Available online at www.isas.org.in/jisas
JOURNAL OF THE INDIAN SOCIETY OF
AGRICULTURAL STATISTICS 73(2) 2019 105–110

Image Processing based Software for Determination of Size and related Physical Properties of Various Grains

Karan Singh[1], Nachiket Kotwaliwale[1], Abhimanyu Kalne[2] and Madhvi Tiwari[1]

[1]*ICAR-Central Institute of Agricultural Engineering, Bhopal*
[2]*Indira Gandhi Agricultural University, Raipur*

Received 30 January 2017; Revised 12 March 2019; Accepted 15 March 2019

SUMMARY

The morphological properties of agricultural commodities, such as size, shape, colour etc. are required in various agricultural applications including quality assessment, crop/ variety identification and design of machinery. Manual measurement of these attributes is arduous, time taking and often not so accurate. An approach based on image processing has been developed as computer software. This approach is a rapid, non-invasive, and quantitative. The software reads an image, taken using flatbed scanner, preferably in TIFF (tagged image file format), and instantaneously provides the physical parameters to an accuracy of 0.1 mm. The aim of the present work was to ascertain accuracy and precision of the developed software by calibration through a known size of the object. The software has been tested on many images of variety grains and results are found to be in agreement with the manual methods. In the case of length and width, the RMSE average values found to be 0.36 and 0.33, respectively.

Keywords: Image processing, Size, Shape, Physical properties.

1. INTRODUCTION

Physical properties of grains are required in various fields of agricultural sciences like agronomy, genetics, engineering etc. These properties are specific to crops, their varieties/ cultivars and may also depend on cultivation practices and geographic conditions. Engineering relevance of these properties is in design of machines for handling, harvesting, transporting, cleaning, separating, packing and processing of grains (Razavi *et al.*, 2010).

Measurement of these properties is a time and labour consuming task. Different methods and instruments/ aids are used to measure the principal dimensions of grains. These include the use of graph paper(s) (Pigeaire *et al.*, 1986), rulers, Vernier callipers (Mandal *et al.* 2012), micro-meters (Haralle, 1984), height gauges, travelling microscope (Singh and Goswami, 1996), etc. Screen sieving is widely used as a standard method of determining seed size distribution in grains. Sieving (manual or mechanical) is inconsistent, laborious and time-consuming. It may potentially cause involuntary damage to the seed coat, which can adversely affect the visual appearance, storability and processing quality of the grains. Moreover, sieving doesn't measure and normally takes care of only one of the principal dimensions. Precision, accuracy and time requirement for these methods vary a lot and therefore the quantity and quality of data may be compromised. Moreover, employment of such methods demands timely measurement of the dimensions, otherwise, the sample may undergo certain changes and properties may get altered.

A quick, efficient and non-destructive method for determining seed and grain size would greatly benefit grain industries. Machine vision or image analysis can be a faster, non-destructive alternative to the traditional sizing equipment and methods currently used in the grain industry (Shahin *et al.*, 2005). Machine vision techniques have been developed and used to determine the physical dimensions of various seeds and grains (Tanabata *et al.*, 2012; Blasco *et al.*, 2009).

Corresponding author: Karan Singh
E-mail address: singhkaran66@gmail.com

A single dimension or multiple dimension are used in describing the shape and size of a grain/particle (Raj Kumar S.M. and Malayalamurthi R., 2017), these shape parameters of all the objects (food grains in the current context) can be determined by using various algorithms written in appropriate software platform. Recent improvements in acquisition of digital images and their analysis provide unique opportunities for describing shape and texture of particles in an automated manner (Vasumathy M and Mythili T., 2017). In recent years, image analysis is widely used to analyse the particle shape characteristics and aggregate parameters (Sebastian B. and Marek P., 2018).

