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Determination of Angle of Repose of Pharmaceutical Materials Based On Image Processing Using Labview

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ABSTRACT: Physical properties of pharmaceutical products are of great importance in handling, drying, heating, extraction and other relevant processing operations. Majorly these properties are affected by the particle size and shape of the material. Flow property and compressibility of the powdered materials used in the pharmaceutical industry can be measured in terms of various parameters like Hausner's ratio, Carr's index, angle of repose and particle size. Tapped density and Bulk density measurements are also required to determine some of these parameters. Most of the conventional methods used for measurement of these parameters are manual and hence prone to error. This paper presents an approach of image processing using Vision Assistant - LabVIEW for determination of the angle of repose of different pharmaceutical materials and the results are compared with those obtained using conventional methods.

KEYWORDS: Angle of repose, image processing, LabVIEW, Flow property, Vision Assistant.

I.INTRODUCTION

Pharmaceutical materials are available in various states and forms like slurries of varying viscosity as well as solid granular powders. Handling and processing of these granular powders is largely dependent on the flow ability and compressibility of the particles. Various processes like dry coating using hybridizer, Magnetic assisted impaction coater, wet and dry granulation methods are used to improve the flow property by evenly coating one material on the other. The resultant materials developed exhibit better physical properties than their original forms which are measured in form of different pre-formulation parameters using conventional methods. One of these parameters of utmost importance is the angle of repose which characterizes the flow capacity of the material.

Many significant efforts have been made in order to calculate the static repose angle based on theoretical methods. The conventional method used to determine the static repose angle includes measuring the height and radius of the pile of the powder formed by suspending it through a funnel on a flat platform. This approach of measurement has the limitation of forming an irregular circular shape of pile for powders that form light to severe agglomerations.

In this paper an effort has been made to apply image processing approach to determine the angle of repose thereby improving the accuracy of the measurement. Firstly, the images of the piles of different pharmaceutical materials have been acquired by the Vision Assistant toolbox – LabVIEW from National Instruments. These images are then converted to other colorspace to enhance the important features and filtered to eliminate noise. This helps to improve the processing performance. Laplacian filtering has been found to be most suitable for this application. Also



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morphology image processing is used to smooth the detected edges. Finally averaging function is used on two angle measurements (from left and right sides of the pile) to achieve the final repose angle. Section II describes the literature survey carried out in this context. In section III, the conventional methods for measurement of the repose angle have been discussed. Section IV presents the proposed image processing approach for angle measurement using LabVIEW. Finally section V and VI presents the comparison of results of measurement and conclusion.

II. LITERATURE SURVEY

Image processing has acquired most of the researcher's attention in recent years. Many applications can be efficiently and effectively developed using machine vision as a result of availability of multiple software toolboxes for image processing. One of the most important advantages of using vision systems is that all the inspections are carried out under same conditions and the results produced are consistent [1],[5]. Image segmentation methods are now used for diversified applications. Segmentation accuracy determines the extent of success of the computerized procedure used for the application while image morphology helps to remove extraneous spurs on the edges of the region of interest [6]. As suggested by Rishi et. al in [2], choice of a segmentation method and the level of segmentation are dependent on the type of image and the problem under consideration. Specifically for an application where size and shape of the particles of material are of major importance, region growing method is more suitable [2][3]. Laplacian based filter efficiently helps to determine correct places of edges as well as it can test wide area around the pixels as suggested by Raman Maini et al in [4].

Various mechanical coating methods are used in the pharmaceutical industries for modification of the surface properties of the particles like impaction coating, mechanofusion and hybridization[7]. Effectiveness of the coating method is evident from the tests conducted to examine the physical properties of the materials. Angle of Repose is one of the parameters that represent the flowability of a material [8]. Angle of repose test is very sensitive to the method used to create the pile. Commonly used method is to suspend the granules of the material from a funnel on a flat surface. Classical method to calculate the repose angle using the relation $\tan(\Theta) = 2h/r$ is subject to caution on account of formation of irregular shaped piles[9].

Optical evaluation methods have also been used by A. B. Spierings et. al in [10] to examine powder flow characteristics for AM –Additive manufacturing for metal powders. Kurkuri et. al in [11] also developed a new optical method for measuring static angle of repose of wheat grains. A novel apparatus was developed by A.P. Chaudhari et. al. as mentioned in [12] to measure the repose angle of five different agricultural materials. The method proposed in this paper uses the LabVIEW platform and the Vision Assistant from National instruments to determine the angle of repose of different pharmaceutical materials. Instead of measuring the repose angle from only one side (left or right), both angle measurements are taken and then using the average function, final angle is calculated.

