Automatic Quality Control Scrutiny of Sugar Crystal using K-Means Clustering Algorithm Image Processing

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Abstract - *Automatic discovery of the size of sucrose crystal is performing a series of contrast improvement techniques, including momentary statistical analysis through standard deviation. In any production industry, a feature of the product is an essential factor. The proposed method measures the quality of sugar crystals after production and at the time of crystal formation itself. Quality measurement depends upon size and shape. A series of algorithms for automatic determination of sugar crystals size using digital image processing was developed. Statistical analysis is implemented to automate the procedure of quality regulator. This supports to match the intensity dissemination in the massecuite pictures at the preprocessing step. The proposed work recognizes the crystal cluster from the massecuite, which supports to characterize crystal size distribution in the crystallization pan. This benefit to equalize the intensity distribution in the massecuite images at the preprocessing stage. It avoids future errors appearing in the product formation.*

Key Words: Clustering, Crystal Cluster, Crystal Size Distribution, Crystallization, K-means Clustering, Massecuite

1. INTRODUCTION

Quality control is a vital part of the sugar production process as manufacturers must ensure that the product complies with the customer's specifications. The look texture of the final product and the solubility, tendency to aggregate, agglomerate, and other properties are important for industrial processes using sugar as raw material[1]. Hence, care can be taken that particles are neither too small nor too big. Traditionally, the particle size determination was carried out by sieve analysis, which was a rather slow, labor-intensive method and commonly subject to measurement faults such as too much example material, worn out sieves, wrong sieve parameters, or simple calculation errors [2]. The key attention is to improve the model that uses a computer algorithm for the automatic dimension of sugar crystal. Particularly in the sugar industry old-style physical control of crystallization is experienced. It is the pan-mans accountability to regulate when seeding should be applied and when to take measurement mostly by feeding more feed syrup to reduce super-saturation in order to stop further nucleation[3]. The pan-man takes examples from the massecuite on a small glass plate to define if there are already enough grains for the batch. He relies on his visual experience to dismiss the nucleation of the massecuite. It can observe that the result of shock seeding depends very much on super-saturation and on the length of the time of nucleation [4]. If the entire process is left to the pan-man without assistance from instrumentation, it is unbearable to control the guaranteed quality of this significant process. Since human control is subject to exhaustion. In this research work, techniques can be classified into the following sets as histogram equalization, K-means, edge detection based, distance transform techniques, crystal labeling[5].

The process of sugar crystallization occurs through the mechanisms of nucleation, growth, and agglomeration of sucrose crystals. In the crystallization pan stage, crystal sugar is manufactured from syrup [6]. The crystallization pan is loaded with sub-saturated syrup and then heated under partial vacuum until the oversaturation phase is reached. At the super-saturation stage, the sugar powder is fed in to pan as seed crystals that grow throughout the boiling process[7]. Several stages of procedure sequences are executed in the vacuum pan; these are the Charge stage, Concentration stage, Seeding stage, Crystallization, and Tightening stage. During the charge stage, the crystallizer is fed with syrup. At the concentration stage, the syrup is acceptable to reach the super-saturation level. Seed crystals are announced into the pan to provoke crystallization at the seeding stage[8]. The materialization of crystals occurs at the crystallization stage. The final preferred size of the crystal is obtaining at the tightening stage. The quality of sugar and best control of sugar crystal growth during the crystallization stage depends on the coefficient of variability of the crystal size distribution. The key factor in crystallization control is super-saturation, followed by crystal content present in the massecuite. The ideal finale product consists of well-formed unbroken crystals of the required size and number in a unit volume. Crystal size distribution, the amount of fine and conglomerates crystal, and crystal color are important parameters that determine the product quality[9]. The formation of conglomerates in the crystallization pan will damage crystal size distribution and product color.