Flatbed scanners are very convenient and economics alternative for taking an image. These scanners cannot only generate an image at a very high resolution but also their camera is having fixed focal length and internal light source, the output image quality is fairly uniform in terms of brightness, contrast, sharpness, colour fidelity and pixel distribution. To establish accuracy and precision of any measurement system, calibration is must, therefore, the objectives of the present study were to calibrate the user-friendly software developed for quick and accurate determination of grain physical dimensions and associated shape properties and to compare the grain dimensions determined by image analysis with the manual method and also for artificial objects of known dimensions created on computer.

2. MATERIALS AND METHODS

The images were captured using a colour scanner at various pixel densities as could be controlled by the scanner software and were used for feature extraction using the developed software.

2.1 Definition of size and shape features as physical properties

The shape and size of an object are defined based on certain features identified in previous research (Agrawal *et al.*, 2012, Haralick *et al.* 1973; Kotwaliwale *et al.*, 2007; Igathinathane *et al.*, 2008). Ten textural features were extracted using the developed algorithm for further processing and analysis. The brief description of captured features for analysis purpose is given below:

2.1.1 Major axis: The longest axis of an ellipse or ellipsoid; passes through the two foci. Length of the major axis of the equivalent ellipse.

2.1.2 Minor axis: Length of the minor axis of the equivalent ellipse.

2.1.3 Ferret diameter: A Ferret diameter is a statistical diameter in particle size analysis. The distance between two tangents on opposite sides of the particle profile that are parallel to some fixed direction. For hydraulic applications, it is recommended that the fixed direction is normally vertical, *i.e.* from top to bottom, in the field of view that includes the image of the particle. The distance between the max ferret diameter ‘start’ and the max ferret diameter ‘end’ is known as max ferret diameter.

2.1.4 Heywood circularity (HC) factor: Perimeter divided by the circumference of a circle with the same area. The closer the shape of a particle is to a disk, the closer the Heywood circularity factor to 1. It is represented by HC.

2.1.5 Elongation factor (EF): Max ferret diameter divided by equivalent rectangle short side (Ferret). The more elongated the shape of a particle, the higher is elongation factor. It is represented by EF.

2.1.6 Compactness factor (CF): Area divided by the product of bounding rectangle width and bounding rectangle height. The compactness factor belongs to the interval [0, 1]. A perfect rectangle would have CF of 1.

2.1.7 Roundness: Roundness = $\frac{A_p}{A_c}$

Where,

A_p : Projected area of the object in natural rest position

A_c : Circle with maximum ferret diameter

2.1.8 Length: Average of maximum ferret diameter and major axis.

2.1.9 Width: Average of minimum ferret diameter and minor axis.

2.1.10 Perimeter: Length of the outer boundary of the particle/ object.

2.2 Development of algorithm

An algorithm was developed for pre-processing and processing of captured images for extraction of required features. The flow diagram of the process of image analysis for determination of physical dimensions is shown in Figure 1.

