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ABSTRACT TITLE Combining Phase Field Modeling and Deep Learning for Accurate Modeling of Crystal Orientation in Solidification Microstructure obtained by Wire Arc Additive Manufacturing

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Processes such as wire arc additive manufacturing (WAAM) involve rapid solidification phenomena that significantly complicate the study and prediction of microstructures [1]. Accurate prediction of the solidification microstructure at the interfaces of the welding beads requires a full-field approach. Accurate knowledge of the transient temperature field during the rapid solidification is necessary to use such a model. Indeed, a coupled thermal equation with a phase evolution equation must be solved [2], [3]. In this work, a method is developed to accelerate computation time using data obtained from experiments and extracted through image recognition.

To avoid solving a coupled thermal problem, it is proposed to determine zones of morphological textures from contours of welding beads using optical images. The direction of the thermal gradient is also determined by using the same method. Then, the connectivity and continuity of these zones are studied using a convolutional neural network (CNN) method based on scanning electron microscope (SEM) images. Finally, modeling of the microstructure of a mm-sized weld bead is performed using Kobayashi-Warren-Carter phase field model [3], based on coupled solving of phase, temperature and crystallographic orientation variable. EBSD Images serve as input data to adjust and verify this latter method. A mapping of several neighboring beads is also performed with information derived from the previous tools.

The combined use of minimal experimental input, image segmentation and artificial intelligence-based phase field modelling leads to the following outcomes:

- the prediction of the crystal texture in the entire bead volume by a phase field approach,
- the phase field simulation of the interfaces between neighboring beads considering the real process chronology,
- a strongly reduced computation time.

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