OPEN ACCESS
CENTIVE 2019
ISBN : 978-602-53004-0-0

Conference on Electrical Engineering, Telematics, Industrial Technology, and Creative Media 2019

Angle of Repose Measurement Tool Development Based on Image Processing with Hough Transform

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Abstract

The flowability parameters of granule are the main requirements for the tablet manufacturing process in the pharmaceutical industry. The smoothness of the granules to the tablet mold will determine the weight, hardness, and uniformity of the tablet. The flowability depends on several parameters, one of which is the angle of repose, so that the angle of repose is very valuable information in the process of making tablet drugs. Many significant attempts have been made to calculate static stationary angles based on theoretical methods. The conventional method that is widely used to determine the angle of rest is to measure the height and radius of a piles of granules. This system is not practical because it involves manual measuring devices such as rulers and squares. Departing from these concerns, the researchers developed a method for calculating the stand angle based on image processing, in which piles of granules pressed on a flat plane were taken images and the stand angle was calculated using a hough transformation, so it is expected that the process of calculating the stand angle will be more practical and the results easily documented. In this study, researchers have succeeded in developing an image-based stationary angle measuring instrument, in which the stationary angle is calculated using a hough transformation. The measuring instrument developed has a precision level of 11.74%. Measurements were made on three types of granules with the distance between the camera and the top of the granule set at a distance of 13 cm, 17 cm, 19 cm and 22 cm.

Keywords: *angle of repose, granule, hough*

I. INTRODUCTION

A. Granulity and Angle of Repose

In industrial and engineering applications, the use of granular materials such as powders, seeds, and soil is inevitable[1]. Granular materials are of substantial importance in many industrial and natural processes[2]. As in the pharmaceutical industry, pharmaceutical ingredients can be found in solid granular powders[3].

Flowability is a key requirement for the pharmaceutical manufacturing process[4]. Tablets are often manufactured in multi-rotating station press tablets by filling dead tablets with powders or granules based on volume. Therefore, the flow of powder from the funnel to the mold often determines the weight, hardness, and uniformity of the tablet's content[5]. In the case of capsule manufacture, powders or fillings in the same amount are widely used.

The flowability depends on several parameters, one of which is the angle of repose or AoR[6][7]. Therefor the AoR is very valuable information in the process of making drugs. The important point is that the angles of repose that characterize the flow of the material[14].

B. Angle of Repose Measurement Methods

Several methods have been developed for angle of repose measurement these methods are[1]:

a. Tilting Box Method[8]
b. Turning Cylinder Method[9]
c. Granule Pile method or Fixed Funnel Method[10]

The methods for angle of repose measurement mentioned above is mechanical in nature and involves measuring with the help of ruler to measure the height of the pile as shown in the Fig, 1.

Figure 1. Angle of Repose

This manual process is definitely not practical and requires patience from the operator. Another approach to measure AoR is using image processing[11], but Misri et.all still use manually approach to detect pile edge. Therefore, in this study we intend to develop a angle of repose measuring instrument using image processing that automatically detect granule slope line.

The image here is an image of a pile of granule which it is edge detected. The purpose of edge detection is to reduces the amount of data and filters out useless information, while preserving the important structural properties in an image[12]. Finally the line that represent granule pile slope is detected using Hough transform.

II. RESEARCH METHOD

A. Hough Transform

Hough Transform was first introduced by Paul Hough in 1962 to detect straight lines[13]. The simplest case of Hough's transformation is detecting straight line. In general, the straight line y = mx + b in XY space (Fig. 2) can be represented as a point (b,m)[13] in the parameter space as shown in the Figure 3.

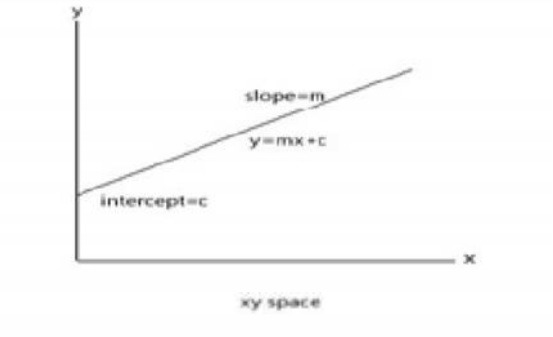

Figure 2. Straight lines in the XY plane

As shown in Figure 3, each has two quantities associated with it, slope (m) and interception (c)). With these two numbers, a line can be drawn as a space parameter, or mc space (Figure 3).

