the ability of algorithms to improve the quality of the built parts or components at low cost and minimizing human interaction. Also, the realistic goal for this research is creating a flexible ML method that allows using various combinations of data from different facilities to achieve desirable properties of parts.