NIST Challenge: Monitoring and Modeling LPBF Powder Spreading Conditions

McGill | Faculty of Engineering

ADML Innovative Design and Manufacturing

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Team: 39

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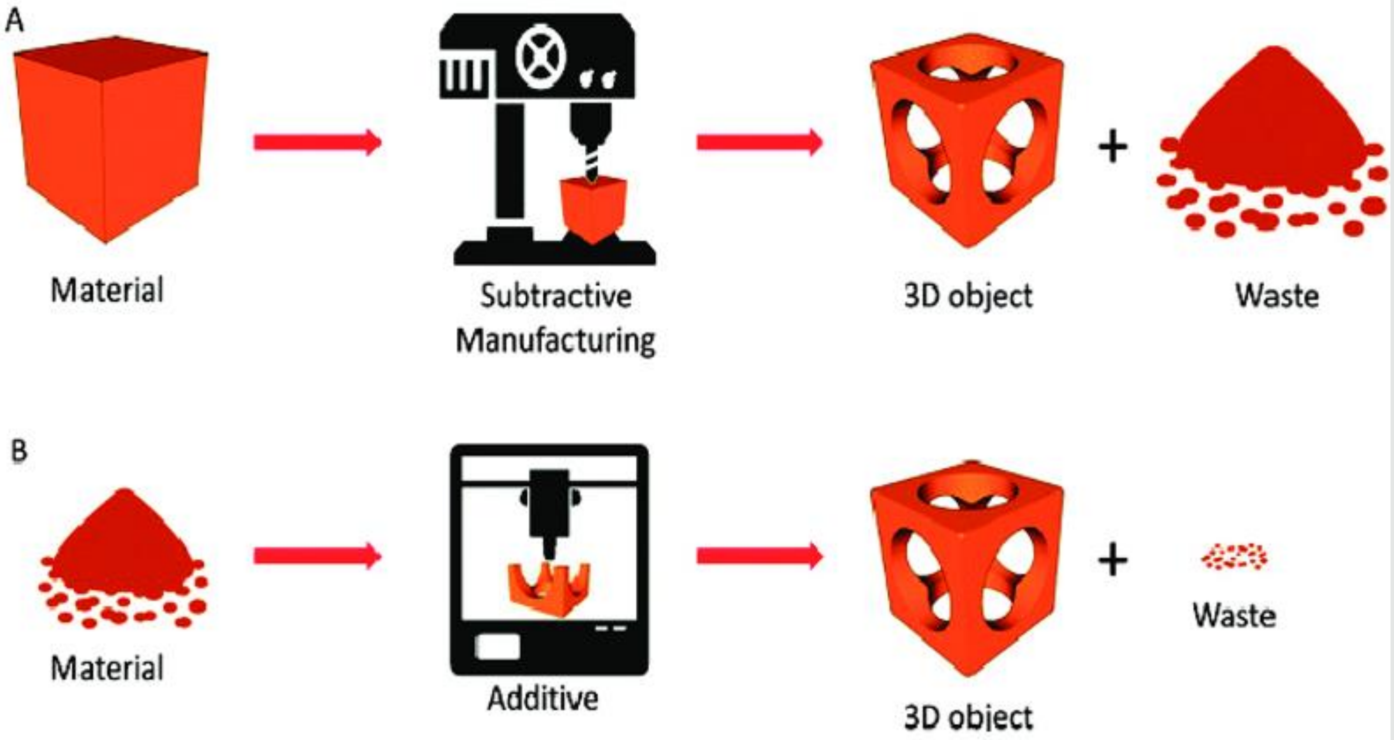
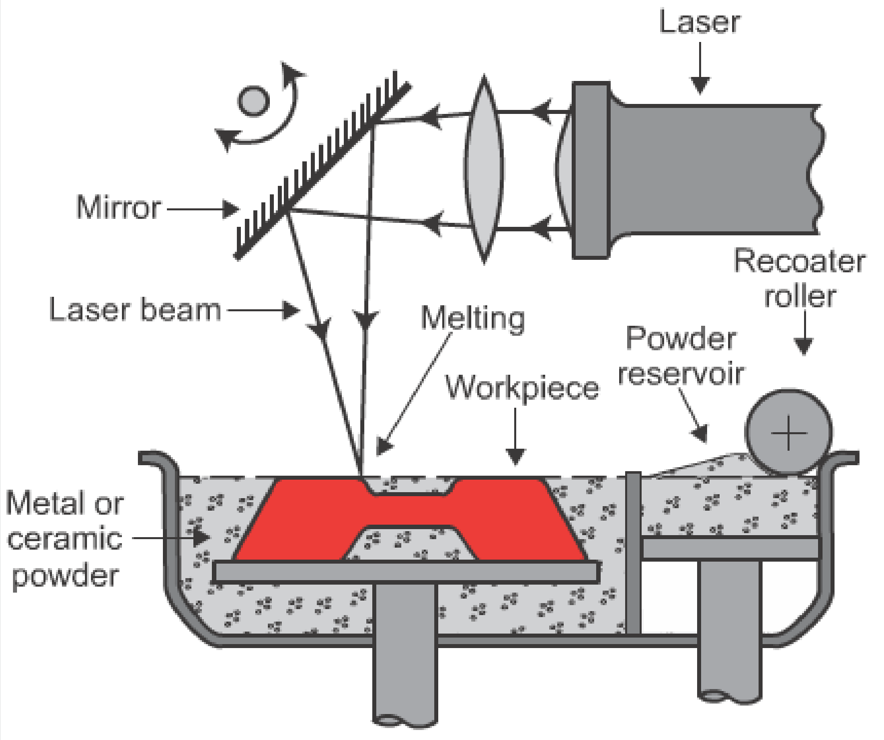
Empowering Mechanical Engineering with Generative Computational Intelligence