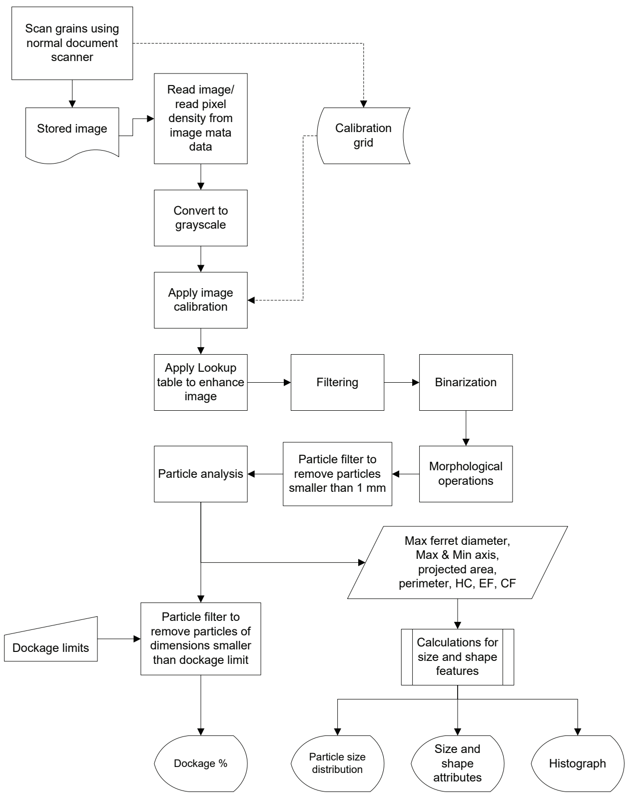

Fig. 1. Algorithm for image processing of grain size and shape

The image is read as a three-layer matrix of RGB (red, green, blue) colour intensity values within a range 0–255 (8-bit). The image resolution is captured from the image metadata and the pixel density in terms of dots per inch (dpi) is calculated. The process includes conversion of the image to 8-bit grayscale, adjustment of the image contrast which maps the intensity values in the greyscale image to new values of adjusted image such that 1% of data is saturated at low and high intensities, respectively of the former image. Then grayscale image converted to a binary image by using OTSU method (Otsu, 1979) to calculate appropriate threshold value. Using morphological operations, unwanted pixels are removed from the binary image and empty regions surrounded by white pixels were filled. The connected components, i.e. different objects in the image are then counted and treated as an individual entity. The size and shape features for these individual entities are then measured in terms of pixel count. These values are then converted to physical dimensions, i.e. mm using the pixel density value read earlier.

2.3 Grain size and shape software

The grain size and shape software is a graphical user interference (GUI) based software (Fig. 2) developed on Matlab platform (Mathworks Inc. Ver. 2018 A). The software, while applying the above logic gives the user a freedom to manually select the cut-off for binary image generation (Fig. 3), does not include the objects in image that are partially touching the boundary can automatically detect the boundary touching grains, provision to export results as a TXT (text file) file that can be opened in spreadsheet software (e.g. Microsoft Excel). Upon analysis maximum, minimum and average values each parameter are then displayed along with frequency distribution chart of certain parameters. The software also calculates and displays five best matching colours as per the Royal Horticultual Society colour definition chart. Regardless of the placement or number of grains or their orientation, *Grain size and shape software* can isolate all seeds and measure their parameters.

