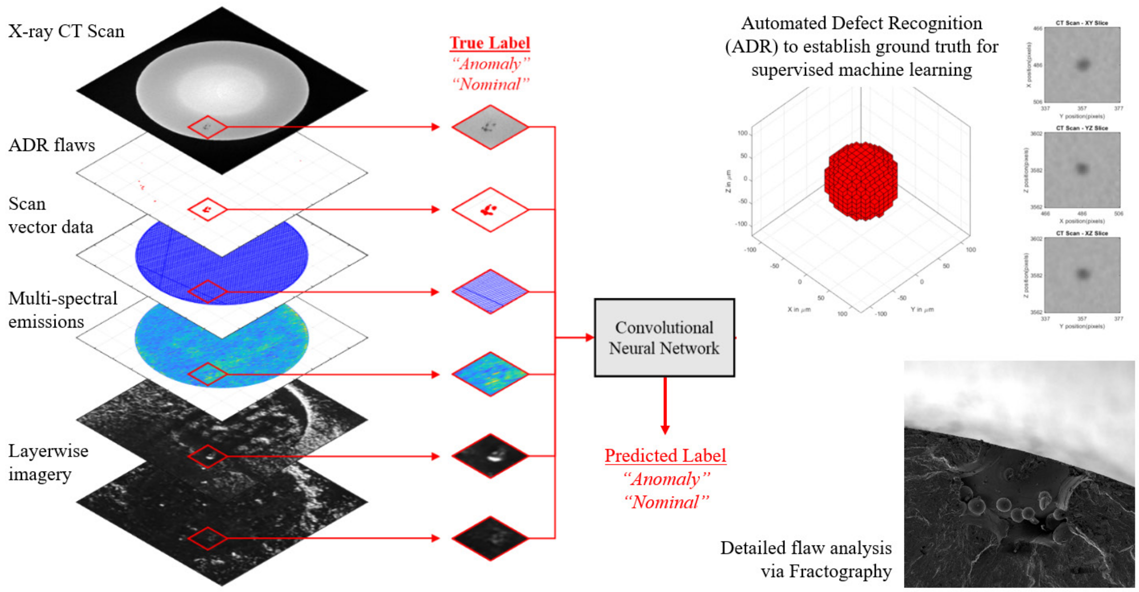
PROJECT SUMMARY 102575.000.5001.001.001.002

Correlating In-Situ Sensor Data to Defect Locations and Part Quality for Additively Manufactured Parts Using Machine Learning



This project combines data from multi-modal in-situ sensors for training a machine learning algorithm to identify the defects in a powder bed fusion build.

PROBLEM

Additive manufacturing (AM) production methods require strict dynamic control of processing parameters and conditions to achieve high-quality, fully dense components. Numerous flaws however may be inadvertently generated during the build when process parameters and conditions deviate or when unforeseen disturbances influence the process. Post process inspection technologies, such as high-resolution 3D X-ray computed tomography (XCT), are available to identify these flaws but there is a pressing need for reliable in-process sensing technologies and associated data analytics that can be employed to enable in-situ monitoring, quality assessment, and even corrective action.

OBJECTIVE

The objective of this project is to establish a quantifiable correlation among the in-situ sensor footprint, process anomalies (i.e. build flaws), and part quality as derived from fatigue testing. The project seeks to use machine learning techniques (a convolutional neural network) to correlate in-situ process monitoring data to flaws identified in post-build XCT scans and to discriminate flaws from nominal build conditions. An additional objective is to couple the presence of flaws (both those identified in-situ and by XCT) to actual fatigue performance.

AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP

This project aligns to: **AM GENOME**

ASTM PROCESS CATEGORY
Powder Bed Fusion

EQUIPMENT
3D Systems ProX 320, Renishaw AM250

MATERIAL
Ti-6Al-4V

TECHNICAL APPROACH

The Pennsylvania State University is leading the effort from their Applied Research Laboratory. Test coupons were previously printed by powder bed fusion AM, and several sensor modalities (layer-wise imagery, multi-spectral emissions, and scan vector data) were captured during the build process. X-ray computed tomography and an automated defect recognition algorithm are being used to identify build flaws in these test coupons. The coupons are then fatigue tested in the non-HIPed condition. Fractography is being used to determine the cause of failure. The identified build flaws and fracture locations are then registered to the machine build plate coordinate system. Data from multiple in-situ sensor modalities is processed and also registered to the machine build plate coordinate system. A machine learning algorithm (a convolutional neural network) is being trained on the sensor data and tested on data from an identical but independent build. The flaw data is then correlated to the results of the fatigue testing and fractography using machine learning and/or regression techniques.

PROJECT START DATE

November 2020

EXPECTED END DATE

May 2021

EXPECTED DELIVERABLES

- XCT data of fatigue coupons
- Fatigue data of failure coupons
- Fractography data
- Final report
- Data management plan

FUNDING

$120K total project budget
($80K public funding/$40K private funding)

PROJECT PARTICIPANTS

Project Principal:
Pennsylvania State University
Applied Research Laboratory

Public Participants:
U.S. Department of Defense