NIST National Institute of Standards and Technology

Hilton Anaheim Hotel
Anaheim, CA
In-Person Presentations, Judging and Awards Ceremony: August 17, 2025
At IDETC-CIE 2025

Introduction



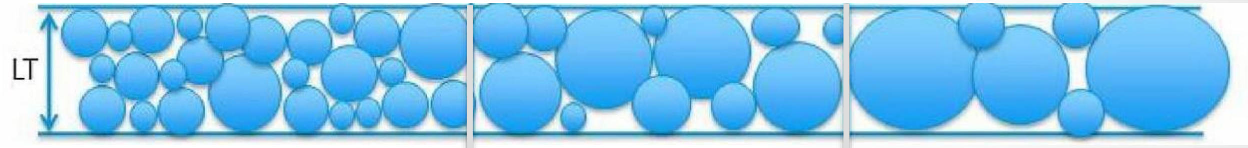


Laser Powder Bed Fusion (LPBF) is a process of building parts layer-wise from powder.

LPBF has challenges due to anomalies during the spreading process.

Spreading Factors

[1]

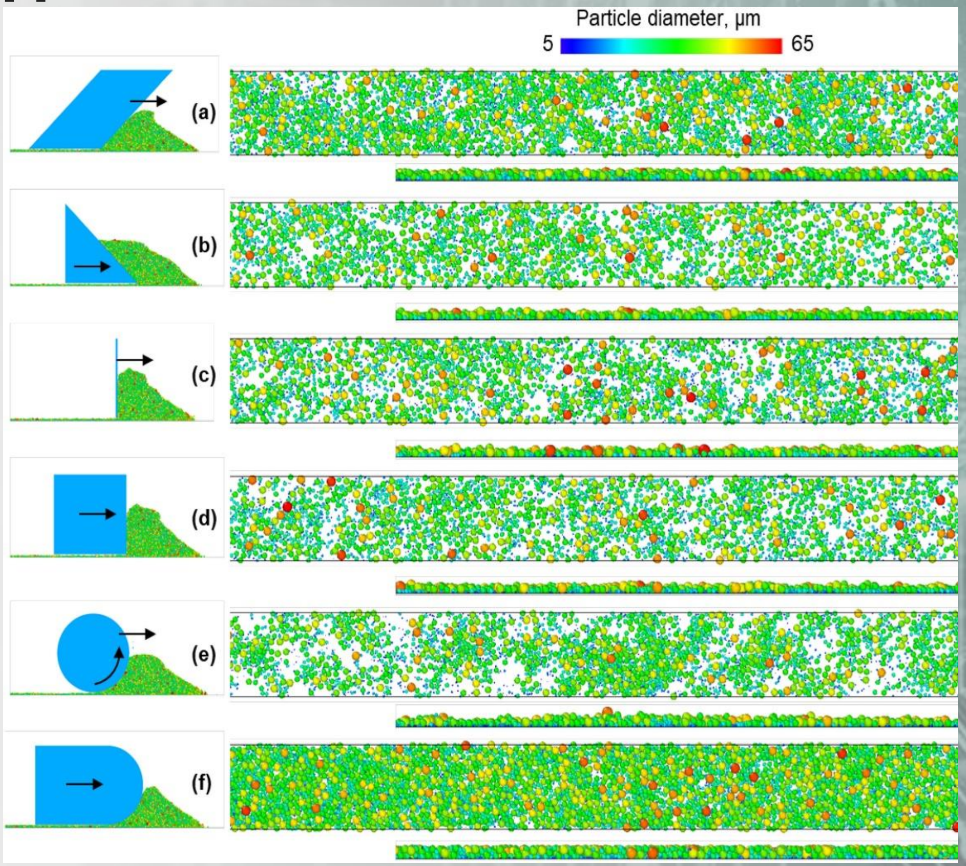


Good packing bad flow | Optimized PSD, and packing for AM | Bad packing good flow