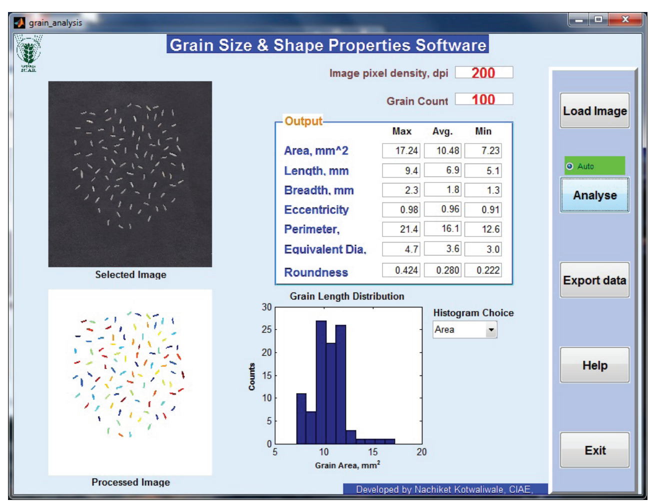

Fig. 2. Main screen of grain size and shape properties software

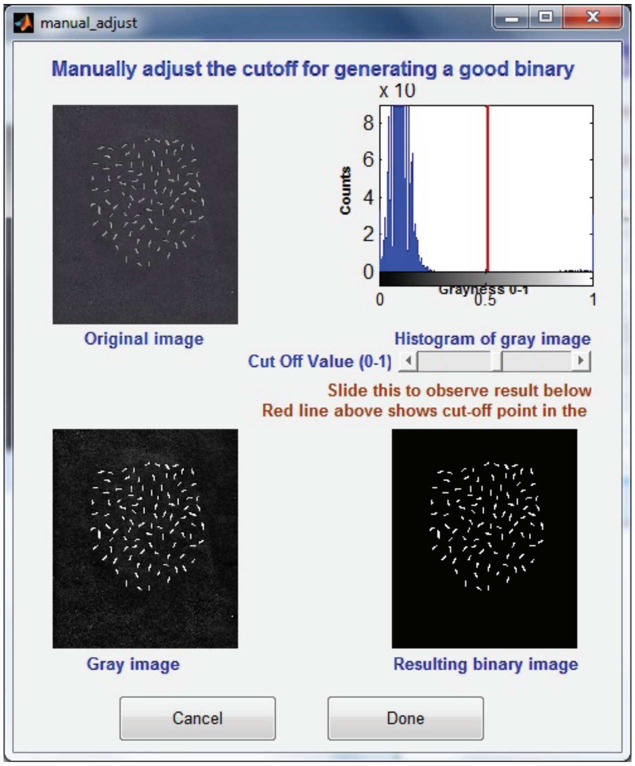

Fig. 3. Screen for manual adjustment of threshold for binary image

2.4 Testing of developed software

2.4.1 Grain samples

Grains of different varieties of paddy/ rice were used for the determination of physical dimension. Fifty grains were randomly selected from the samples for determination of grain dimensions manually and using grain analysis software. A Vernier callipers with least count of 0.01 mm was used to determine length and width of grains manually. Three replications each with 50 grains were carried out to test the software.

2.4.2 Fabricated shapes

Dummy image sample (Fig. 4) of different shapes with known dimensions were created using CorelDRAW-10 software. Fourteen images of ellipse and rectangles of known dimensions and of a different colour, with different background and different rotation angle, were used to determine the accuracy of the *Grain Size & Shape Software.* Dimensions of the small and big ellipse were 20 mm × 10 mm and 10 mm × 5 mm, respectively and the dimensions of the small and big rectangle were 20 mm × 15 mm and 15 mm × 11.25 mm, respectively.

Fig. 4. Dummy image with various shapes considered for calibration

2.4.3 Imaging

Images of paddy grains were captured using a document scanner (Make: Canon, Model: CanoScan LiDE 100) and saved as TIFF (tagged image file format) files. Grains were spread uniformly on the scanner bed so that they were not touching each other, and were scanned at different pixel densities varying from 100 to 600 DPI. Black or white background was provided during scanning to generate appropriate contrast between the object and background. To prevent entry of stray light on the scanner camera, a frame made of styrofoam was mounted on the periphery of the scanner lid. The scanning process required 50 seconds for scanning of approximately 100-120 grains as one image.

3. RESULTS AND DISCUSSION

Since the principal, as well as secondary dimensions/ shape indicators for fabricated shapes, were known, these images were used for calibration of the software. Root mean square error (RMSE) was used as an indicator of the magnitude of extreme and average errors. The values of length (L) of the shapes (largest principal dimension) measured by image analysis and actual values are presented in Figure 5. The lowest and highest percentage difference of L was found zero and 0.67, respectively, the average RMSE between actual and measured values was 0.05 and extreme value of RMSE was 0.10. Figure 6 represents the values of second principal dimension width (W) measured in the case of fabricated shapes by Image analysis and their actual values. The maximum difference of width of fabricated shapes was 2% and the minimum was zero, the average RMSE between actual and measured values was 0.07, with an extreme value of 0.10. These error values are negligible and can be attributed to the minuscule errors occurring during conversion of the image from vector to raster (in Coreldraw-10) and also during binarization of image.

A comparative study of L and W measurement by Grain Size & Shape Software and manual method using Vernier callipers was carried out. The values of L measured for grain samples by Image analysis and manual method are presented in Figure 7. In the case of L, the lowest and highest percentage difference in manual and image analysis method was found to be zero and 8.23, respectively, the average RMSE of manual and image analysis method was found to be 0.36. The figure 8, represents the measured values of W for grain samples by image analysis and manual method. The maximum difference of width of paddy in image analysis method was 16.84% higher than manual method and the minimum was zero. In the case of W, the average and extreme values of RMSE were 0.33 and 0.50, respectively.

