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A Novel Low-Dimensional Learning Approach for Automated Classification of 2-D Microstructure Data in Additive Manufacturing

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Novel production paradigms like metal additive manufacturing (AM) have opened many innovative opportunities to enhance and customize product performances in a wide range of industrial applications. In this framework, high-value-added products are more and more characterized by novel physical, mechanical and geometrical properties. Innovative material performances can be enabled by tuning microstructural properties and keeping them stable and repeatable from part to part, which makes microstructural analysis of central importance in process monitoring and qualification procedures. The industrial practice for microstructural image data analysis currently relies on human expert's evaluations. In some cases, grain size and morphology are quantified via synthetic metrics like the mean grain diameter, but these features are not sufficient to capture all the salient properties of the material. Indeed, there is a lack of methods suited to automatically extracting informative features from complex 2-D microstructural data and utilizing them to classify the microstructures. Aiming to fill this gap, this study presents a novel low-dimensional learning approach, where both the morphological grain properties and the crystal orientation distribution features are extracted and used to cluster real microstructure data into different groups moving from complex 2D patterns to a lower-dimensional data space. A case study in the field of metal AM is proposed, where the proposed methodology is tested and demonstrated on electron backscattered diffraction (EBSD) measurements. The proposed methodology can be extended and generalized to other applications, and to a broader range of microstructures.

Keywords

Microstructure data, low-dimensional learning, dimensionality reduction, clustering, additive manufacturing

Classification

Both methodology and application

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