Types of Spreader

- **Wiper (Blade)**
  - Flat blade
  - Wide blade
- **Roller**
  - Counter-rotating
  - Forward-rotating
- **Vibration**
  - Vibrating bed
  - Vibrating roller

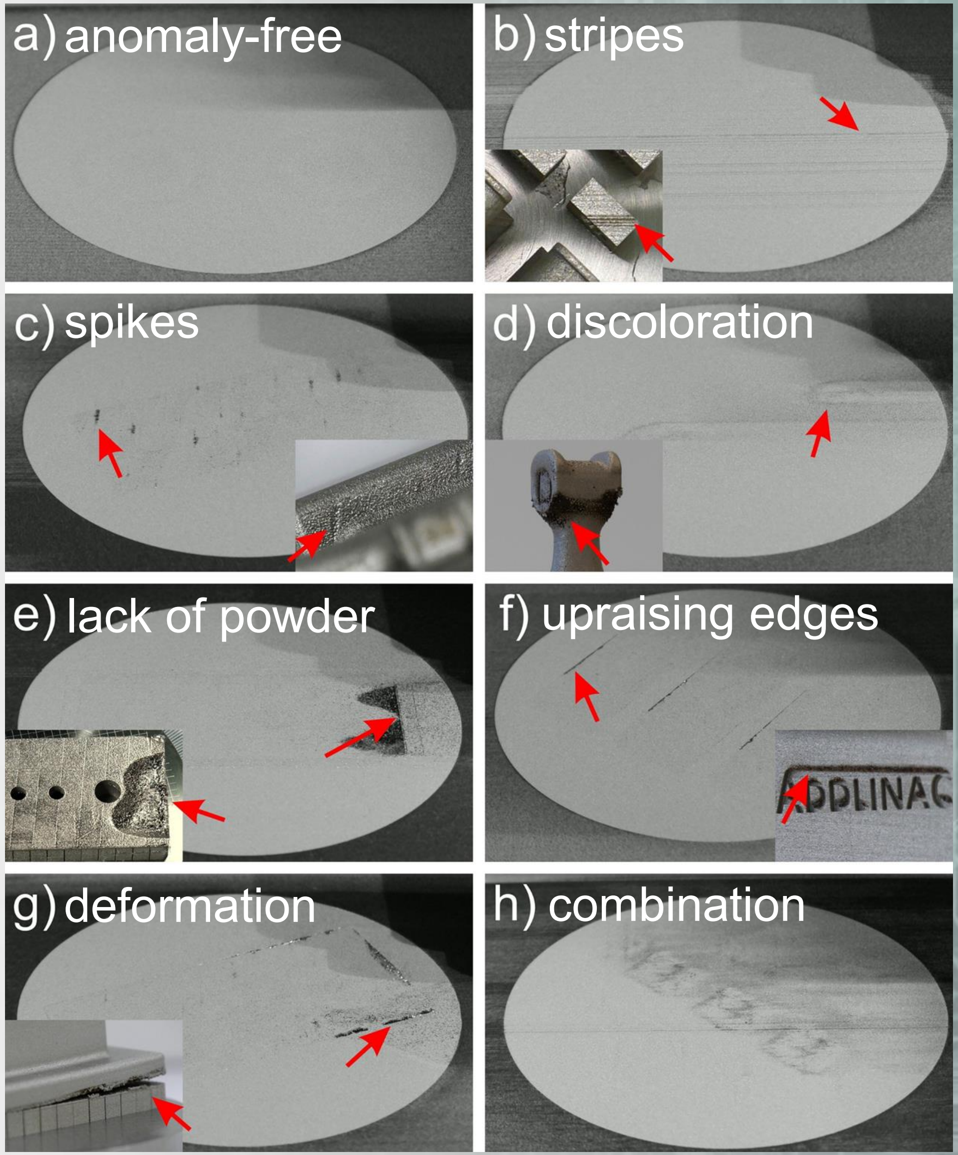
[1]



