DESIGN CREDIT PROJECT

Title :- Image Analysis of Particles

Team Members:-

1) Rahul Garg(B22CH025)
2) Sahil Bhaskar(B22CH052)

1. Introduction :-

In this report, we present an analysis of particle size distribution using image processing techniques implemented in MATLAB. The objective of this project is to accurately determine the size distribution of particles in a given image, which is crucial for various applications across different fields such as pharmaceuticals, environmental science, and material science. This report provides a detailed overview of the methodology used for particle size analysis, the results obtained, their implications, and recommendations for future research.

Software used for Image Analysis :-

1.1 MATLAB :-

The MATLAB code preprocesses the input image by converting it to grayscale if necessary and applying thresholding to segment particles from the background. This ensures that only the relevant features, i.e., particles, are considered for further analysis.

Connected component analysis is performed using MATLAB's bwconncomp function to identify individual particles in the binary image obtained after thresholding. Each particle is labeled, and its properties such as area and bounding box are extracted using MATLAB's regionprops function. This allows for precise characterization of each particle in the image.

Particle sizes are calculated based on the dimensions of the bounding box of each identified particle. The MATLAB code determines particle size by considering either the width or height of the bounding box, depending on whether the particle is uniform or non-uniform in shape. This approach provides a simple yet effective means of quantifying particle size distribution.

1.2 ImageJs :-

In addition to MATLAB, ImageJ, an open-source image processing software, can also be utilized for particle size distribution analysis. ImageJ offers a user-friendly interface and a wide range of plugins for various image analysis tasks, including particle analysis.

Similar to MATLAB, ImageJ can be used to preprocess images by converting them to grayscale and applying thresholding to segment particles from the background. ImageJ provides intuitive tools for adjusting threshold levels and refining segmentation results.

ImageJ's particle analysis tool enables the identification and measurement of individual particles within an image. It offers functionalities for calculating particle size, area, perimeter, and other geometric properties. The results can be exported for further analysis or visualization.

ImageJ provides built-in functions for generating histograms, scatter plots, and other visualizations to analyze particle size distribution. These tools allow for the easy interpretation of data and the comparison of results across different samples or experimental conditions.

2) <u>Background</u> :-

Particle size distribution (PSD) analysis is a fundamental aspect of material characterization with wide-ranging applications across various industries. PSD refers to the distribution of particle sizes within a sample, providing critical information about the physical properties and behavior of materials. Understanding PSD is essential for optimizing processes, controlling product quality, and ensuring the efficacy of formulations.

In industries such as pharmaceuticals, the size distribution of drug particles directly influences factors like dissolution rate, bioavailability, and stability. For example, smaller particle sizes generally lead to faster dissolution rates and improved bioavailability, which are crucial for drug efficacy. In contrast, larger particles may have slower dissolution rates and can lead to issues such as poor absorption or inconsistent dosing.

In environmental science, PSD analysis is used to characterize particulate matter in air and water samples. Particle size affects the transport, dispersion, and deposition of pollutants in the environment, influencing factors such as air quality, water clarity, and sedimentation processes. Understanding the size distribution of particles helps in assessing environmental impacts, designing mitigation strategies, and monitoring pollution levels.

3) <u>Methodology</u> :-

3.1 Image Preprocessing :-

The provided MATLAB code preprocesses the input image by converting it to grayscale if necessary and then applying thresholding to segment particles from the background.

3.2 Particle Identification and Labeling :-

Connected component analysis is performed to identify individual particles in the binary image obtained after thresholding. Each particle is labeled, and its properties such as area and bounding box are extracted using regionprops function.

3.3 Particle Size Calculation :-

Particle sizes are calculated based on the dimensions of the bounding box of each identified particle. For uniform particles, the size is determined by the width or height of the bounding box, while for non-uniform particles, an average of width and height is used.

