Methodology

Data Collection

FESEM imaging was used to collect the experimental data.The image of the materials' microstructure is captured using the cutting-edge technology known as field emission scanning electron microscopy (FE-SEM). Because gas molecules have a tendency to affect the electron beam and the produced secondary and backscattered electrons utilized for imaging, FE-SEM is normally carried out in a high vacuum. The primary electrons are concentrated in a high vacuum column, where an electronic lens deflects the blasted electrons onto each object. Each item emits secondary electrons in this way. The velocity and angle of secondary electrons are strongly influenced by the surface characteristics of any item. A detector captures these electrons and produces an electrical signal as a result. This signal is converted into a video-scan image that can be recorded for later processing and seen on a monitor. The research lab within the academic institution served as the data's data source for the experimental data and the FESEM images.

Data Preprocessing

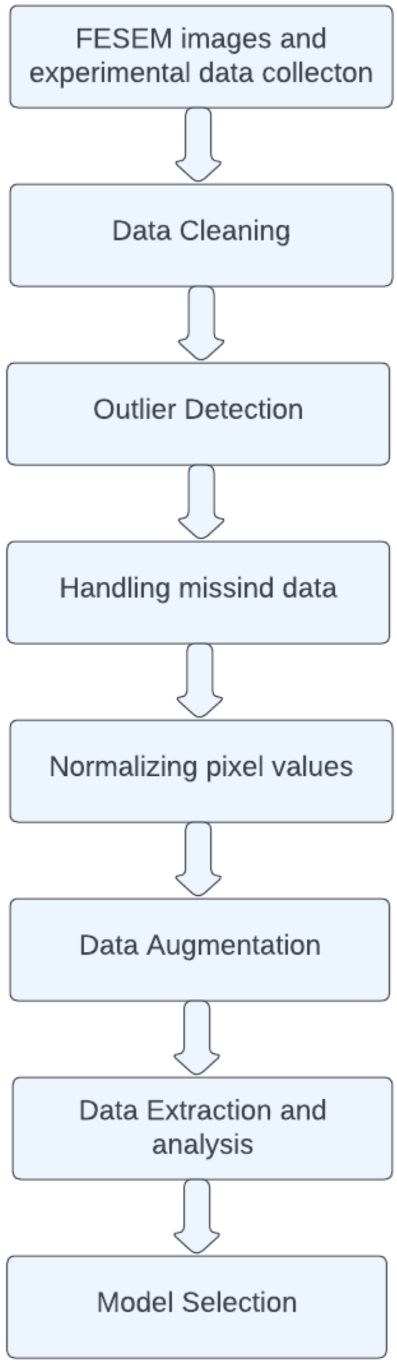
Load FESEM images into your ML environment using libraries such as OpenCV, PIL, or scikit-image. After an image is collected, the data must first be structured and prepared for the image processing in order to extract the required information; this process is known as preprocessing or data preparation. Data is cleaned, processed, and changed into different formats in this step so that it can be utilized as supplemental data. Image quality assessment is one technique for data preparation.

The geometrical texture and properties of the input image fluctuate greatly, therefore evaluating the image's quality is necessary to decide which functions to use in what order. Due to the complex spectral/optical qualities associated with FESEM devices, as well as the geometrical, chemical, and physical conformations of the material surface, FESEM images contain distinctive figure-by-figure and pixel-by-pixel features. We confine the scope of our attention throughout the image processing to the accuracy of segmentation of grey-scale SEM pictures. We carefully categorize the hidden data features (pixel- and object-based qualities) in order to do this.

Outlier detection: Locate and eliminate any extreme values or outliers from your dataset. The performance of the model and the training process might be dramatically impacted by outliers.
Handling Missing Data: We examine the FESEM images for any missing data. We exclude samples with missing data or impute missing values if there are missing images or characteristics.
Normalize pixel values of FESEM images using Min-Max scaling. This transformation ensures that all pixel values fall within the same scale, making it easier for the model to learn.

We may need to resize FESEM images to a consistent resolution. Common image sizes are 128x128, 224x224, or 256x256 pixels. We then apply data augmentation techniques to increase the diversity of your training dataset. This can include random rotations, flips, translations, and brightness adjustments. Data augmentation helps prevent overfitting and improves the model's generalization. Feature extraction from FESEM images involves capturing meaningful information from the images that can be used as input to an ML model. Depending on the dimensionality of the extracted features, we may perform feature selection to choose the most relevant features for our ML model.

Flowchart


FESEM images and experimental data collecton
Data Cleaning
Outlier Detection
Handling missind data
Normalizing pixel values
Data Augmentation
Data Extraction and analysis
Model Selection