(a) inclined (b) declined (c) Flat
(d) wide (e) roller (f) round blade

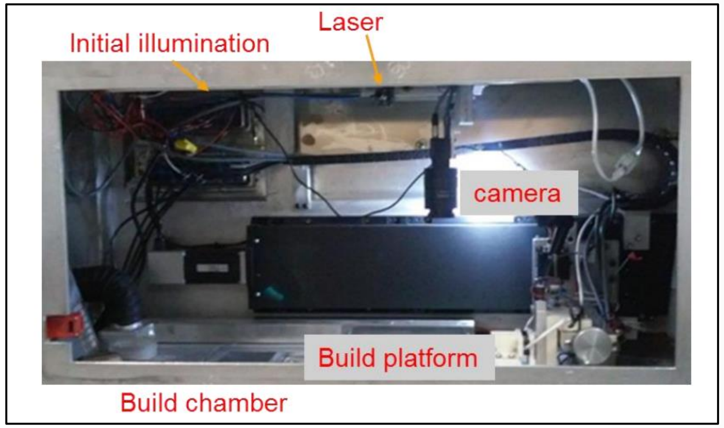
Spreading

[2]

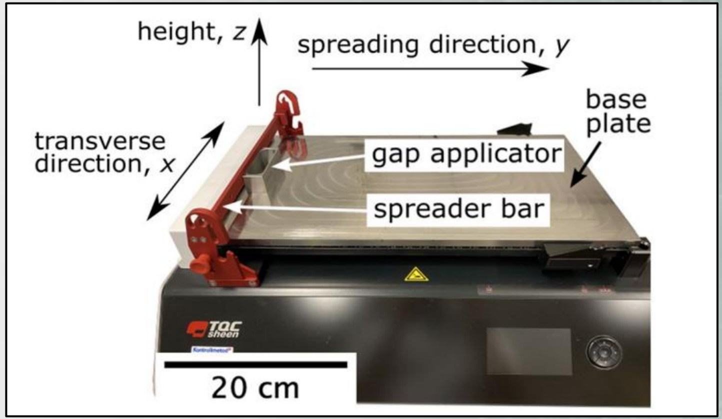


Anomaly	Associated Print Anomaly
Streaking	▪ Partially melted particles ▪ Oxide inclusion ▪ Porosities
Bright spot	▪ Poor powder coverage ▪ Dimensional inaccuracies ▪ Lack of fusion

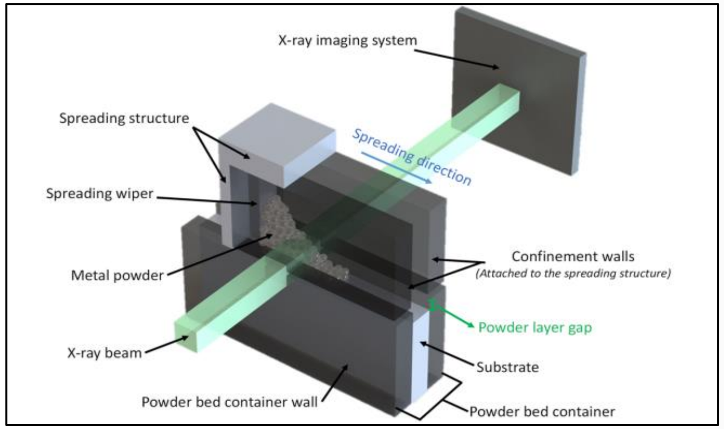
Literature Review



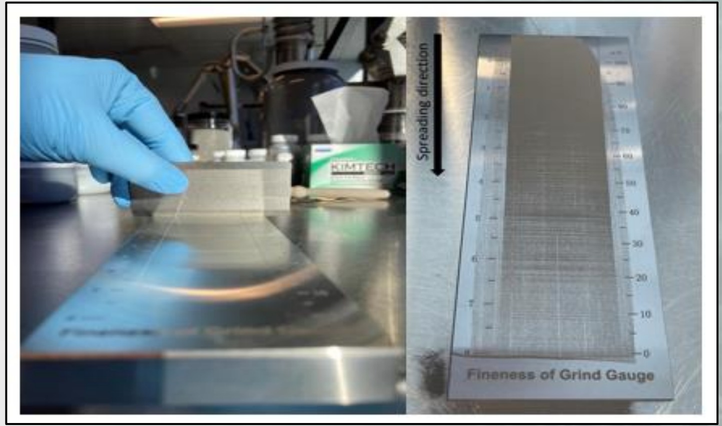
High-resolution visual camera LPBF images
[Non-numeric image data]



Automatic film applicator
[Numeric continuous data]



