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In materials science, it is well-known that the properties of manufactured parts depend on their microstructures, which are closely linked to the solidification and recrystallization pathways. Processes such as wire arc additive manufacturing (WAAM) involve rapid solidification phenomena that significantly complicate the study and prediction of microstructures.

Accurate prediction of the solidification microstructure at the interfaces of the welding beads requires a full-field approach. Precise knowledge of the transient temperature field during the rapid solidification of the « additive-manufactured » part is necessary to use such a model. Indeed, a coupled thermal equation with a phase evolution equation must be solved. In this work, a method is developed to accelerate computation time using temperature field data obtained from experiments and extracted through image recognition. This method also provides information on solidification microstructure using low-cost tools.

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, a total modeling of the microstructure of a welding bead is performed using Kobayashi-Warren-Carter phase field model, 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 informations derived from the previous tools.

