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Particle Size and Shape Analysis using Imagej with Customized Tools for Segmentation of Particles

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***Abstract*— Image Processing is becoming important area of study in many industries including food processing, medical science, particle technology, cement industries, powder industries, etc., given the easy of measuring different dimension of particles including size, shape, color (RGB) analysis. Based on the computer algorithms to perform image processing on digital images, it not only allows for accurately measurement of the different physical properties of the object but gives various like size, size distribution, shape factors, color composition of the object very fast and real time analysis is possible. The efficacy of this technique depends on the factors such as- image quality, better noise reduction technique, and good filtration and segmentation techniques. Platforms like Matlab, ImageJ, Olympus, PAXit, etc., are available for the image processing. This work uses the platform ImageJ and a plugin will be developed for the segmentation of the overlapping and touching particles which are difficult to separate through in-built software are works fairly well for the circular particle. In the end, after incorporating this plugin, we will measure the size and shape factors of the different particles**

Keywords*— *Digital Images Processing, ImageJ, Binary, Watershed segmentation, etc.

I. INTRODUCTION

Digital image processing are increasingly being used in many industries including food processing, medical science, particle technology, cement industries, powder industries, etc., given the easy of measuring different dimension of particles including size, shape, colour (RGB) analysis. It is based on the programme based algorithms to perform image processing of the digital images. A much wider range of algorithms can be developed to be applied to the input data. One important feature of the image processing is that it can be modelled in the form of multidimensional systems. With the dawn of the 21st century, many high speed computers and signal processors have been developed making image processing popular and because of its utility to different kind of uses and being presumably the cheapest option.

In powder processing industries image analysis is becoming very handy in determining the flowability of the powder which depends on the size and shape of the particles. The flowability of powder is important area of study in many industries including pharmaceuticals, food processing. Flowability is measure of force acting between particles and that of between particle and handling and storage surface. [1] The surface forces of interaction acting between particles can be categorised into two parts: internal friction and cohesion force. Cohesion force arises due to Van der Waals forces and capillary forces due to liquid bridging. These surface forces of interaction vary depending upon powder material and its surface properties. It is flowability which determines the inclination and opening of hopper and silo. Powder flowability depends upon several surface and physical properties of the powder of which surface charge; surface texture, moisture content, and size have dominant effect. Generally for a particular powder smaller particle tends to have less flowable because of the high surface area per unit volume. [2] Increase in storage temperature enhances wall friction for flour and tea, but have opposite effect on whey permeate. Increase in storage time does not affect the wall friction for wheat and reduces the wall fraction for whey permeate and tea. [3] Similar trends are also observed with increase in relative humidity leads to decrease in flowability except for wheat flour.

Correct measurement of particle dimension or proper image processing requires precision in edge detection, noise elimination, segmentation of touching and overlapping particles, etc. But, the tools such as macros developed in image processing software such as ImageJ and MATLAB is unable to accurately measure the exact size and shape of the object. So, the segmentation technique becomes very important for the accurate size measurement. MATLAB and ImageJ (Java based, a free ware) are the two most popular applications for the image processing. Various inbuilt tools are available to determine the size of the objects or particles. But, these tools are sometimes unable to give the accurate measurement of the size and shape of the objects. Hence, there is wide scope of the modification to improve its efficacy and accuracy.

Micro level image analysis particularly in medical and morphological studies with the development of scanning electron microscopy (SEM) become very handy as high quality image is processed in ImageJ to not only analyse the morphology of the particles distribution but also to determine the particle size as well as the size distribution of fine GRP (Gas reinforced plastic waste) powder. Hence it indicates a larger utility of this approach to find the grain size, size distribution of GRP before assessing the recycling options. Waste of GRP materials are usually comes from the auto, locomotives, building and construction and it's related and aerodynamics after its life is been exhausted. [4] Apart from

this, ImageJ can also be used for the magnetophoretic measurement. Measurement of magnetophoretic mobility may be an effective tool for the detection of disease biomarkers captured by the using velocity of super paramagnetic particles if the attachment is of comparable size. [5] ImageJ can also be used in the analysis of the scattering-intensity data to find the size of the particles involves in the same. [6]

II. Literature Survey

ImageJ is a free-ware, written in Java language, an image processing platform originally developed by National Institutes of Health, U.S.[4][5] Developed on an open architecture providing various extension tools such as plugins and macros.[6] Acquisition of the data, and plugin for its analysis and processing are developed on its built-in editor and a compiler. Customised and self-developed plugins can be used for image analysis problems, from live-cell imaging [7] to radiological image processing,[8] multiple imaging system data comparisons[9] to automated haematology systems.[10] ImageJ's plugin has made it a popular platform for teaching image processing.[11][12] It can be installed and get run on an online applet including downloadable application, and on any computer with a Java 5 and later virtual machine.