It is evident that the differences in measurement measured in terms of RMSE were higher for the actual grains than for the fabricated images. This has to be due to the error in the manual measurement of grain sizes. In fact, testing with fabricated images gives such a confidence that the manual measurement will always be questionable. One of the major and most tangible advantages of using machine vision approach is time-saving. The time required to determine grain size manually (≈ 1.5 h for 50 grains) is much higher than the image analysis method (≈2 min for about 100-150 grains). Moreover, the grain images once saved can be used later for any other kind of analysis and validation as well. The limitation of the software may be proper selection of image covering all grains.

4. CONCLUSION

The grain size and shape software is developed to determine physical shape and size of grains required for various applications. It is capable of measuring the

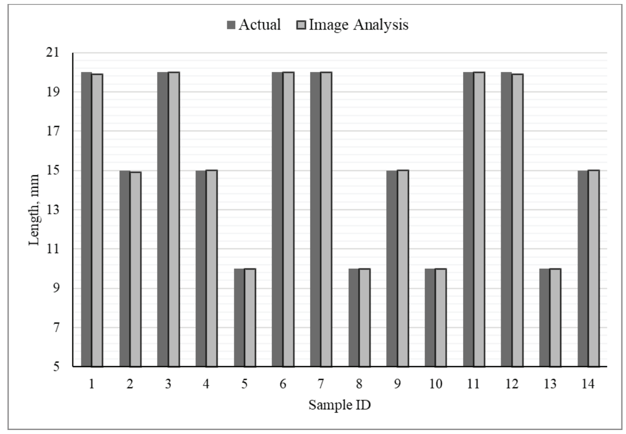

Fig. 5. Comparison of length between actual and image analysis

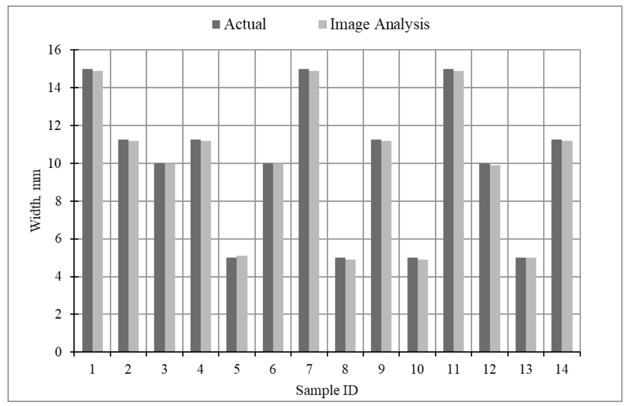

Fig. 6. Comparison of width between actual and image analysis

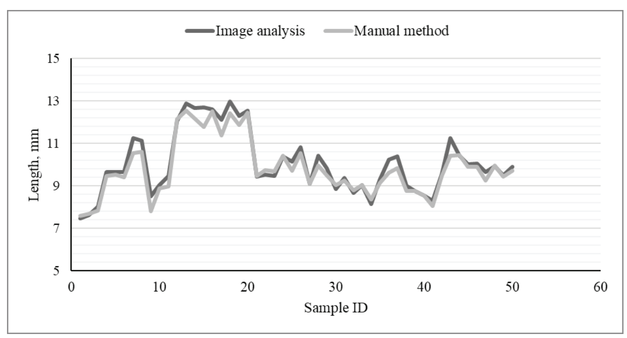

Fig. 7. Comparison of length between image analysis and manual

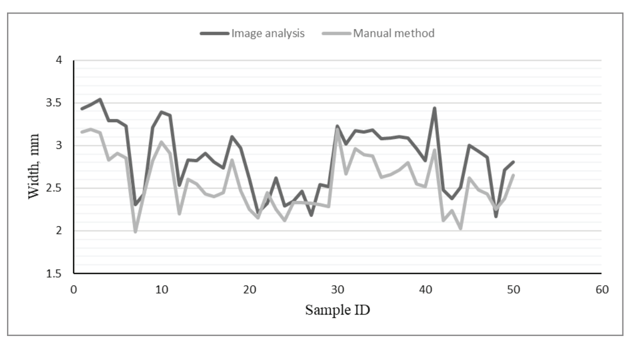

Fig. 8. Comparison of width through image analysis with measured

correct dimensions of the captured features in addition to time saving. The software has been calibrated, tested and validated by varying the sample size of grains of rice several times through image analysis and manual method. In the case of length, the lowest and highest percentage difference in manual and image analysis method was found to be zero and 8.23, respectively. The maximum difference of width of fabricated shapes was two percent and the minimum was zero. The results are in agreement with manual method as compared to length and width, the RMSE average values found to be 0.36 and 0.33, respectively.

REFERENCES

Agrawal K.N., Singh K., Bora G.C., Lin D. (2012). Weed recognition using image-processing technique based on leaf parameters. *J. Agril. Sci. Tech.*, 2 (8B), 899-908.

Blasco J., Aleixos N., Cubero S., Gomez J. and Molto E. (2009). Automatic sorting of satsuma (Citrus unshiu) segments using computer vision and morphological features. *Comp. Electr. Agril.,* **66**, 1-8.