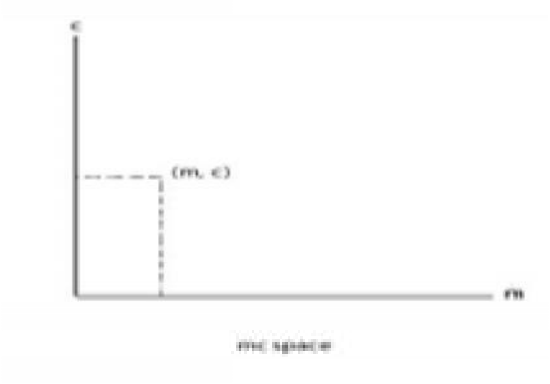

Figure 3.Single Line representation in the mc plane

The point representation in the xy plane in the mc space parameter will be the infinite intersection of the lines. Figure 4 illustrates this. Hough's transformation is a transformation that transform a line in xy space to a point in mc space[13].

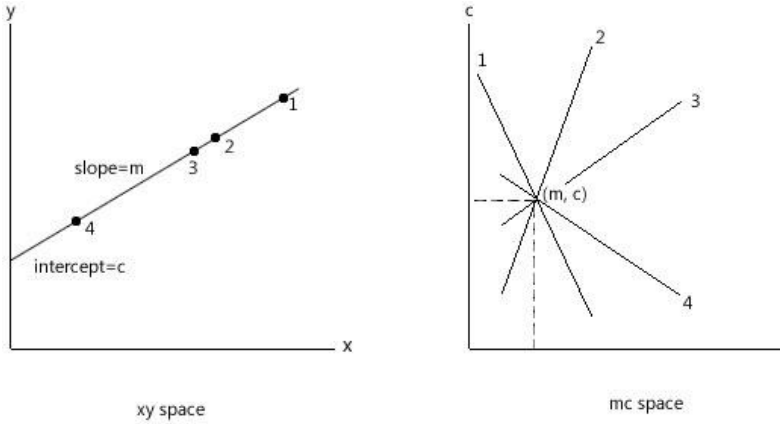

Figure 4. Presentation of straight lines in the XY plane to the mc plane

B. Proposed System and Flowchart

The proposed granular angle of repose measurement tool hardware is a computer based system with the block diagram as in Figure 5. The camera is used to obtain granule pile images.

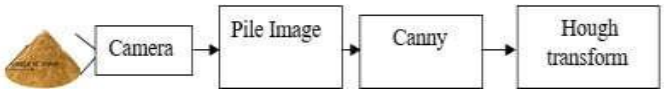

Figure 5. Proposed system block diagram

Pile image will be converted in to gray scale image. The edge of gray image will be detected by using the canny operator. Then the line the result of the image from the canny operator will be detected by using hough transform. All process metioned before is depicted in Figure 6.