Image Processing most important steps involves the filtration and segregation for overlapping particles so literature review can be summarised in the following heads:

1. Image acquisition

Image analysis and processing by different methods and it involves:

2. Filtration-

i. Median

ii. Gaussian Blur

3. Segmentation-

i. Histogram-based thresholding

ii. Skeletonization by Influence Zone

iii. Watershed segmentation

But, filtration techniques such as Gaussian Blur and Median work well which creates a new image by generating a image based on the Gaussian function and median function whose parameters are calculated from the original picture. After this, subtraction of newly created image with original image is done to create a new image. Which is then converted to binary image, then segmentation is done to separate the touching and overlapping particles. So my emphasis would be on the filtration technique particularly improving the Watershed segmentation by writing a plug-in in Java.

Skeletonization by Influence Zone

It is more complex approach of segmentation. It gives accurate results for mostly powder having spherical shape particle. The steps involved are:

• Convert image into binary

• Select regions are eroded till the overlapped and touched particles get segregated to great extent

• Background is then skeletonized resulting in a network of fine lining between particles remained

• This skeleton is subsequently deduced from the original image, after that fine boundary formed between particles

• This approach is highly useful when particle size involved stands more or less homogeneous.

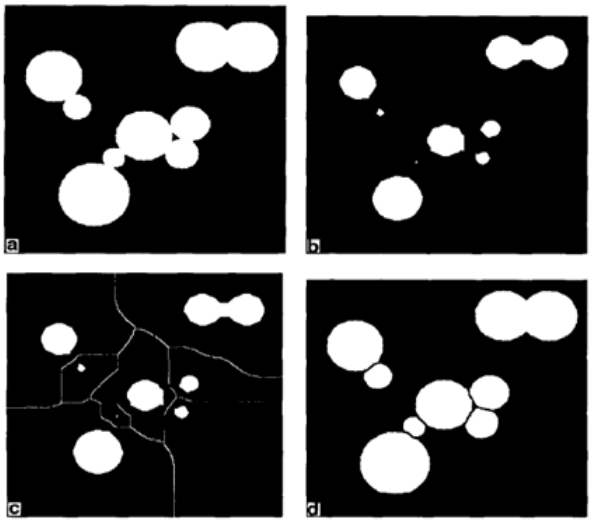

Fig. 1 SKIZ algorithm for segmentation of particles: (i) Binary image of image, (ii) partially eroded shape, (iii) skeletonized background image, (iv) final image after segmentation, if overlapping particles is large then separation is incomplete [16]

Watershed segmentation

It is widely used and gives accurate result for almost all types of particle shape. The steps involved are:

• Convert image into binary image

• Differentiate the selected pixels in accordance with the distance from the border area

• All the particles producing maximums in the ‘distance map’ image

• Maximums thus produced should be considered as the seeds for the further treatment of the binarized image

• Expansion using thickening with the condition that neighboring regions are remain unconnected till the entire image got filled up

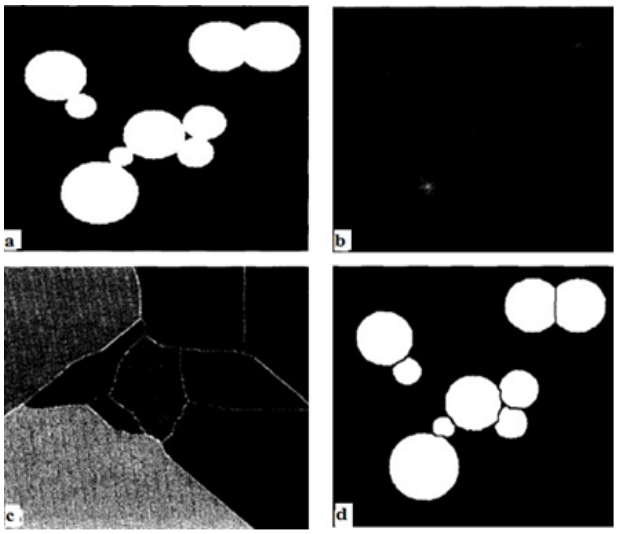

Fig. 2 Watershed algorithm for segregation of overlapped and touching particles: (i) Binary image, (ii) depicting distanced map, (iii) watershed segmented image, (iv) separated particle [16]

But it has been found that this method fails to segment the highly irregular particles because of inherent presumption in this hypothesis based on the watershed. So this paper will focus on developing a technique which will break the particle based on not only the curvature of the respective parents' particles but also in the ratio of their respective sizes.

III. POWDER SIZE DISTRIBUTION BY IMAGE ANALYSIS

The steps involved in the image processing are given below in the flow chart.