To the growth of income from sugar export and continue competitiveness in the world marketplace on a sustainable basis, it is essential to conduct milling technology research to governor the quality and progress of the effectiveness of the raw sugar production process. One key feature of sugar grain

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 12 | Dec 2022 www.irjet.net p-ISSN: 2395-0072

production is essential to enhance and monitor the grain growth rate in the crystallization pans. First, monitoring this process at the seeding stage of crystallization is required to inaugurate an adequate population of sugar grains at the beginning of the process. Secondly, it is required to establish whether or not the size distribution is bimodal, which will affect the overall crystal growth rate. Once a problem is detected, the necessary process control conditions need to be adjusted in order to assure the quality of the final output fixed by commercial specifications (adequate size and homogeneous grains). The crystallization process is determinant for the crystals size distribution. The main influencing factors are seed quality, super-saturation field distribution, and secondary nucleation[10]. The principal objective of sugar manufacturing operations is to achieve a consistent and acceptable product quality, which is achieved at a low cost. High sugar yields in conjunction with good mother liquor exhaustion during crystallization are important requirements to achieve this target. As a consequence, process control is of major importance. The critical feature that needs to be monitored during the crystallization process is the super-saturation of mother liquors and the crystal content of the massecuite[11]. The search to boost production has led to numerous measurement methods to regulate crystals growth in the sugar industry.

2. METHODOLOGY

The general objective of this learning is to discover the feasibility of obtaining the real-time mean sugar crystal size directly from sugar images captured using a 0-500X portable Digital Microscope Endoscope Lab measurable camera magnifier with 640 x 480 optimum resolutions[12].

2.1 Histograms Equalization

The histogram is one of the essential features which are very linked to image enrichment. The histogram does not only give us a general summary of some useful image statistics, but it also can be recycled to prophesy the appearance and intensity characteristic of an image [13]. If the histogram is focused on the low side of the intensity scale, the image is generally a dark image. On the other side, if the histogram is focused on the high part of the scale, the image is generally a bright image. If the histogram has a short dynamic range, the image usually is an image with a poor contrast[14].

The sample size is a key factor to obtain reliable and meaningful results. There are many methods to get the size of the sample, in the case of grain is common to use stratified sampling, probabilistic or random sampling[15].

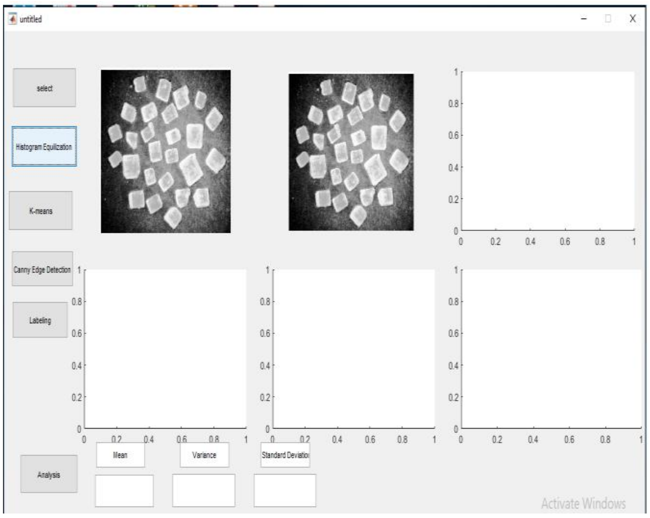

Fig -1: Histogram Equalization

2.2 Binarization

An image binarization method covering the steps of setting a threshold value range for a value regarding a Y value representing brightness of a pixel particular from an image and extracting a pixel with the value concerning the Y value in the image within the threshold value scope, wherein when a pixel is nominated in the image, the threshold value scope is set in a range of adding a predetermined value to the value concerning the Y value of the choose pixel and/or subtracting the predetermined mark point, and wherein when after the pixel is choose, a pixel various from that pixel is choose, if the value concerning the Y value of the choose pixel is greater than the value concerning the Y value of the pixel for which the threshold value scope is set, between the predetermined value added to the value concerning the Y value of the choose pixel and a lower limit value in the threshold value scope, a new threshold value scope is set, or if the value concerning the Y value of the choose pixel is smaller than the value concerning the Y value of the pixel for which the threshold value scope is set, between the predetermined value subtracted from the value concerning the Y value of the scope pixel and an upper limit point in the threshold value range, a new threshold value range is set[16].

The binarization Method converts the grey scope image (0 up to 256 gray levels) into black and white images (0 or 1). The result of OCR highly relates to binarization. The great class binarized image can give maximum accuracy in character recognition as compared original image because noise is present in the original image[17].

2.3 Edge Detection

Edge detectors of some kind, particularly step edge detectors, have been an essential part of many computer vision systems. The edge detection process help to simplify the criticize of images by drastically reducing the amount of data to be processed, while at the same time preserving.