III. MEASUREMENT BY CONVENTIONAL METHOD

Angle of repose is the maximum possible angle between the surface of pile of powder and the horizontal plane. Figure 1 shows an example of measuring the repose angle of a pile of iodized salt powder. It is indicative of the flow properties of the powder.

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Fig. 1 Angle of repose measurement of pile of iodized salt

Manual measurement of this angle is done by drawing a free hand circle making the boundary of pile of the powder material. The height of the pile is kept fixed as the distance between the flat platform and the tip of the funnel from which the powder is suspended onto the platform.

Many instruments have been commercially available to measure the angle of repose to check the flow property of the material. The methods involve formation of pile of the powdered material on a flat platform by suspending the powder through a funnel. The height of the pile is recorded or is kept fixed for convenience. The radius of the pile is then measured. Finally using equation (1), the angle is calculated.

$$\theta = \tan^{-1} \left(\frac{h}{r} \right) \quad (1)$$

Some devices record the varying height of the pile instead of the radius which is kept constant thus forming the ratio (h/r). Figure 2 and 3 show two devices to measure the repose angle from Gardco, Paul N. Gardener Company incorporated. For a given height and radius of the pile formed, the angle can be directly measured using a testing machine shown in figure 3.

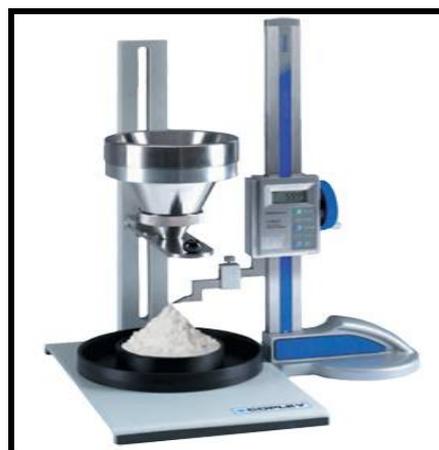


Fig. 2 Flow ability Tester BEP2 (Gardco)

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Vol. 6, Issue 3, March 2017



Fig. 3 Repose angle testing machine (Gardco)

IV. PROPOSED METHOD OF MEASUREMENT

The image processing approach is carried out according to the flow diagram given in figure 4. Firstly, the images of the piles are acquired using the iBall Super-View C8.0 web camera interfaced to Vision Assistant. The experimental setup for measurement is shown in figure 5.

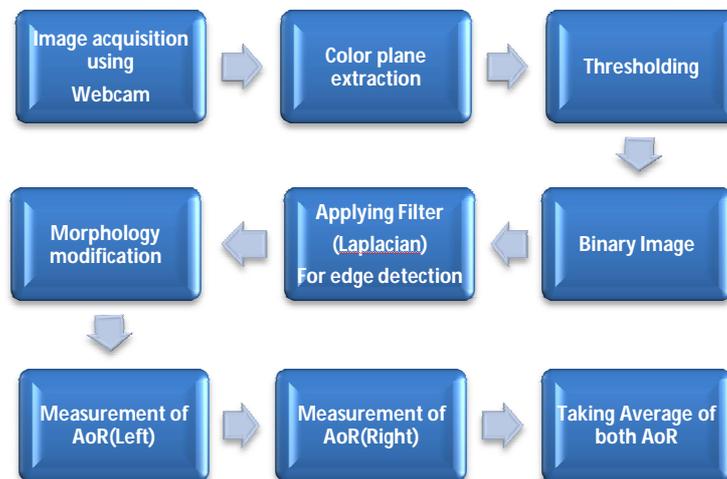


Fig. 4 Flow diagram of the image processing method for repose angle measurement

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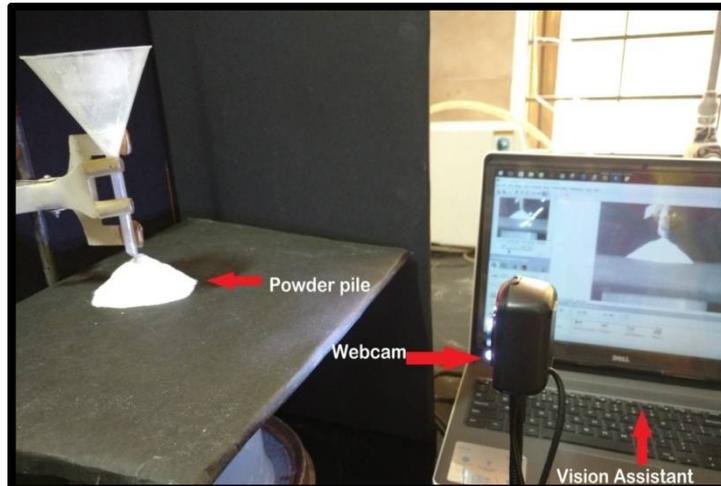


