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The Influence of Image Processing and Layer-to-Background Contrast on the Reliability of Flatbed Scanner-Based Characterisation of Additively Manufactured Layer Contours

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Abstract: Flatbed scanners (FBSs) provide non-contact scanning capabilities that could be used for the on-machine verification of layer contours in additive manufacturing (AM) processes. Layer-wise contour deviation assessment could be critical for dimensional and geometrical quality improvement of AM parts, because it would allow for close-loop error compensation strategies. Nevertheless, contour characterisation feasibility faces many challenges, such as image distortion compensation or edge detection quality. The present work evaluates the influence of image processing and layer-to-background contrast characteristics upon contour reconstruction quality, under a metrological perspective. Considered factors include noise filtering, edge detection algorithms, and threshold levels, whereas the distance between the target layer and the background is used to generate different contrast scenarios. Completeness of contour reconstruction is evaluated by means of a coverage factor, whereas its accuracy is determined by comparison with a reference contour digitised in a coordinate measuring machine. Results show that a reliable contour characterisation can be achieved by means of a precise adjustment of image processing parameters under low layer-to-background contrast variability. Conversely, under anisotropic contrast conditions, the quality of contour reconstruction severely drops, and the compromise between coverage and accuracy becomes unbalanced. These findings indicate that FBS-based characterisation of AM layers will demand developing strategies that minimise the influence of anisotropy in layer-to-background contrast.

Keywords: flatbed scanner; additive manufacturing; on-machine verification; image processing; contour detection; geometrical quality

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1. Introduction

Additive manufacturing (AM) processes have reached a high degree of maturity during the last decade. Evolving from a reduced number of applications, mainly related to aesthetic models and conceptual prototypes, AM is currently formed by a growing number of processes capable of achieving small-to-medium batch size productions and industrial-level requirements. This evolution has been sustained on better machines and processes capable of handling diverse materials, but also on reducing the gap between AM parts' quality and that achieved with traditional manufacturing processes. In any case, according to Gartner, complete industrial adoption of AM is still 5 to 10 years away [1]. There are many reasons behind this gap in development, but a frequently highlighted issue is the difference between dimensional and geometrical accuracy achieved in AM parts, when compared with traditional manufacturing [2]. The usual approach regarding dimensional or geometrical assessment of AM parts is to measure or verify the final 3D part, once it has already been released from the machine [3,4]. Nevertheless, a tendency involving on-machine measurement (OMM) approaches with integrated measuring devices is currently gaining momentum [5–8]. These approaches will provide clear advantages when they become fully developed and incorporated to production-level machines [9]. Hence, dimensional