• Contour Detection and Hierarchical Image Segmentation

The Canny multi-stage edge detection algorithm is recycled to identify the edges in the segmented image. Crystal edge pixels have strong intensities compared to other pixels. It is an optimal edge detector algorithm with a low error rate. The canny algorithm ensures that edges occurring in images should not be missed; also, there should not be any response to non-edge pixels[18]. The distance between the calculated edge pixels and the actual edge is minimum to ensure edge localization. This algorithm is ensuring only one response to a single edge, therefore, eliminating the chance of multiple possibilities. In this technique, initially perform smoothing techniques with a Gaussian filter to reduce desired image details and then calculate the image gradient at each pixel. If the gradient magnitude at a pixel is superior to those at its two neighbors in the gradient direction, the pixel is observed as the crystal edge. Otherwise, the pixel is marked as the background. In conclusion, the weak edges are removed by hysteresis Thresholding [19].

Edge detection is a process that recognizes the availability and places of edges constructed by correct changes in color intensity (or brightness) of an image. It provides a modern contour detector, combining local and global image information. It gives extensive quantitative evaluation and the release of a new annotated data set.

2.3 Edge Detection

Data clustering is the method of grouping data features constructed on a specific aspect of similarity between the features in the group. EM clustering will eliminate the problem of overlapping. Clustering is the foremost method applied for the clustering of mathematical and image data in data mining and image processing applications. Clustering can perform the job of image retrieval easy by finding the images as equal as given in the query image [8]. The images are clustered combine in some given number of clusters. Image data are cluster on the basis of a few attributes such as tone, shape color etc. consist of the images in the form of pixels. For the subject of efficiency and better results, image data are segmented before applying clustering. Clustering is the unsupervised grouping of patterns such as observations, data items, or feature vectors into groups named as clusters. Applications of clustering are growing nowadays very rapidly because it saves time period, and the results obtained from the clustering algorithm is very suitable for the algorithms in the later stages of the applications[9]. The data in every group are similar to each other, but shortly dissimilar to the data in different groups. So, the data which are clustered together are similar to each other.

$$\sum_{j=1}^{k}\sum_{m=1}^{s_p}\left\|X_j-\mu_p\right\|^2 \qquad (1)$$

Where Xj is a vector representing the mth data point and up is the geometric centroid of the data points in Sj.

3. QUALITY CONTROL MEASURE

3.1 Matching Attribute

The size and shape of a crystal are significant features in the process of quality control. Crystals have a regular shape to meet this constraint, so consider the area of a crystal must be almost the same that the area of a bounding box containing it[10]. Therefore, Matching Attribute (MA) is defining as the ratio between the area of the crystal and the area of the bounding box, thus:

$$MA=\frac{A_c}{A_b}100\% \qquad (2)$$

Eq.(2), Ac is the area of the crystal and Ab the area of the bounding box. The typical values could be between 60 % and 80 %.

3.2 Mean Diameter Weighted by Particle

The mean particle diameter is the most vital single statistical parameter because it allow us to compute other parameters of interest such as particular surface area and the coefficient of variation. The Mean Diameter Weighted by Particle (dwp) is a reference measure used in the food industry to determine the ideal crystal size sugar can be calculated by summing all equivalent diameters (MA) and dividing the result by the number of crystals, that is,

$$d_{wp}=\frac{\sum MA_i}{N} \qquad (3)$$

Where MAi represents the MA for each crystal and N the numbers of crystals.