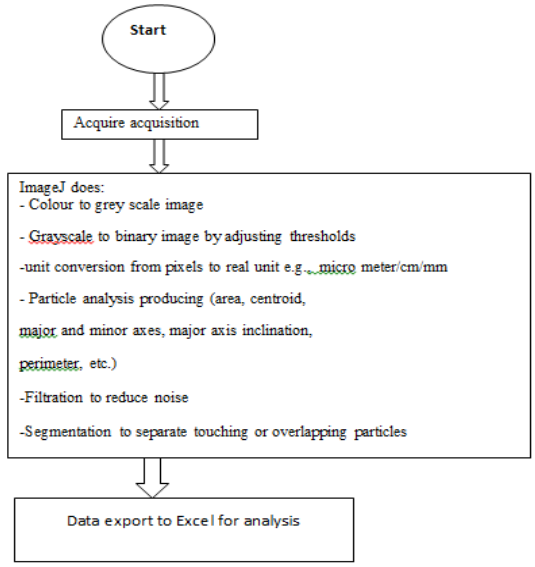

Fig. 3 Flow diagram of particle dimensions measurement and plugin algorithm.

Image analysis is one of the best methods for measuring powder size distribution. ImageJ software, which is freeware Java based Image Processing software, has been used in this paper for particle size distribution analysis. Other methods discussed in this paper is PCI software based technique and Sieve Analysis technique. It is a quicker and more accurate than sieve analysis provided image quality is good. Various size and shape parameters, e.g. size distribution, perimeter, feret diameter, circularity, etc. can be measured using Image Processing. The advantage of Image Processing is that it can be automated if method has been identified for a particular type of powder. Problem involves handling of overlapping and touching particles. Image Analysis technique can be applied to wide ranges application including mining, pharmaceutical, bio-medical, catalyst, powder technology, and food processing industries.

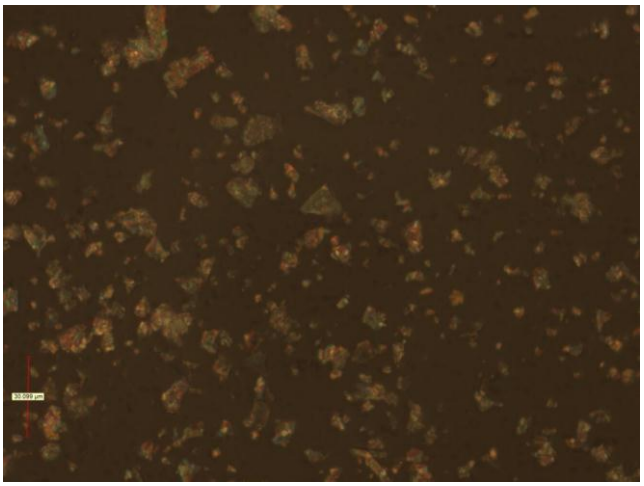

Fig. 4 Microscopic image of the talk powder

Fig. 5 After converting previous image in binary, filtration and segmentation using modified approach

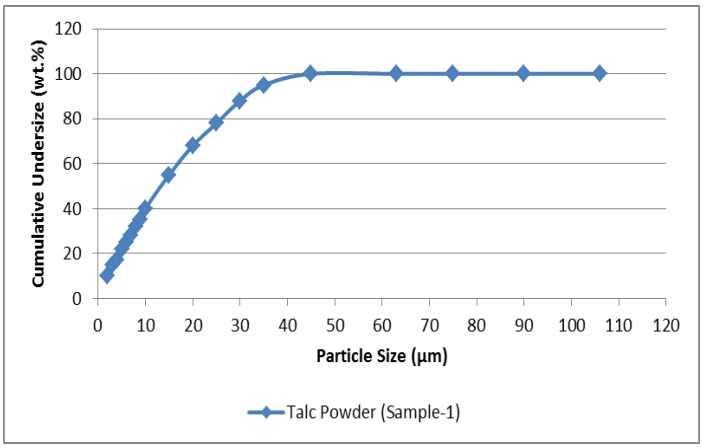

Fig. 6 Cumulative undersize variation with particle size for Talc powder

IV. CONCLUSION

Image processing is very convenient and cost effective approach to the various physical properties measurement e.g., size, shape, color composition, texture of the particles. Various platforms are available for the image processing many of those are in public domain. One of those is ImageJ which is in public domain and works well for the varieties of the particle types in general and spherical shape in particular. Therefore this paper proposes a mechanism to address the shortcoming of the existing watershed segmentation technique. It is found that after incorporating the abovementioned watershed segmentation worked well for irregular particles fairly well but still not gives so accurate result for the highly irregular particles. So, my future efforts will be on addressing the above shortcoming: To modify the watershed segmentation technique so as to minimize the error for the highly irregular shaped particles;

• To check the efficacy of such an approach with comparing the result with the actual values

• Using the modified tools to find the size and shape of the particles

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