A computer vision approach to predict powder flowability for metal additive manufacturing

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Abstract

Additive manufacturing (AM) is a transformative technology to many industries that enables the fabrication of parts with complex geometries. For the AM techniques using powder feedstock, powder packing behavior and flowability significantly affect the defect density, such as porosity, and, eventually, the reliability of as-built parts. Experimental characterization of these powder properties, such as Hausner ratio, Carr index, and angle of repose, is rather time consuming and cost inefficient. Here, we show a fast, low-cost, and reliable computer vision approach to predict powder flowability. We employ seven machine learning models to "learn" from the 2,000 scanning electrons microscopy (SEM) images of 16 types of powders commonly used in metal additive manufacturing. Our results indicate that the vector of locally aggregated descriptors (VLAD) model with speed up robust features exceeds by about 12% mean absolute percentage error (MAPE) value, which is at least 3% lower than traditional convolutional neural network model. The performance of all the models is robust to the changes of image brightness and contrast. This result verifies the established computer vision model can predict the flow properties of metal powder that does not exist in the dataset. Our study demonstrates that the computer vision approach is a powerful tool to automatically analyze powder flow properties, providing a new opportunity to inspect and evaluate the flowability for the powders used for AM.

1. Introduction

Metal powder-based additive manufacturing is a novel technology to fabricate parts with complex and flexible structures. The merits of low-cost and low-wastage accelerate its applications in