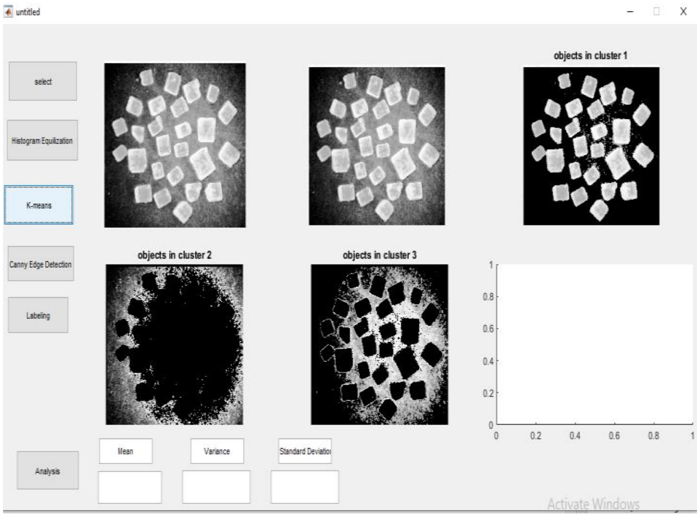

Fig -2: Image Segmentation using K-means Algorithm

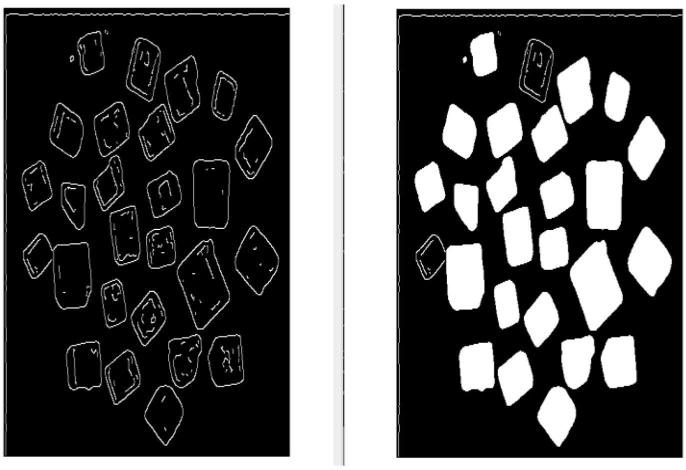

Fig -3: Edge of Segmented Image

3.3 Coefficient of Variation Weighted by Particle

The coefficient of variation (CV) is a measure of the spread of the crystal sizes is basically standard deviation expressed as a percentage. The CV can be weighted by particles or volume. Hence, the CV weighted by particles CVwp can be calculated by:

$$CV_{wp} = \frac{\sigma}{\overline{x}}.100\% \tag{4}$$

3.4 Coefficient of Variation Weighted by Volume

Express the size uniformity of sugar crystals by using a CV weighted by Volume CVwp. Although the CVwp is applied to estimate the crystal sizes, the CVwp is the most benefited method to compute the morphology variation in the sugar industry. The CVwp consists of modeling the crystal as perfect spheres [11][4]. The CVwv is based in the Mean Diameter Weighted by Volume (dwv), which can be calculated by,

$$d_{wv} = \frac{\sum MA_i V_i}{\sum V_i} \tag{5}$$

Where MAi represents the MA for each crystal, and Vi is the crystal volume modeled as sphere.

Once the MAi is calculated, the CVwv can be computed from,

$$CV_{wv} = \frac{\dfrac{\sqrt{\sum (MA_i - d_{wv})^2 V_i}}{\sum V_i}}{d_{wv}} * 100\% \tag{6}$$

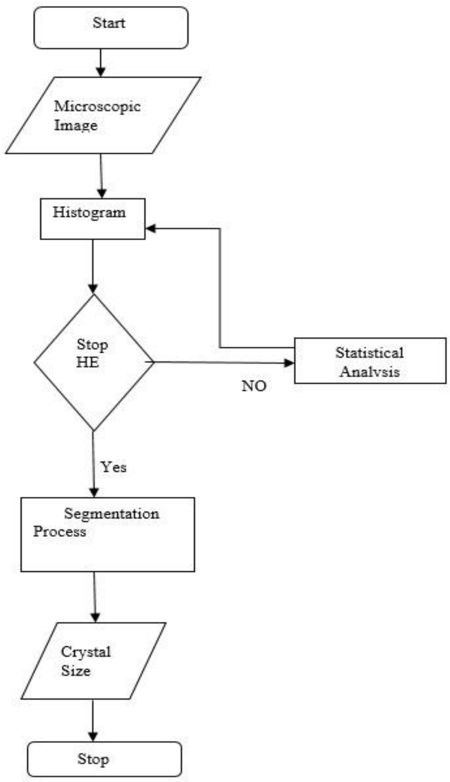

Fig -4: Flowchart of Sugar Crystal Image Analysis

Table -1: Statistics Obtained For Sugar Crystal Sample of Fig. 2

Statistic	By Particle	By Volume
Mean(x)	0.9781	01.3487
Variance (σ^2)	0.0914	10.4470
Standard Deviation (σ)	0.2975	00.3547
Coefficient of Variance (CV)	31.25	20.8421

3. CONCLUSION

The possibility to measure sucrose crystal size parameters using digital image processing was announced. An automatic computerized method has been industrialized to measure sucrose crystal size parameters directly from images. Since the image contains multiple objects of interest, the algorithm was speedily and fruitfully executed using MATLAB. Individual objects were identified after segmentation operation and implemented the region of interest according to their connected components. The crystal size distribution of the individual crystals was estimated as well as the background of the image was openly identified from the focal point by a separation process. In this project, 25 samples of the sucrose crystal were taken unsystematically to determine the region of interest's crystal size distribution using Distance Transform and Foreground Background algorithms. In conclusion, the result of the algorithms was compared with manually clicked images and well-established techniques used in the factory for the determination of grain size parameters precisely MA and CV.