3.4 Histogram Plotting :-

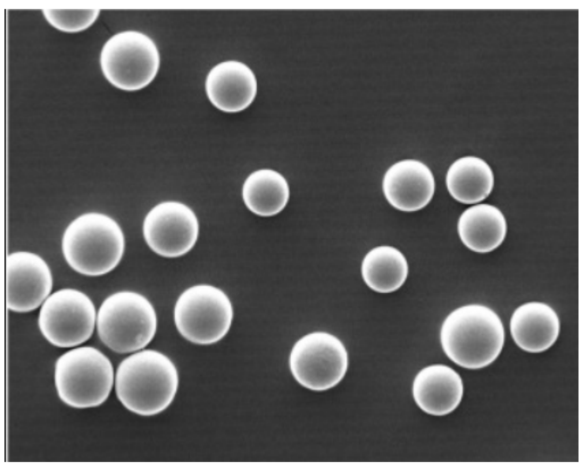
A histogram showing the distribution of particle sizes is plotted using the calculated sizes. Adjustments such as bin width can be made for better visualization of the distribution.

4) <u>Results</u> :-

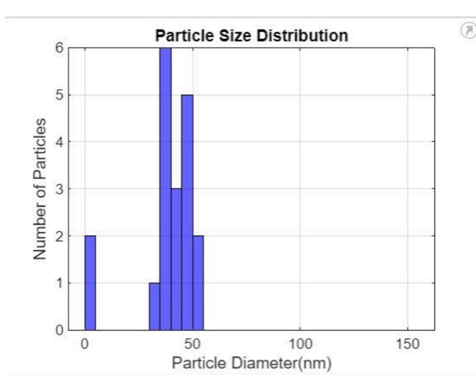
The results of the particle size distribution analysis are presented in the form of a histogram, which illustrates the number of particles at different size ranges. Analysis of the distribution pattern reveals insights into the characteristics of the particle sample, such as the presence of distinct size groups or the presence of outliers.

Result Obtained in MATLAB :-

Image of Particle :-

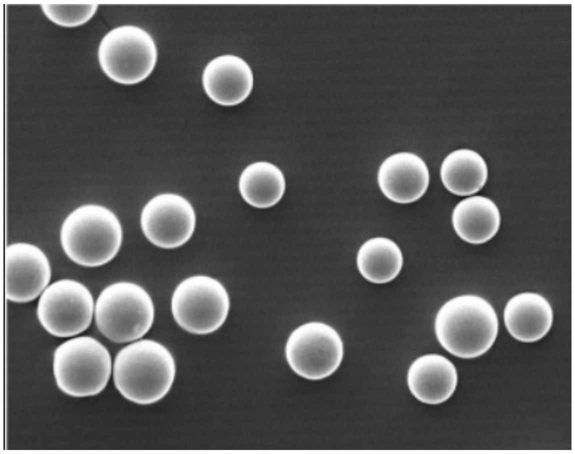


Plot Obtained in MATLAB :-

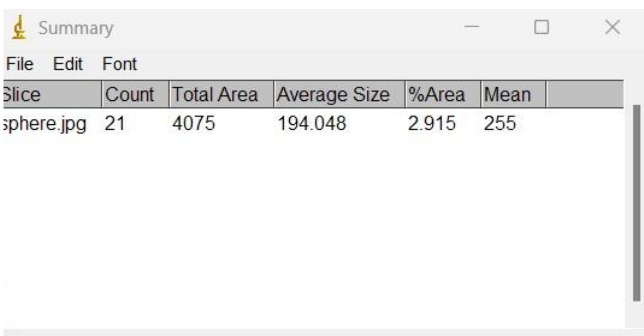


Result Obtained in ImageJs :-

Image of Particle :-



Counted No. of Particles :-



Summary

File Edit Font

Slice	Count	Total Area	Average Size	%Area	Mean
sphere.jpg	21	4075	194.048	2.915	255

Count the number of particles = 21 .

