Thesis Project Portfolio

Probabilistic Printability Maps for Laser Powder Bed Fusion via Functional Calibration and Uncertainty Propagation

(Technical Report)

Evaluating the Identity and Disruptive Potential of Additive Manufacturing: A Stakeholder-Focused Perspective

(STS Research Paper)

An Undergraduate Thesis

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Nicholas Ruiyuan Wu

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Department of Materials Science and Engineering

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Sociotechnical Synthesis

Both the technical and STS portions of this work are concerned with additive manufacturing (AM) technologies, which are colloquially known as 3D printing technologies. Broadly speaking, AM technologies are manufacturing processes in which parts are built additively, in contrast with traditional manufacturing methods which are often subtractive (e.g, by cutting the desired shape out of a block of solid material). For example, Fused Deposition Modeling (FDM) is the most common consumer-grade AM technology, in which parts are built layer-by-layer by extruding filament onto the workpiece in successive passes.

The technical thesis, "Probabilistic Printability Maps for Laser Powder Bed Fusion via Functional Calibration and Uncertainty Propagation," is concerned with an AM technology known as Laser Powder Bed Fusion (LPBF), which is a metal based AM technology in which layers of metal powder are melted together by a scanning laser. In LPBF, selecting appropriate processing conditions (e.g laser power, laser scanning speed) in order to achieve the desired product quality can be costly and time-consuming. Thus, in this work, an efficient data-driven computational framework for assessing the relationship between processing conditions and resulting part quality was developed. The framework is expected to be of utility to computational scientists, experimental scientists, and process engineers in developing new methods for controlling quality in LPBF and related AM processes.

The technical thesis focused narrowly on a highly technical problem for a specific AM technology. In contrast, the STS work takes a broader look at the social implications of AM technologies and the discourse surrounding such technologies in different spheres. As AM technology emerged in recent decades and gained traction in both consumer and industrial spheres, there was great interest and excitement about the potential impacts of AM on current social systems. For example, a recent development is the notion of Industry 4.0, an imagined "factory of the future" where data-driven modeling and process control are integrated with on-demand manufacturing (fulfilled via AM) to respond rapidly to changing production cycles and demand. More broadly, proponents of AM argue that AM is poised to become a dominant manufacturing method and radically restructure current social organization, e.g by disrupting supply chains and shifting manufacturing nearer to consumer outlets. In the STS work, this claim was evaluated using the Social Construction of Technology theory, gathering evidence from a range of stakeholders domains such as retail manufacturing, government and policymakers, and the biomedical industry.

Developments in my technical work echo some ideas of "Industry 4.0," especially the use of modern statistics and machine learning approaches to facilitate process control in AM. So, the implicit goal of my technical work can be seen as aligned with the goals of AM (and "Industry 4.0") proponents, who envision applications of AM becoming more widespread and well-integrated with advances in computing and information technology. In this sense, the technical work is a direct participation in and contribution to the larger socio-technical system analyzed in the STS thesis.