Laser Processing using Machine Learning for Real-Time Monitoring and Control

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The intensities available with modern lasers are sufficient for a wide range of processing challenges. There is now an emphasis towards making the laser machining process more efficient, increasing manufacturing productivity.

Here, we take advantage of recent developments in Machine Learning, specifically Neural Networks (NNs), in order to achieve real-time monitoring and control of laser machining via camera images of the work-piece. We demonstrate three techniques highlighting where NNs have applications in an industrial laser environment.

Firstly, we demonstrate a NN able to determine the type of material being machined, along with the number of pulses and laser power used [1]. Detecting material type has applications when removing a layer of unknown thickness, for example during laser-cleaning of rust.

Secondly, we show a NN, which detects transformations in the beam, specifically translation and rotation of the beam shape. Of particular interest here is the high level of precision achievable, as the NN can detect positional shifts below the pixel-size of the camera.

Thirdly, we demonstrate a NN able to cease laser machining exactly when a thin film is machined through completely, whilst also being able to predict the number of remaining laser pulses needed until breakthrough. This will alleviate the need for an excessive exposure time or laser power to ensure a process completes with near-100% certainty, whilst reducing the chance of damage to the work-piece through overheating or unintended material removal.

Although we demonstrate femtosecond laser machining on a size-scale of tens of microns, we anticipate that these techniques will be applicable to all forms of laser-based fabrication where imaging of the sample during machining is possible.

[1] Ben Mills, Daniel J Heath, James A Grant-Jacob, Yunhui Xie, and Robert W Eason, Image-Based Monitoring of Femtosecond Laser Machining via a Neural Network, JPhys Photonics (2018) IN PRESS