A Structured Light System for Monitoring Metallic Powder Bed Additive Manufacturing

Michael Todd*, Niall O'Dowd*,† and Adam Wachtor+

* Department of Structural Engineering, University of California San Diego, 9500 Gilman Drive 0085, La Jolla, California 92093-0085 USA
e-mail: mdtodd@ucsd.edu

† Phase 3D, Chicago, Illinois 69608 USA
Email: niall@phase-3d.com - Web page: http://additivemonitoring.com

+ Los Alamos National Laboratory, Los Alamos, New Mexico 87545 USA
Email: ajw@lanl.gov

Key Words: metallic additive manufacturing, structured light, uncertainty quantification

ABSTRACT

Powder bed-based metallic additive manufacturing (MAM) processes are rapidly maturing and being adopted in numerous industrial sectors ranging from aerospace to energy to transportation. Build processes and control of those processes are both still in an evolving state, leading to variable part quality. Part quality control has emerged as one of the big challenges, since most fabrication processes require meeting quality assurance protocols. This paper describes a structured light system using a low-cost camera and projector that exploits digital fringe projection to achieve surface profiling of MAM parts. The novelty in this approach lies in a measurement model that propagates uncertainty in captured pixel images (whether due to shot noise or frame-to-frame other sources of variability) to converted phase noise and ultimately to surface profile uncertainty. Another advantage of the model is that the surface profile is given in absolute physical units, as opposed to unreferenced units or relative measurements. Fundamental Gaussian pixel noise is propagated nonlinearly through phase conversion and surface profile estimation to yield a posterior probability density function of the surface profile; this posterior probability density is analytically tractable and supports a very generalized correlation model in the noise both in time and space. Such as posterior enables the measurement process to provide the probabilistic support required for MAM part quality control decisions. Results from a prototype system on MAM parts are demonstrated, including validation of the measurement model, on manufactured surface defects in a powder bed MAM build.