NIST Challenge: Monitoring and Modeling LPBF Powder Spreading Conditions

Background

Laser Powder Bed Fusion (LPBF) is a leading metal additive manufacturing (AM) technology valued for its ability to fabricate complex, high-performance components. However, the process remains vulnerable to defects that compromise part quality and repeatability. One of the most critical—and often overlooked—sources of such defects is the powder spreading step, where anomalies like streaks or debris can lead to uneven powder layers and downstream printing issues.

Monitoring the layer-wise powder spreading conditions is essential to identify potential defects early in the printing process. As machine vision and data-driven methods become more capable, image-based inspection has become a promising tool to automate the quality control of powder spreading process. Still, challenges remain in robustly detecting anomalies under varying lighting and surface conditions, and in generating high-fidelity synthetic data to support model development.

This challenge invites participants to explore both: building models to segment powder spreading anomalies and generating realistic powder-bed images to enhance quality monitoring in LPBF.

Challenge Tasks

Task 1 – Anomaly Segmentation for Powder Spreading Monitoring

Participants will develop a segmentation model to detect spreading anomalies—such as bright spots and streaks—in layer-wise images captured during the LPBF process. The dataset includes 3,000 cropped PNG images collected under three lighting conditions (a, b, c) using NIST's Additive Manufacturing Metrology Testbed. Each layer is imaged three times—once per lighting—and all three images share a single ground truth mask. The dataset is split into:

- Labeled Training Set: 1,800 images with segmentation masks
- Unlabeled Training Set: 600 images (no labels provided)
- Test Set: 600 images (no labels provided)

Participants may use any lighting condition or fuse multiple conditions, and are encouraged to explore supervised, semi-supervised, or unsupervised learning. Final submissions must include PNG-format segmentation masks for the test set.

Task 2 – Generation of Synthetic Powder Spreading Images

Participants will train a generative model to synthesize 100 realistic PNG images that replicate powder spreading conditions in LPBF. The goal is to model the visual characteristics of both normal and anomalous spreading behavior under varied lighting. Submissions will be evaluated on:

- Fidelity: How realistic the images are compared to actual data
- Diversity: How well the synthetic set captures variation in lighting, texture, and anomaly patterns