Image-guided Additive Manufacturing
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Industrial relevance
The proposed project will address defects, improve build quality, reduce costs, and increase the yield of additive manufacturing.

Facts:
- Customization – easier to build complex, highly customized parts, add more flexibility in the design and manufacturing.
- Rapid growth of market – $4 billion in 2015, $10.8 billion in 2021.
- High rejection rate (>2%) – various types of defects induced by process variations (e.g., thermal effects and extraneous noises).
- Long post-build inspection (~25% of the manufacturing time) – low yield (e.g., for engine parts) and high cost.

Urgent need: In-situ process monitoring and control.

Thrust area: Intelligence
Current TRL: TRL-4
Final TRL: TRL-8
Project type: Proposed project
Percent complete: 30%

Problem statement
Motivation
Process variations (e.g., laser or galvo instabilities or drift, thermal effects, variations in powder feedstock) perturb build quality and generate residual stress → the distortion or embedded flaws → impact mechanical properties such as fatigue strength.

Gaps
- Depend on post-build inspection or destructive tests.
- Lack the ability to extract pertinent information about process dynamics from images.

Need
Quality control and process repeatability are critical to mass use of additive manufacturing.

Objective
Develop an in-situ image sensing, fusion and decision-support system for real-time defect mitigation in additive manufacturing.

Approach and method
- In-situ image sensing (high-resolution DSLR camera, infrared thermography and CT scanner with >1000 Hz frame rate)
- Network GLR chart for real-time detection of defects
- Characterization of network variations → address defects

Deliverables and benefits
- An in-situ image sensing system that will record in-process images and CT scans of every single layer of the product while it is built.
- A software package with graphical user interface that will extract pertinent features about process dynamics from images for the real-time defect mitigation and optimal control.

Project plan and progress
- Review current literature, data cleaning and pre-processing.
- Extract features from image data to characterize process.
- Develop data-driven models to derive quantitative relationships between image features and defect evolutions.
- Develop image-guided control policy of additive manufacturing.
- Evaluation and validation

Current state of practice and research
- Spectral band selection approach (Du et al. 2007) – analyze hyperspectral images of poultry carcasses.
- Low-rank tensor decomposition + multivariate control chart (Yan et al. 2015) – monitoring sequential flame images.
- Adaptive Gaussian process (Zhang et al. 2015) – characterize wafer thickness.
- Spatiotemporal control chart (Megahed et al. 2012) – detect non-conforming tiles.

Gap: Very little work has been done to develop new image-guided additive manufacturing.

How ours is different
Our proposed approach
- Just-in-time
- In-process control
- High-dimensional images
- Dynamic image streams

Existing practices
- Inventory
- Post-build inspection
- Low-dimensional quality variables
- Static images

References