Fig. 5 Experimental setup to measure angle of repose using image processing

The blocks shown in Figure 4 represent various stages of the processes undergone by the acquired images. Once the images are acquired, their colorspace is changed to gray scale by extraction of one of the red, blue or green component. This is required to apply the thresholding process to convert the RGB image to binary. The resultant binary image is segmented into different regions based on the threshold value selected. Next stage involves detection of the edges of the regions separated in order to emphasize the shape of the pile of the powdered material. Laplacian filter with appropriate Kernel size is chosen to clearly detect the edges.

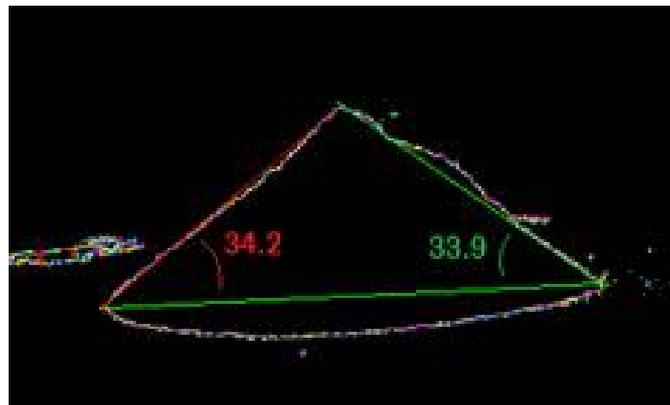


Fig. 6 Measurement of left and right angles of the pile

After this, the image undergoes morphological dilation to enhance the edges detected. Finally, the measurements of the angle are done from both sides, left and right as shown in Fig. 6 and their average is considered to be the actual measurement.

V. RESULT AND DISCUSSION

On execution of the Virtual instrument code, the front panel shown in figure 8 appears. The Front panel displays the results (Angle of Repose – Final) as well as some of the intermediate processing indicators and controls like threshold range and filter size.

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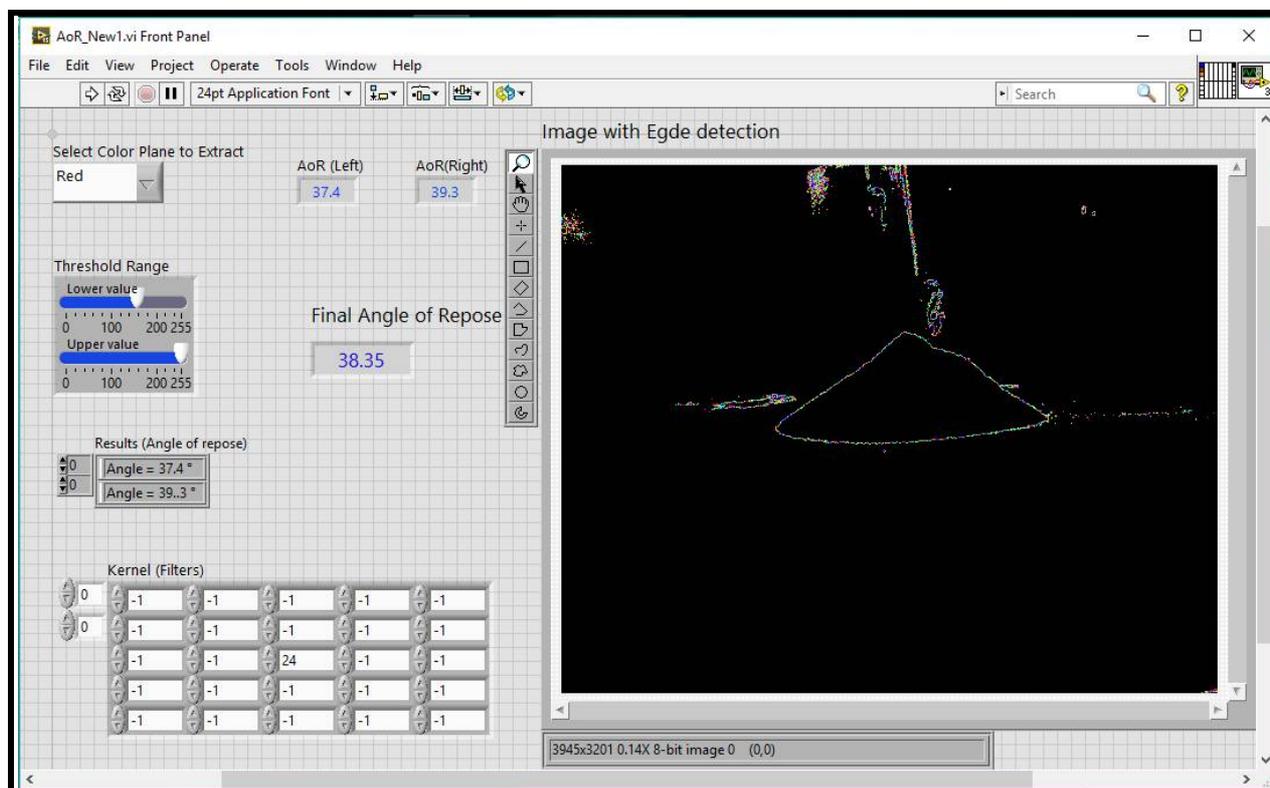


