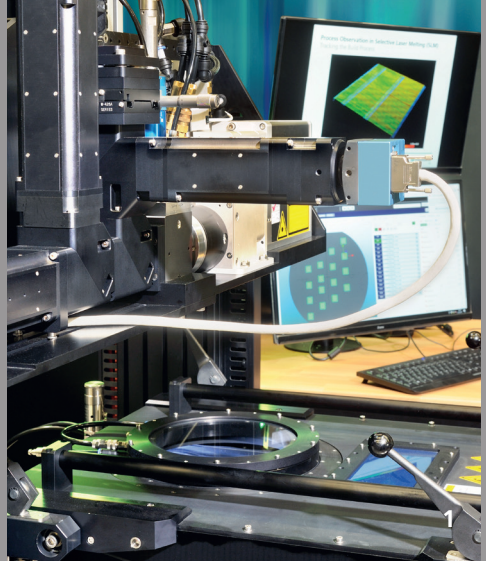

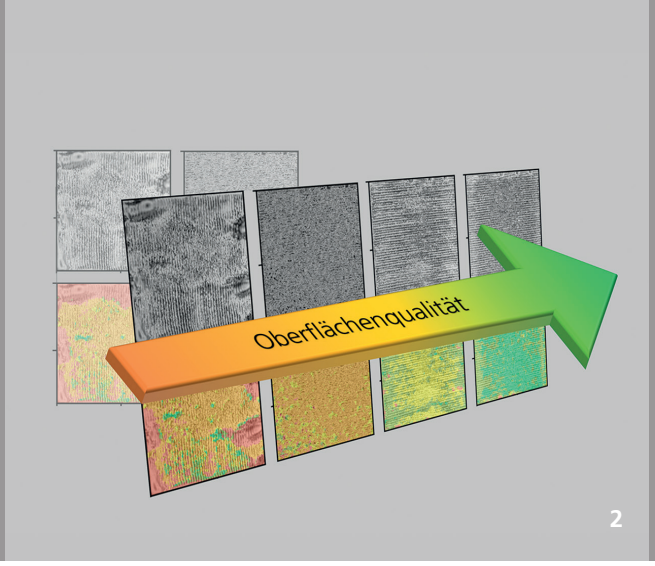

REINFORCEMENT LEARNING FOR THE OPTIMIZATION OF SURFACE ROUGHNESS IN LASER POWDER BED FUSION

Task

In addition to recognizing patterns in complex data streams, artificial intelligence can make further contributions to increasing the efficiency and quality of laser material processing. In practice, it has been shown time and again that unwanted deviations in component surface quality occur during laser powder bed fusion (LPBF) since a wide variety of variables influence the results. To compensate for such cross-layer process deviations, conventional control systems are often unsuitable for representing the complex interaction mechanisms in laser material processing due to the assumptions made during the design phase.

Method

Machine learning processes can provide a remedy by having an AI algorithm integrated into the machine learn an optimized strategy to meet the defined process goals based on real measurement data. To this end, Fraunhofer ILT is developing a process for laser powder bed fusion (LPBF) that first uses a convolutional neural network (CNN) to evaluate the surface roughness of LPBF components layer by layer using high-resolution HDR camera images of the component surface.

1 Experimental setup for in-situ process monitoring during LPBF.

2 AI-based roughness analysis of LPBF component surfaces.

In the next step, reinforcement learning (RL) is used for the software agent to learn a strategy so that it can set the process parameters for the next component layer. Based on the surface image data evaluated by the CNN, the agent learns how to select process parameters adapted to the situation, a selection that results in the lowest possible surface roughness and a low number of surface defects.

Results

The process has been tested on the basis of real data under laboratory conditions and shows that it successfully improves surface quality while needing only a few layer-by-layer parameter adjustments. In further investigations, Fraunhofer ILT will examine the ability of the system to automatically and continuously adapt the learned parameter strategy to new process situations and target variables.

Applications

The method can basically be transferred to other machining processes and also used to optimize as well as control a process in real-time if the measurement technology is adapted accordingly.

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