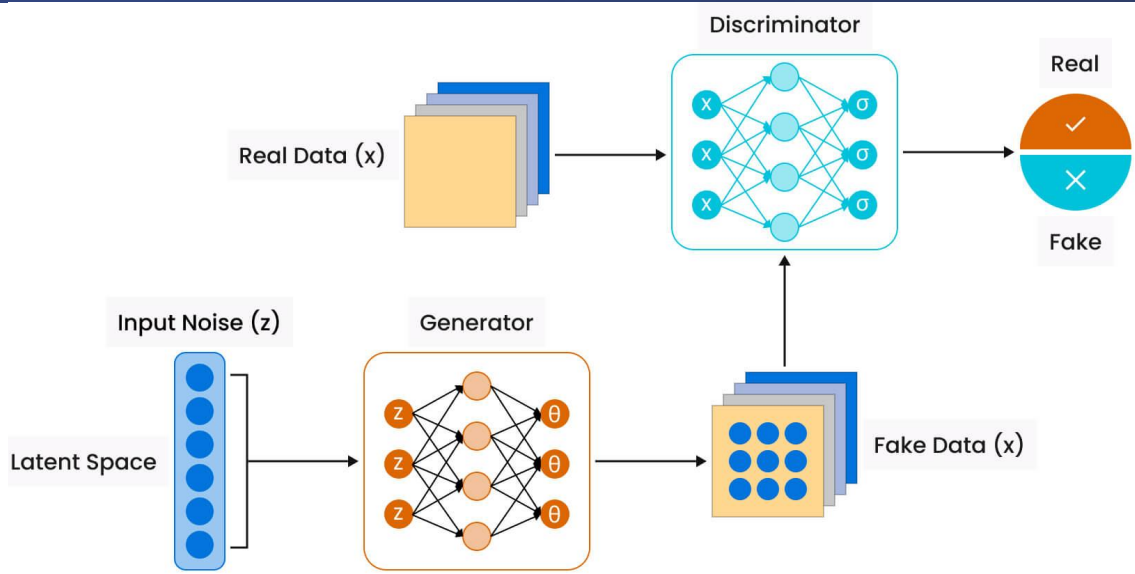
GAN-Based Microstructure Synthesis for Materials Science



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Why GANs for Microstructure Synthesis?

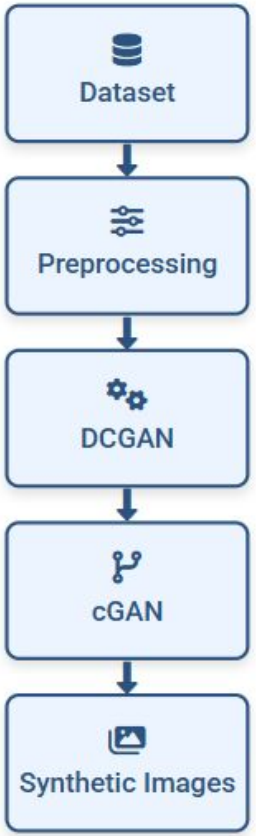
- Microstructure determines material properties
- Experimental SEM/OM imaging is time-consuming, costly, and limited
- ML/AI needs large datasets → synthetic augmentation required
- GANs can generate realistic microstructures, reducing cost & time

Datasets & Methodology

Dataset	Description
EMPIAR	SEM/TEM images, public archive
MicroLib	SEM/OM images for steel, alloys, ceramics
Materials Project	Limited SEM/OM data
OMERO	General microscopy datasets

Preprocessing Steps:

- Resize images to standardized dimensions
- Normalize pixel values to [0,1] range
- Extract and categorize material labels



Step-by-Step Implementation Roadmap

1

Literature Review

Comprehensive review of GAN architectures and microstructure synthesis applications in materials science

2

Dataset Collection & Preprocessing

Gather SEM/OM images from multiple sources and apply standardized preprocessing techniques

3

DCGAN Training (baseline)

Develop and train Deep Convolutional GAN as initial architecture for microstructure generation

4

Conditional GAN Training

Implement parameter-controlled synthesis with conditional inputs for specific microstructure properties

5

Evaluation

Assess model performance using FID, IS metrics and detailed microstructural statistics comparison

6

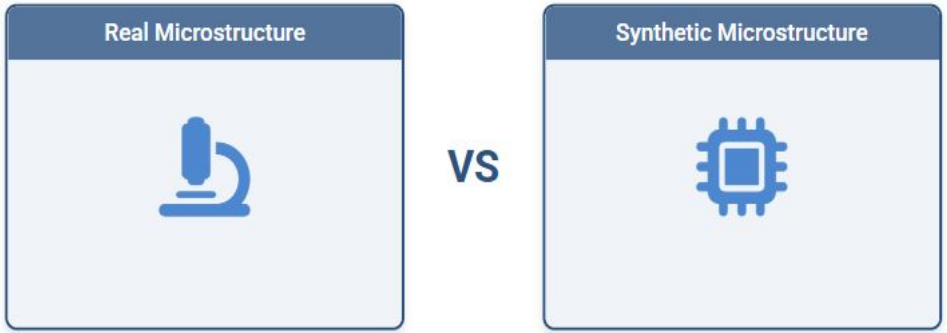
Deliverables

Produce synthetic image bank, model repositories, comprehensive documentation and final report

Outcomes & Deliverables

Expected Outcomes

- GAN-generated realistic microstructures
- Conditional synthesis with parameters
- Improved baseline with cGAN



Deliverables

- Synthetic Microstructure Image Bank
- Source Code Repository
- Comprehensive Project Report

Final Presentation

References

Academic Papers

1. Goodfellow et al., Generative Adversarial Nets, 2014.
2. Radford et al., DCGAN, 2015.
3. Mirza & Osindero, Conditional GANs, 2014.
4. Kench et al., MicroLib, 2022.

Datasets & Resources

5. EMPIAR: https://www.ebi.ac.uk/empiar/
6. MicroLib: https://zenodo.org/record/4284050
7. Materials Project: https://materialsproject.org/
8. OMERO: https://www.openmicroscopy.org/omero/