ISSN: 2321-7782 (Online)
Impact Factor: 6.047

Volume 4, Issue 11, November 2016

International Journal of Advance Research in Computer Science and Management Studies

Research Article / Survey Paper / Case Study

Available online at: www.ijarcsms.com

Size Measurement and Color Calibration in Image Based Grain Examining

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Abstract: The significance of size and color is in consumer acceptance of grain appearance. Price of the item depends on color of final product. Colors are the first parameters considered for quality by consumers. Consumer acceptance of grain and food are highly depends upon the appearance. Appearance affects the quality of the grain. Wide research is going on for color and size measurement of the grain. Image analysis has proven effective solution for measuring grain quality. Though tedious, but it is very important to do the qualitative analysis of the individual seed.

In this article, an attempt is made to provide size measurement and color calibration methods for image based digital grain analyser. With this image based grain analyser, grain is put to flat tray/conveyer belt and grain image is captured for analysis. With this approach grain seeds have different angular position which needs to be considered while measuring quality parameters. Size measurement is done for angular position of the grain seeds. Color calibration is done for meeting the different organisation naming criteria. Different grain organisation works with different grains and different grain varieties. So it is very difficult to provide different grain analysis solutions for them all. To deal with this, the calibration mechanism is provided. With this method, interested color combinations' ranges are found using few samples. These color combinations are considered as a base and named according to organisation choice. Two different approaches are used for getting such combinations. This base data is considered as input for measuring other grain samples. Experiments are carried out with different grain types, but with this paper only rice grain experiments are focused.

Keywords: image acquisition, image processing, feature extraction, grain analysis, grain analyser.

I. INTRODUCTION

Grain analyser is developed for measuring the quality of the grain sample. This grain analyser uses the flat tray while capturing the grain image. As being flat there is a high chance that the seeds are not arranged with same angle with grain tray angle. Tray can be replaced with conveyer belt for achieving online image based grain benefits. So while calculating the size, angle should be considered. Moreover resolution of the image also impacts the length and width measurement of the seed. With this work efforts are put to measure length and size based on its angularity. Color calibration is required as all industries are uses different color name for the grain sample. Same seed have different quality parameters with different organisations. To prepare a generalised grain analyser it is require providing customised mechanism by which calibration is made for achieving same quality results.

A. *Color Calibration:*

Color is very important for accepting or rejecting any food. Different color cereals have different quality parameters associated with it. The food product produce from different colored cereals have different color and different taste.

Color calibration is required for the analysis of colored image and to generate results from them. For color calibration at granule level, it is require measuring the pixel color. Any individual pixel in image have the RGB combinations value based on that pixel color is identified. To get the seed color as a whole it is require to find maximum number of the same RGB combinations pixels in the seed. That RGB combination acts as color value for the seed.

For color calibration the different configurations instruments like cameras, scanners are considered. Calibration is also needed for the scenes are taken with different lightning conditions. Different 3D viewpoints are analysed taken with either same or different instruments/environment conditions. Color calibrations are also useful for the true-color LED to enhance the performance of true-color image display [1]. Temperature, lightning conditions and different instruments manufacturing process lead to different results for the displays. It results in visual fatigue and low quality of color perception [2]. As summary, all the images (taken with different configuration, different instruments or different lightning conditions) are then correlated based histograms or other mapping functions. Generally calibration is made for producing same parameter based input images for analysis software to apply common imaging algorithms without change.

With this work instead of the above discussed approach, calibration is provided at user level. It does image analysis first, segment them and produce the final output. The final output is then calibrated according to organisation standards. Color calibration is made for the images captured with the same environment conditions. This work focuses on the identifying and naming the color group available in grain sample.

All organisations have their own identification mechanism for colored grain seeds. Same set of color range have different implications base on organisations internal criteria. Calibration method should be provided to mark these RGB combinations according to organisation standards. If we consider all the real possible RGB combinations, then it is mostly impossible to classify them all and moreover they don't fall under the domain range. There is requirement of identifying the interested RGB combinations for that. Only these combinations are needs to be considered for the analysis process. To identify this kind of interested RGB combinations, two approaches are considered.

