sensors

MDPI

Article

Layer Contour Verification in Additive Manufacturing by Means of Commercial Flatbed Scanners

David Blanco *, Pedro Fernandez, Alvaro Noriega, Braulio J. Alvarez and Gonzalo Valiño

Department of Construction and Manufacturing Engineering, University of Oviedo, c/Pedro Puig Adam, E.D.O.5, 33203 Gijon, Asturias, Spain; pedrofa@uniovi.es (P.F.); noriegaalvaro@uniovi.es (A.N.); braulio@uniovi.es (B.J.A.); gvr@uniovi.es (G.V.)

* Correspondence: dbf@uniovi.es

Received: 22 November 2019; Accepted: 16 December 2019; Published: 18 December 2019

Abstract: Industrial adoption of additive manufacturing (AM) processes demands improvement in the geometrical accuracy of manufactured parts. One key achievement would be to ensure that manufactured layer contours match the correspondent theoretical profiles, which would require integration of on-machine measurement devices capable of digitizing individual layers. Flatbed scanners should be considered as serious candidates, since they can achieve high scanning speeds at low prices. Nevertheless, image deformation phenomena reduce their suitability as two-dimensional verification devices. In this work, the possibilities of using flatbed scanners for AM contour verification are investigated. Image distortion errors are characterized and discussed and special attention is paid to the *plication* effect caused by contact imaging sensor (CIS) scanners. To compensate this phenomena, a new local distortion adjustment (LDA) method is proposed and its distortion correction capabilities are evaluated upon actual layer contours manufactured on a fused filament fabrication (FFF) machine. This proposed method is also compared to conventional global distortion adjustment (GDA). Results reveal quasi-systematic deformations of the images which could be minimized by means of distortion correction. Nevertheless, the irregular nature of such a distortion and the superposition of different errors penalize the use of GDA, to the point that it should not be used with CIS scanners. Conclusions indicate that LDA-based correction would enable the use of flatbed scanners in AM for on-machine verification tasks.

Keywords: additive manufacturing; flatbed scanner; layer contour verification

1. Introduction

Additive manufacturing (AM) encompasses a wide range of processes whose common characteristic is that three-dimensional parts are built from two-dimensional layers deposited on top of each another. During the last decades, AM has experienced a continuous development, evolving from merely part prototyping to full-functional part manufacturing. Nevertheless, although industrial development of AM is not expected to reach the plateau of productivity until the next decade [1], current figures indicate that industrial AM systems have experienced a great impulse during last few years, whereas sales of desktop 3D printing systems (under $500) are clearly declining [2].

Generalized industrial adoption of AM has to face several challenges, like broadening the range of available materials, increasing production batch size or improving part quality [3]. Although part quality is a broad concept that encompasses aspects such as physical properties or durability, dimensional and geometrical accuracy of AM parts have always stood out among researchers' main concerns during the last decade [4–8]. These works analyzed the lack of dimensional or geometric quality in three-dimensional features in final parts, which enabled optimization of process configuration, or even for the modification of part design, so that an improvement in quality could be achieved in the