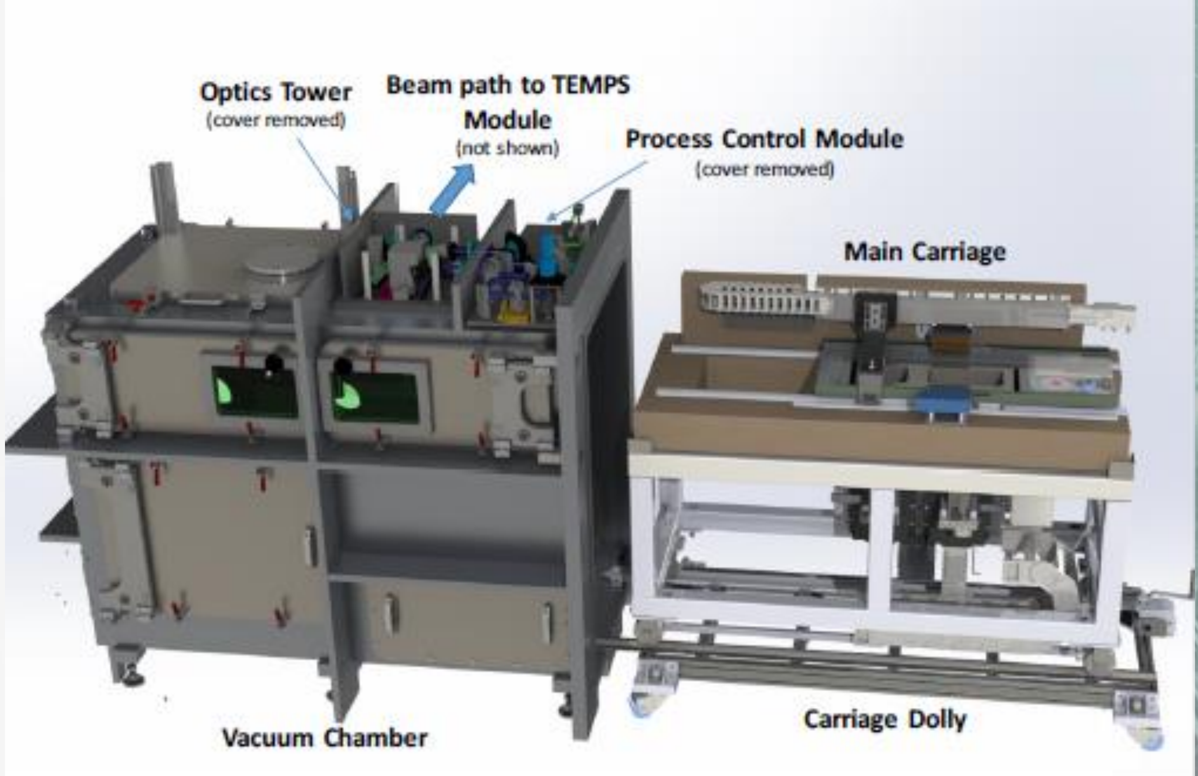
High-energy x-ray imaging of spreading
[Non-numeric image data]