REFERENCES

[1] Manuel Cardona," Sugar Crystals Characterization for Quality Control Inspection Using Digital Image Processing," Conference: 2016 IEEE 36th Central American and Panama Convention, Nov.2016

[2] Sreedhany L R, Philomnia, Lancy Thomas, "Automated Massecuite Sucro Crystal Size Characterization System for Crystallization Pan in Sugar Industry," 2016 International Conference on Information Technology (InCITe)-The next Generation Summit,pp.82-86,2016

[3] Paithane, Pradip Mukundrao, and S. N. Kakarwal. "Automatic Pancreas Segmentation using A Novel Modified Semantic Deep Learning Bottom-Up Approach." International Journal of Intelligent Systems and Applications in Engineering 10.1 (2022): 98-104.

[4] N. Faria et al., "Quantification of the morphology of sucrose crystals by image analysis," ELSEVIER Power technology 133(2003),54-67

[5] Paithane, Pradip M., and S. A. Kinariwal. "Automatic determination number of cluster for NMKFC-means algorithms on image segmentation." IOSR J. Comput. Eng.(IOSR-JCE) 17 (2015): 12-19.

[6] Dalzlel et al., "An image analysis system for sugar crystal sizing" in Proc.Aust.Soc.Sugar Cane Technol,21:366-372,1999.

[7] Paithane, P. M., & Kakarwal, S. N. (2018, December). Automatic determination number of cluster for multi kernel NMKFCM algorithm on image segmentation. In International Conference on Intelligent Systems Design and Applications (pp. 870-879). Springer, Cham.

[8] Ingram and steindll, "Rapid Crystal Sizing on the pan stage by Digital Image Analysis," Proc.Aust.Soc.Sugar Cane Technol,23:361-368,2001

[9] B. Zhang et al., "Monitoring crystal growth based on image texture analysis using wavelet transformation," IFAC, 2012

[10] Paithane, P. M., Kakarwal, S. N., & Kurmude, D. V. (2020). Top-down method used for pancreas segmentation. Int. J. Innov. Exploring Eng.(IJITEE), 9(3), 1790-1793.

[11] A. K. Jain," Fundamentals of Digital Image Processing," Englewood Cliffs, NJ: Prentice-Hall, 1989.

[12] Paithane, P. M., Kakarwal, S. N., & Kurmude, D. V. (2020, December). Automatic Seeded Region Growing with Level Set Technique Used for Segmentation of Pancreas. In International Conference on Soft Computing and Pattern Recognition (pp. 374-382). Springer, Cham.

[13] W. K. Pratt," Digital Image Processing." New York: Wiley, 1978

[14] J. Canny, "A computational approach to edge detection," IEEE Transaction on Pattern Analysis and Machine Intelligence, vol. 8, pp. 679698, 1986

[15] Kakarwal, S., & Paithane, P. (2022). Automatic pancreas segmentation using ResNet-18 deep learning approach. System research and information technologies, (2), 104-116.

[16] Wagh, S. J., Paithane, P. M., & Patil, S. N. (2021, December). Applications of Fuzzy Logic in Assessment of Groundwater Quality Index from Jafrabad Taluka of Marathawada Region of Maharashtra State: A GIS Based Approach. In International Conference on Hybrid Intelligent Systems (pp. 354-364). Springer, Cham.

[17] P Arbelaez, "Contour Detection and Hierarchical Image Segmentation" IEEE Transaction on Pattern Analysis and Machine Intelligence, vol 33, No 5,2011

[18] Soong-Der Chen, Abd. Rahman Ramli, "Minimum Mean Brightness Error Bi-Histogram Equalization in Contrast Enhancement, "IEEE Transactions on Consumer Electronics, Vol. 49, No. 4, 2003

[19] Paithane, P. M., Kakarwal, S. N., & Khedgikar, S. S. (2020). Semantic Web Technology and Data Mining for Personalized System to Online E-Commerce. *International Journal of Progressive Research in Science and Engineering*, *1*(5), 136-139.

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