Department of the Navy SBIR/STTR Transition Program

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Topic # N181-085

Feed-Forward Controls for Laser Powder Bed Fusion Based Metal Additive Manufacturing

Applied Optimization, Inc.

WHO

SYSCOM: ONR

Sponsoring Program: 2019 Quality Made FNC

Transition Target: Naval Air Systems Command Additive Manufacturing and Digital Thread

TPOC:
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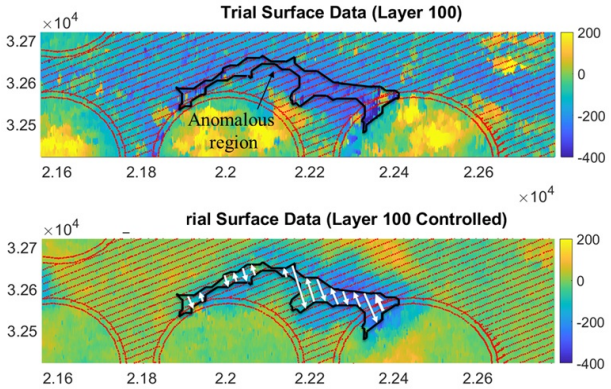
Other transition opportunities: Aircraft Launch and Recovery Equipment (ALRE), H-1, H-53, LPD 17

Notes: The methods developed in this project allow the layer-by-layer update of the scan path parameters for the purpose of mitigation of build defects. The scan path track vectors are analyzed and corrective measures are applied at locations where build conditions are anomalous. Its purpose is to mitigate defects before they are buried under the deposition of subsequent layers.



AM Parameters and Scan Vector Direction are updated

WHAT

Operational Need and Improvement: To develop feed-forward control (FFC) hardware, algorithms, and multi-physics-based models to allow real-time tracking of powder bed layer variability and corresponding laser processing compensation to improve the quality of laser fusion-based metal additive manufacturing (AM) parts.

Specifications Required: Process the in-situ sensing data to evaluate the potential location of build anomalies, compute and apply the control action to mitigate build defects in near-real time,

Technology Developed: This project demonstrates a prototype of a feed-forward control (FFC) system for the laser powder bed process to produce higher quality AM builds. The FFC is designed to compensate for the systemic variability arising from the statistics of the additive layer, powder bed, and thermal phenomena. The compensation is performed on a full set of laser processing parameters. FFC is implemented as three subsystems to correct for the layer, powder bed, and thermal variability, respectively. The output of FFC for layer and powder bed variability is input for FFC for thermal variability. The disturbance signals are measured using VIS, MWIR sensors and a 3D laser scanner. The sensors are selected to meet the cadence and resolution requirements for FFC, which is performed on a layer-by-layer (L-L), track-by-track (T-T), and point-by-point (P-P) basis.

Warfighter Value: Provides means to produce high-quality as-built AM components using inexpensive, off-the-shelf sensors and guidance from AM process simulations to perform AM parameter compensation and powder bed process control.

WHEN

Contract Number: N68335-19-C-0366 **Ending on:** September 3, 2022

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Enable layer-by-layer build plan update	High	Ability to modify and apply the build plan track vectors	4	TBD
Enable compensation of AM process parameters	High	Ability to compute the change in AM process parameters to enhance build quality	4	TBD
Perform feedforward control on a layer-by0layer, track-by-track and point-by-point basis	High	Ongoing	4	TBD

HOW

Projected Business Model: Demonstrate lower cost to produce high-quality as-built AM materials using process control, which is supported by the guidance developed by the AM process simulation. AO will offer software to perform anomaly flagging and process control to perform anomaly correction. The process control includes four critical elements, namely software to predict feature-specific AM process parameters, ability to collect high-resolution, simultaneous VIS and IR in-situ sensing data anywhere on the build plane, ability to modify laser scan path track vectors on a layer-by-layer basis and the ability to specify feature-specific process parameters for anomaly correction. These four technologies are pivotal pieces needed to produce high-quality, as-built material for AM structural parts, which are of great interest across the DoD and industry. AO can offer the technology as a value-add package to original equipment manufacturers of laser powder bed systems.

Company Objectives: Develop AM process simulation procedure and mature it such that the numerical trial-and-error can be used to optimize the AM process parameters at a lesser cost than performing a deposition trial.

Potential Commercial Applications: AM fabrication of critical, structural parts

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