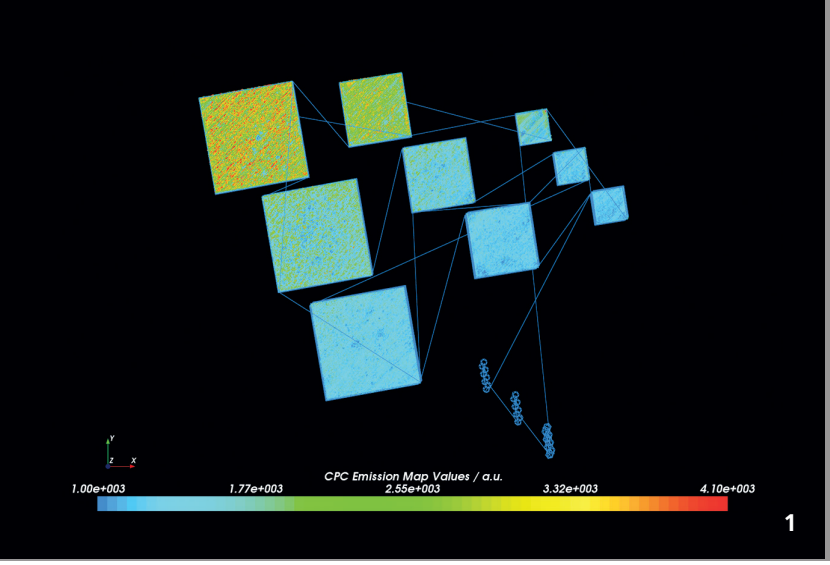
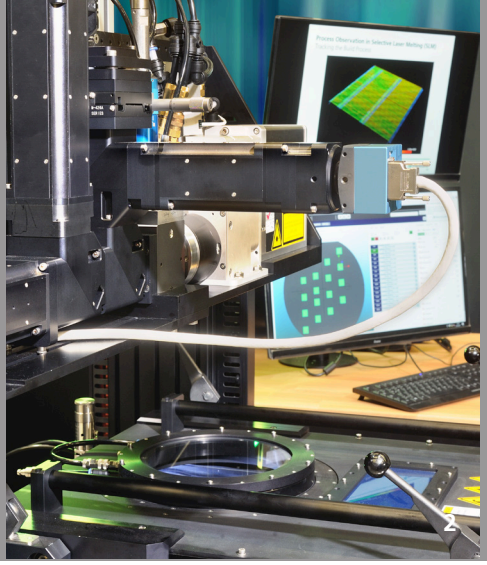


1



2

DEEP LEARNING FOR QUALITY DIAGNOSIS IN LASER MATERIAL PROCESSING

Task

Today's process observation systems make it possible to capture the interaction zone in laser material processing in multiple dimensions. This multi-dimensionality is achieved by high-resolution camera systems, which observe the process zone locally and/or resolve it spectrally. The resulting large amounts of data must be evaluated in a suitable manner in order to identify the current process status unequivocally.

Method

Today, neural networks can be used to processing sensor data because appropriate data processing systems have become available. Above all, graphics processing units (GPUs) make it possible to process large amounts of data in parallel and, thus, to create complex models.

After the neural network is defined structurally, a training phase is performed. In this phase, a large number (> 10,000) of process-specific examples of combinations of multidimensional measurement data and the associated process state are given to the algorithm. The free parameters of the model are optimized until the required prediction accuracy is achieved. The resulting model is then able to classify multidimensional measurement data into previously defined process condition classes based on specific learned characteristics. In the case of laser material processing, the process data can be divided into different classes, such as, for example, different process errors or quality gradations.

Results

For the simultaneous detection of the focus position and the supplied laser power, a convolution neural network (CNN) was defined and trained on a high performance GPU cluster. The IR image data was recorded during a welding process and combined with the corresponding process parameters, all of which serve as a database for model training. The application of the generated model shows that Deep Learning can extract specific image features that can predict the focus position and the laser power independently of each other.

Applications

In situ measurements and analyzes in the process zone make it possible to respond to deviations in the process by means of a downstream control strategy. For example, seam imperfections during welding can be identified in multi-dimensional process data. Overall, this sensor system enables users to develop data-intensive process monitoring concepts for different industrial applications.

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1 In-situ pyrometer data from one component layer.

2 LPBF system with integrated sensor system.