Fig. 8 Front Panel of the Virtual Instrument in LabVIEW

Table 1 given below shows the comparison between the measurements of the repose angle done manually and by using the image processing approach. Figure 9 shows the comparison chart of these measurements. The blue graph represents the angles measured using the conventional method and red represents those measured using the image processing approach. It is observed from these results that the measurements made using image processing methods are consistent with those obtained by conventional methods.

Sr. No.	Powder Material	AoR (degrees) (Conventional method)	AoR (degrees) (Image Processing)
1.	Microcrystalline cellulose	40.2	38.35
2.	Sodium Carboxymethyl cellulose	42.56	41.56
3.	Lactose	52.0	51.84
4.	Paracetamol	51.9	50.75
5.	Nimesulide	48.0	47.45

Table 1 Comparison of conventional and proposed methods for AoR measurement

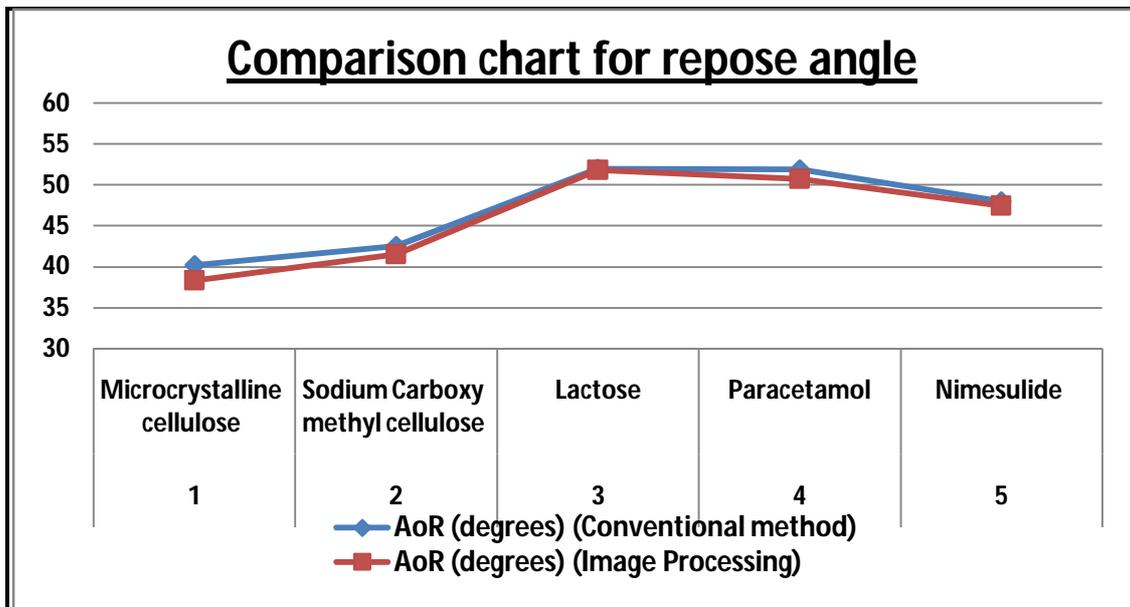


Fig. 9 Chart for comparing the AoR results

VI.CONCLUSION

Image processing using LabVIEW Vision Assistant proves to be an efficient tool for measurement of the repose angles. The same can be applied for measurements of large grain size particles like granular sugar or rice grains. The results obtained using the image processing approach, are consistent with those achieved by other conventional methods. Thus it allows effective measurement of the repose angle. Accurate results obtained so, provide significant aid in further processing and handling of the pharmaceutical materials.

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