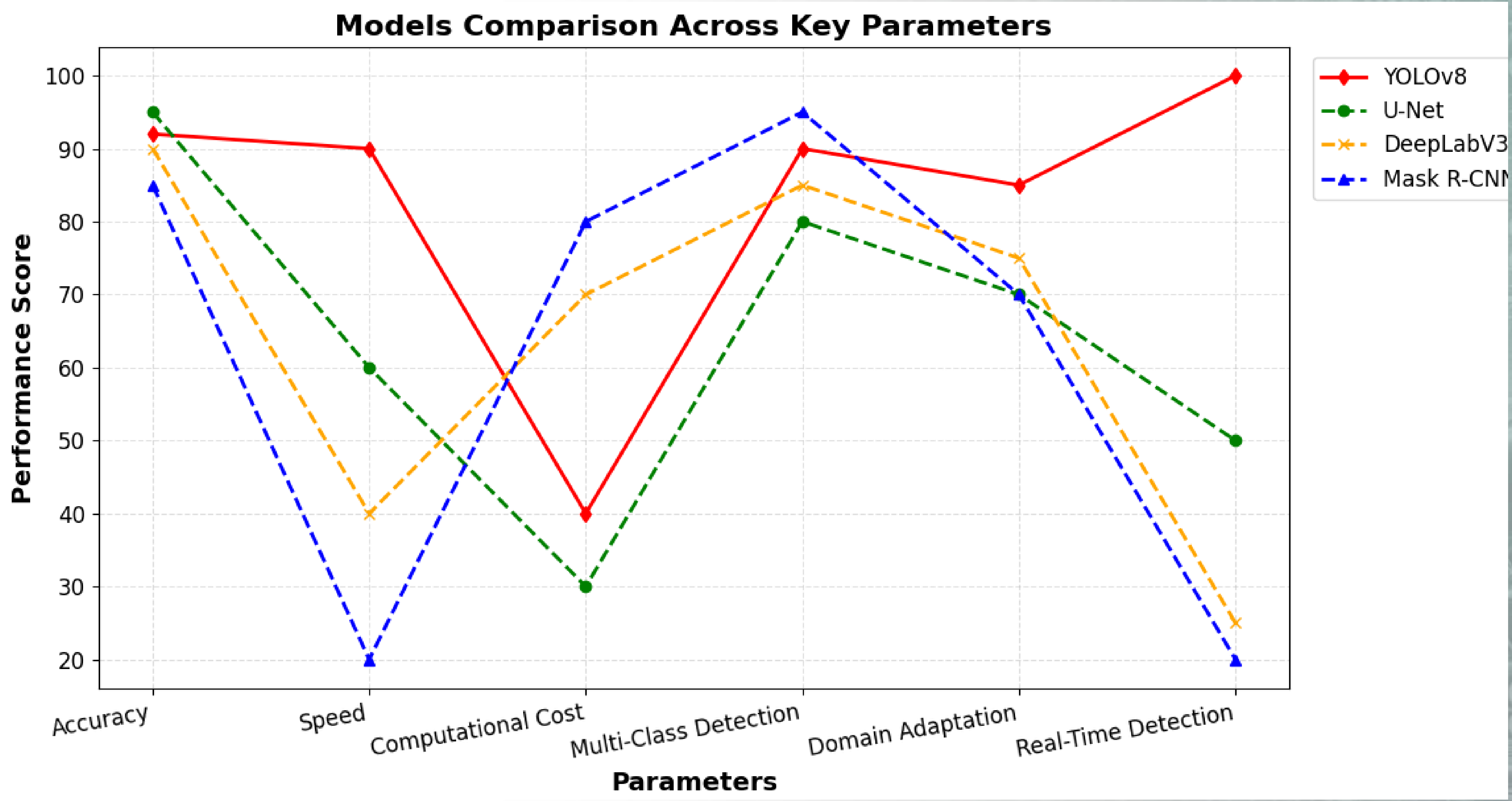
The Hegman gauge spreading tool
[Numeric continuous data]

Why AI Monitoring in LPBF

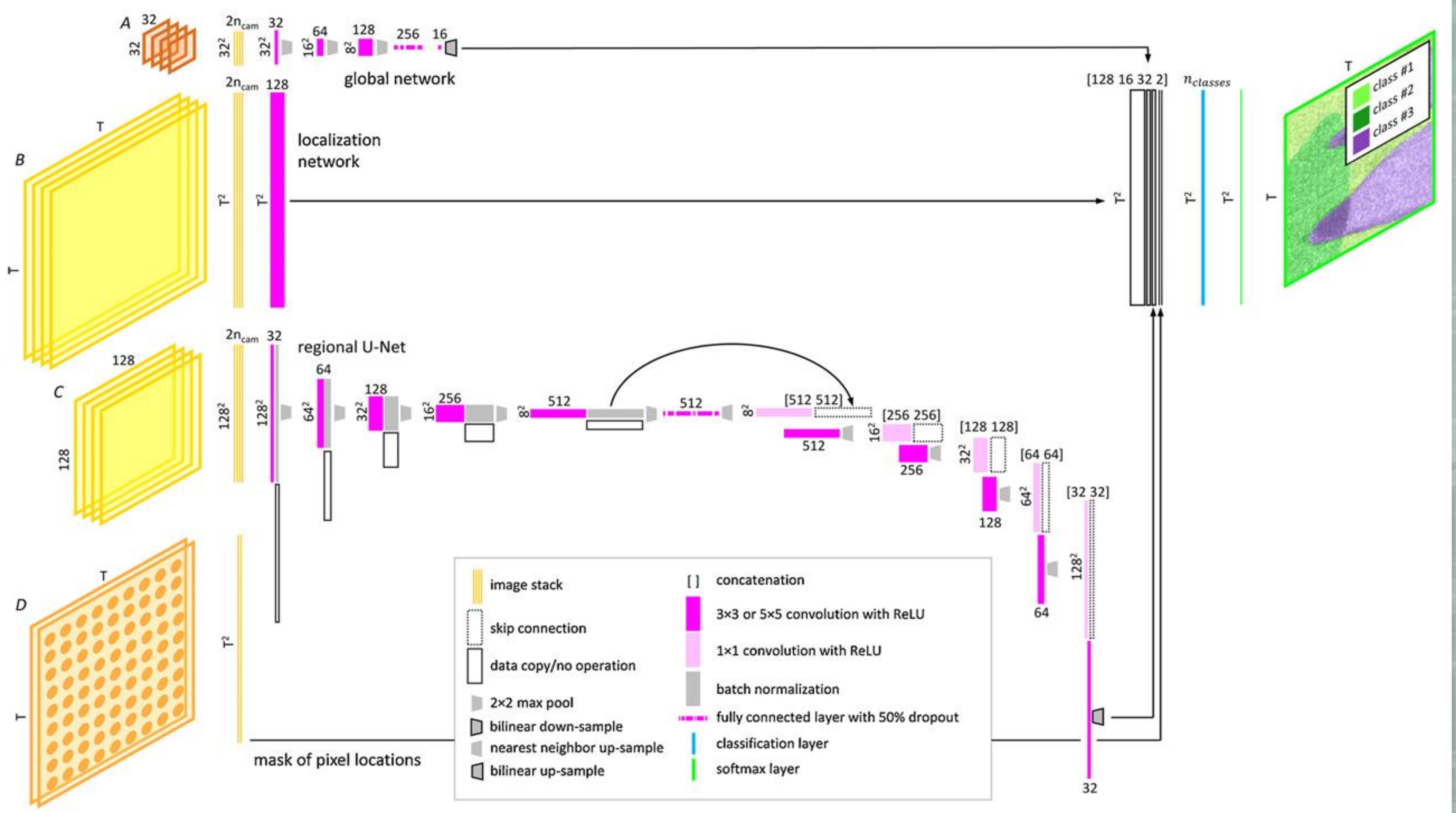
- Real-time process monitoring
- No interference with operation
- Automated anomaly detection
- Adaptable to different defects