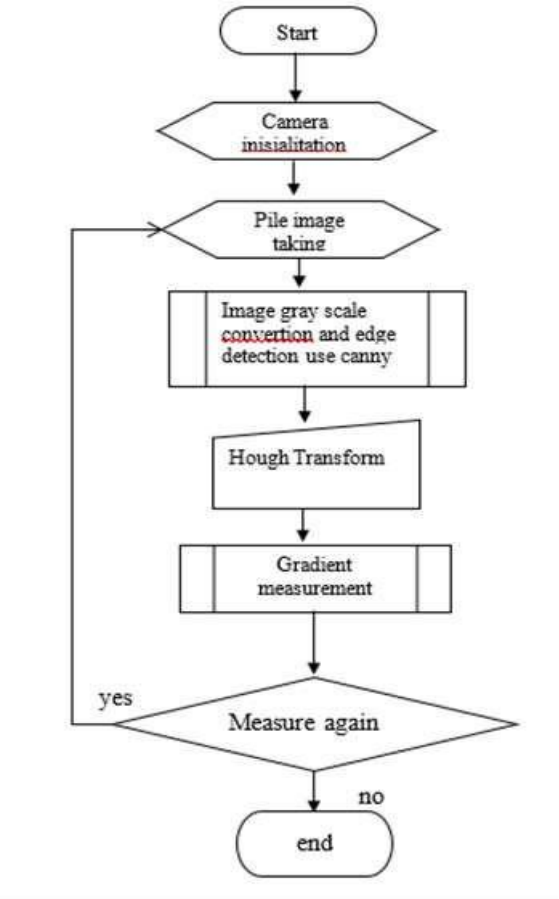

Figure 6.Angle of repose flowchart

III. RESULT

A. Proposed System Prototype

The prototype of the proposed system is designed with dimensions as shown in Figure 7. USB camera is connected to a computer. The computer runs angle of repose measurement program that was built using Python and OpenCV.

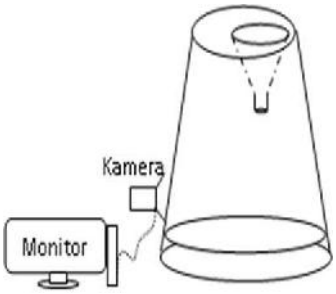

Figure 7.Angle of repose measurement device prototype

The peripheral device used to capture images is a standard USB camera that is widely available in the market. The USB camera used in the experiment was a USB camera produced by the Sturdy camera type PC511. The image of overall system is depicted at Figure 8.

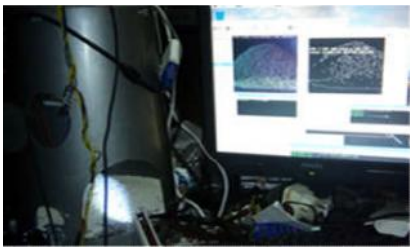

Figure 8. Proposed device prototype

B. Result

Testing of angle of repose measuring devices prototype is done by test the tool to measure angle of of repose from two granule piles (granule A and B) that we known before for their angle of repose value . The piles of granules were taken with the camera position placed at 22 cm, 19 cm and 13 cm measured from the top of the granule pile.

The experimental results are displayed from Figure 9a to Figure 9d. Figure 9a is image of granule A with a 22 cm camera position calculated from the top of the piles of granules. Granule A has a pre-measured angle of repose 37^o.

For granule B with manually measured angle of repose is 33^o , the testing procedure result depicted in Figure 10a to Figure 10d. Figure 10a is shown image of granule B with camera position at a distance of 22 cm, Figure 10b with camera position at 19 cm and so on until Figure 10d.

The red line in the images is the granule pile slope being detected, and the angle of repose is shown as text (blue color) on the image respectively