5) <u>Validation and Accuracy Assessment</u> :-

To validate the accuracy of the analysis, comparisons can be made with manual measurements or alternative methods for particle sizing. Factors influencing the accuracy of the analysis, such as image quality and segmentation errors, are discussed. Recommendations for improving accuracy and addressing limitations are provided.

MATLAB:-

Our MATLAB code correctly predicted the number of particles present in the image .
As , image contains the number of particles = 20.
Also our MATLAB code projected the same number of particles = 20 .
So, we can say that it 100% correctly predicted the number of images with 100% accuracy.

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Number of particles: 20
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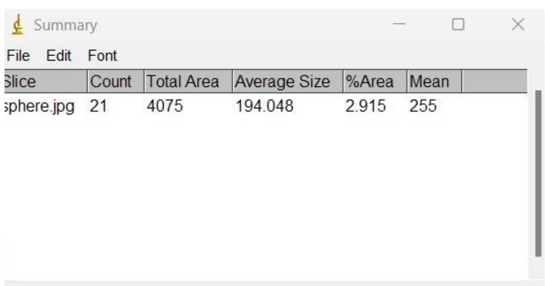
ImageJs :-

Almost correctly predicted the total number of particles as present in the given image .
Image contains 20 particles . ImageJs mentioned 21 images . So , we can say that it correctly predicted the number of images.



Slice	Count	Total Area	Average Size	%Area	Mean
sphere.jpg	21	4075	194.048	2.915	255

7. <u>Applications and Implications</u> :-

Particle size distribution analysis has broad applications across various industries, with significant implications for product development, process optimization, and regulatory compliance.

Pharmaceutical Industry :-

In drug development, PSD analysis helps in formulating dosage forms with optimal bioavailability and stability.

Regulatory agencies require thorough characterization of particle size distribution for approval of generic drug formulations.
Quality control measures rely on PSD analysis to ensure consistency and uniformity of drug products.

Environmental Science :-

PSD analysis of airborne particulate matter is critical for assessing air quality and understanding health risks associated with inhalable pollutants.
Monitoring changes in sediment particle size distribution in aquatic ecosystems helps in assessing environmental impacts and implementing conservation measures.

Material Science and Engineering :-

PSD analysis is essential for optimizing powder processing techniques such as compaction, sintering, and granulation in industries like metallurgy and ceramics.
Understanding the size distribution of filler particles in composite materials enables tailoring of mechanical properties and performance characteristics.

Food Industry :-

Controlling particle size distribution of ingredients like flour, sugar, and spices is crucial for achieving desired product attributes such as texture, mouthfeel, and appearance.
PSD analysis supports product development efforts aimed at creating innovative food formulations with improved sensory qualities and nutritional profiles.

8) Implications :-

The implications of particle size distribution analysis extend beyond product development and manufacturing to impact broader aspects of society, including public health, environmental sustainability, and economic development. By leveraging advanced analytical techniques and tools like MATLAB, researchers and industry professionals can gain valuable insights into the complex relationships between particle size, composition, and performance, driving innovation and progress across diverse fields.

8) <u>Conclusion</u> :-

Particle size distribution analysis plays a critical role in various industries, offering insights into the physical properties and behavior of particulate samples. Through the utilization of image processing techniques implemented in MATLAB, this project has demonstrated an effective approach to quantitatively analyze particle size distribution from digital images.

By following a systematic methodology encompassing image preprocessing, particle identification, size calculation, and histogram plotting, we have obtained valuable data on the distribution of particle sizes within the sample. The results obtained provide valuable information for understanding the characteristics of the particulate sample and can inform decision-making processes in product development, process optimization, and quality control.

Furthermore, the versatility and flexibility of MATLAB in handling image data, implementing complex algorithms, and visualizing results make it a valuable tool for particle size distribution analysis. However, it is essential to acknowledge the limitations and potential sources of error inherent in the analysis process, such as variations in image quality, segmentation errors, and calibration uncertainties.