Model Selection



Model Architecture



Data Preparation

Two prominent anomalies:

- Bright spot
- Streak

Data split:

- Labeled training set: 498 layers
- Unlabeled training set: 249 layers

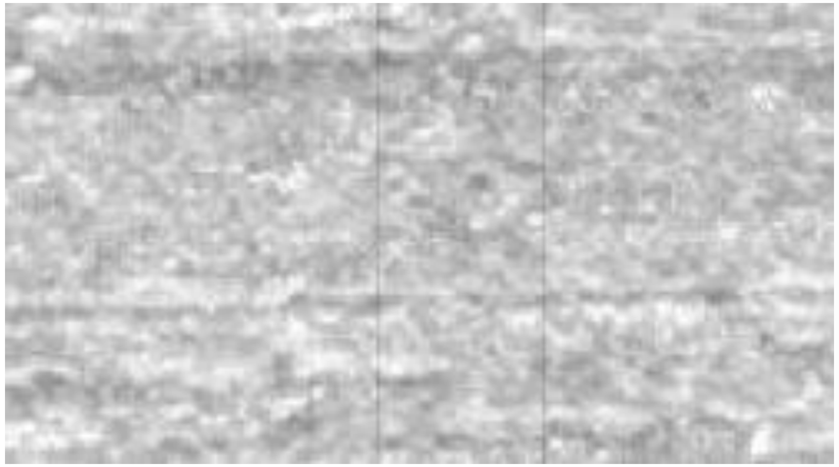
Dimensionality reduction

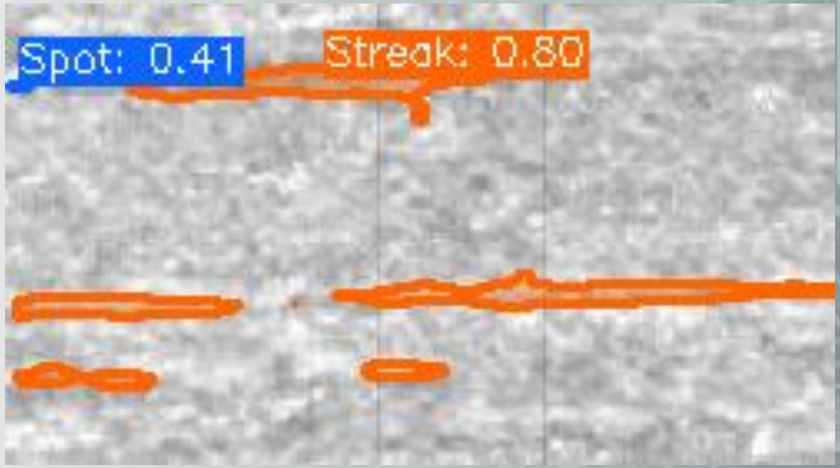
RGB images grayscale & image labelling

Data normalization & correcting imbalance

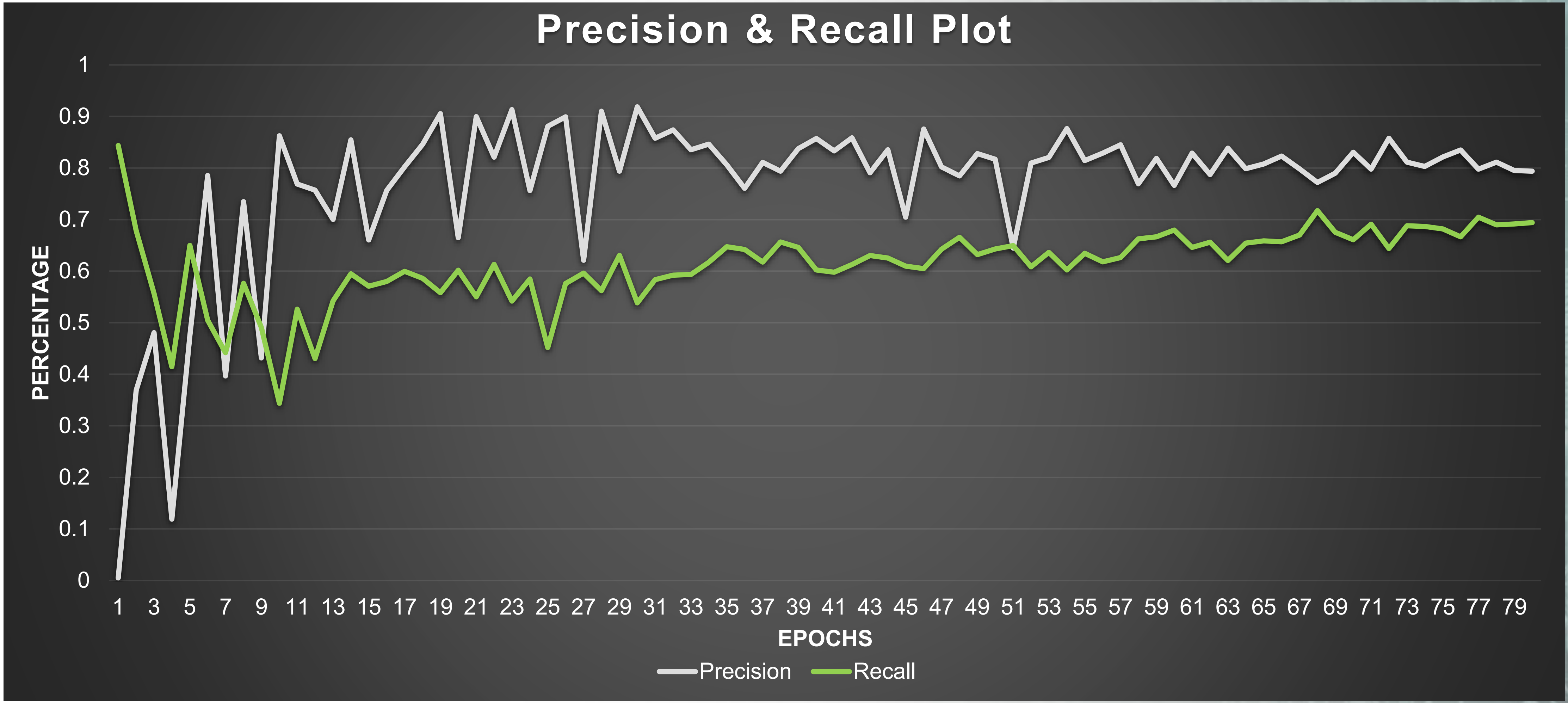
Result

Class	Data (Augmented)	Precision	Recall	mAP50	mAP50-95
All	600	0.918	0.844	0.789	0.777
Streak	498	0.823	0.826	0.837	0.815
Spots	597	0.796	0.809	0.741	0.739





Result



Model: YOLOv8 segmentation, **Epoch:** 80 epochs, **Layers:** 195 layers, **Batch:** 16, **File size:** ~158 MB, **Max precision:** 0.918 @30 epoch, **Max Recall:** 0.844 @1 epoch

Limitations & Future Works

- Lack of computational resources to run heavy models.
- Limited time.

- Perform time series analysis layer wise behavior.
- Explore domain adaption and transfer learning capabilities.

Conclusion

- Re-coater mechanism impacts the quality of powder spreadability in LPBF.
- AI-based monitoring enables reliable anomaly detection and is adaptable to different conditions.
- Spread quality affects the surface finish, strength, and print quality.
- Bright spots and streaks remain the most critical anomalies

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Thank you!

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References

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