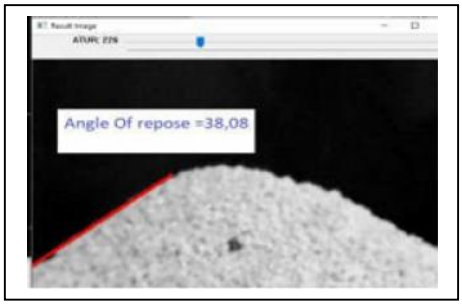

Figure 9a. AoR of granule A was measured at distance 22 cm

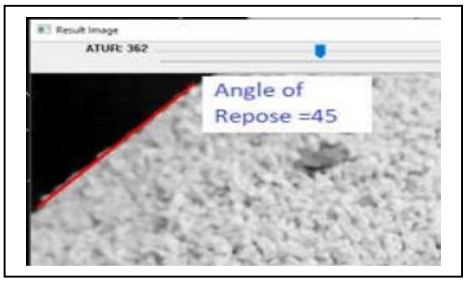

Figure 9b. AoR of granule A was measured at distance 19 cm

Figure 9c. AoR of granule A was measured at distance 17 cm

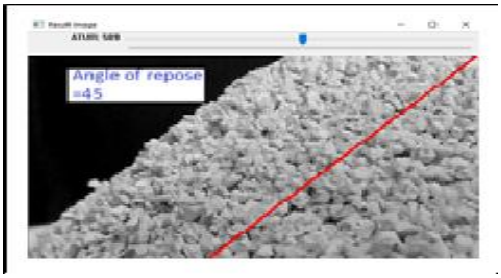

Figure 9d. AoR of granule A was measured at distance 13 cm

Figure 10a. AoR of granule B was measured at distance 22 cm

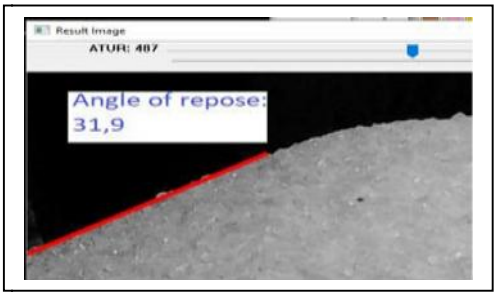

Figure 10b. AoR of granule B was measured atdistance 19 cm

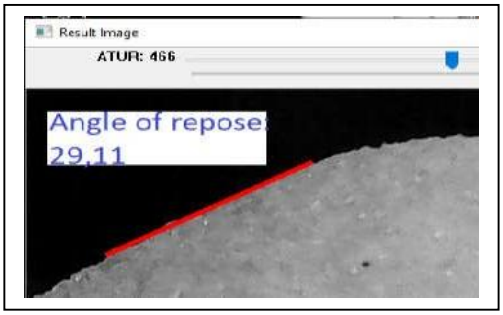

Figure 10c. AoR of granule B was measured atdistance 17 cm

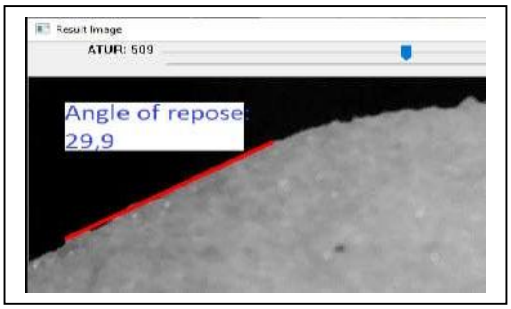

Figure 10d. AoR of granule B was measured at distance 13 cm

The results of the above experiment are tabulated in Table 1. It can be seen in table 1 that there was a large enough average error that is equal to 15.8%. This is because the result when measurement with distance 13 cm, 17cm and 19 cm is fairly large, this is causedbecause the image that taken at those distance is not perpendicular enough with horizontal plane. However, this method of measuring the still angle gives quite good results when taking as far as 22 cm (with error at 2,7%). This is due to the image taken with long distance result image that quite perpendicular with horizontal plane.

The same results were also seen in the measurement of granule B. It is seen that the measurement results for granule B had a relatively smaller average error compared to the results of granule A measurement which was 7.68%. However, it gives a pretty good result when measuring at a distance of 22 cm, which give an error of 0.3%.

TABLE I
AOR MEASUREMENT RESULT FOR GRANULE A (WITH AOR 37^{o})AND B(WITH AOR 33^{o}) WITH VARIOUSCAMERA DISTANCE FROM PILE

Granule	Camera Position distance (cm)	AoR based Hough Transform(^{o})	Error	Eror (Average)
Granule A	13	45	21,6%	15,8%
	17	40	8,1%	
	19	45	21,6%	
	22	38	2,7%	
Granule B	13	29.92	-9,3%	7,68%
	17	29.11	- 11,78%	
	19	31.91	-3,3%	
	22	33.1	0,3%	

IV. CLOSING

A. Conclusion

In this study based on the results of our experiments, the use of the Hough method for the measurement of the stationary angle of repose gives a decent result where the measurement results give good reliability by showing the average deviation of 11.74% of the measurement results manually. The best results are done by placing the camera at a considerable distance (22 cm) from the top of the granule, which is obtained an average error of 1.5%.

B. Sugestion

The main cause of the deviation mentioned above, according to our assumption, is caused by an incorrect placement of the image on a flat plane, because setting the camera to be able to take the image really in a horizontal position is difficult when shooting close to the top of the granule.

ACKNOWLEDGMENT

Researchers would like to thank especially LPP UAD who have funded this research for the 2018/2019 fiscal year.

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