Haralick R.M., Shanmugam K. and Itshak D. (1973). Textural features for image classification, IEEE Transactions on Systems, Man and Cybernetics, Vol. SMC-**3(6)**, 610-621.

Haralle J., (1984), Roller Micrometer Analysis of Grain Shape: Research Method Paper, *J. Sedimentary Petrology*, **54(2)**, 643-645.

Igathinathane C., Pordesimo L.O., Columbus E.P., Batchelor W.D. and Methuku S.R., (2008). Shape identification and particles size distribution from basic shape parameters using Image *J. Comp. Electr. Agril.*, **63**,168-182.

Kotwaliwale N., Weckler P.R., Brusewitz G.H., Kranzler G.A., and Maness N.O. (2007). Non-destructive quality determination of pecans using soft X-rays. *Postharvest Bio. Tech.*, **45(3)**, 372-380.

Mandal S., Roy S., Tanna H., (2012). A low-cost image analysis technique for seed size determination, *Current Science*, **103(12)**, 1401-1403.

Otsu N., (1979). A Threshold Selection Method from Gray-Level Histograms, IEEE *Transactions on Systems, Man, and Cybernetics*, **9(1)**, 62-66.

Pigeaire A., Duthion, C., Turc O. and Gonthier J., (1986). Characterization of the final stage in seed abortion in indeterminate soybean, white lupin and pea, *Agronomie*, **6(4)**, 371-378.

Raj Kumar S.M. and Malayalamurthi R. (2017). Measurement of particle size distribution attained from the sago sizing mechanism, *Int. J. Scien. Res. Dev.*, Vol. **5**, No. **08**, pp. 58-62.

Razavi, S.M.A., Bostan A. and Razaie M., (2010). *J. Food Process. Engg.*, **33**: 51-64.

Sebastian B. and Marek P. (2018). Grain size determination and classification using adaptive image segmentation with shape information for milling quality evaluation. *DIAGNOSTYKA*, 2018, **19**(**1**), pp 41-48.

Shahin, M. A. and Symons S. J., (2005). *Canadian Biosystems Engg.*, **47**, 349-355.

Tanabata T., Shibaya T., Hori K., Ebana K. and Yano M., (2012). SmartGrain: High-throughput phenotyping software for measuring seed shape through image analysis, *Plant Physiology*, **160(4)**, 1871-1880.

Vasumathy M. and Mythili T. (2017). Shape determination of aspired foreign body on pediatric radiography images using rule-based approach. *Advanced Image Processing Techniques and Applications*, pp 12.