B. *Size Measurement:*

Length and width of grain are critical parameters for grain samples classification from top level as short grain, medium grain and long grain. According to research thin seed breaks while milling, this needs to be separated out. Based on this concept trend is set for improved milled rice yield and head rice yield. When cooked, ***long-grain*** brown rice fluffs up readily and tends to separate when cooked. Because of this quality this kind of rice is choice for pilafs, casseroles, salads and baked dishes. It also has a firmer, dryer texture and feel in the mouth. That means your rice will fall apart, rather than stick together while ***medium-grain*** varieties are stickier and a good choice for paella, a pungent spanish dish that incorporates seafood and meat and stuffing for vegetables. ***Short-grain*** brown rice has a bit creamy texture that lends itself well to dishes such as risotto rice pudding. Weight provides information about density of grain; moisture retains capacity and cooking capacity. Two samples have different quality which are having same size appearance but different in weight. These discussed features of rice are useful for agricultural breeding and categorization of grain for exporting.

II. Related Work

The length and width of a rice grain are important attributes that determine the class of the rice. Color and appearance are important factors in grading grains. Prepared food item's color based on the color of the grain used for cooking it. Color has first sensation of grain quality even before eating. Research is made for color distribution of L*a*b* color space [3]. Calibration algorithms are also developed for depth and color camera pair. Calibration is done for the inter-camera, which is important where multi – cameras are used [4] and it is require to combine and analysis scenes taken from different cameras. Because of the multiple cameras there are possibilities of multi-view images. There is a color difference with the images taken from same configuration camera. The issues are arising with accurately reproducing color consistency in multi-view 3D imaging systems [5]. Investigations are made for measuring scanner to scanner variability and color correction mapping functions are developed for independent grain inspection [6]. Color calibration is done based on local descriptors and area based co-relations methods, followed by formulation of over determined linear systems. This work shapes the dynamic range to ensure the high contrasts. [7]

III. Image based Intelligent Grain Analyser

With discussed image based grain analyser, grain sample is gently spread over the flat conveyer belt and image of all static seeds is captured using camera. Then features are extracted for quality measurement as shown in figure 3. After feature extraction seeds are classified in group.

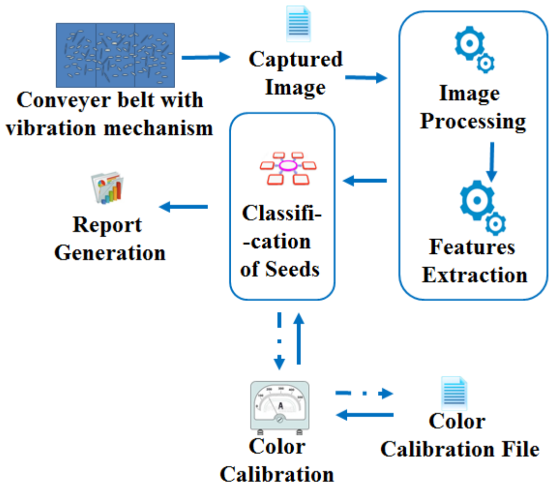

Fig. 1: Proposed solution architecture

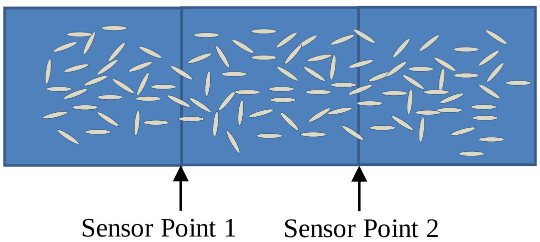

Fig. 2: Conveyer belt with vibration mechanism

Conveyer belt (Fig. 2) used with this solutions having vibration mechanism which help in separating out touching seeds. However, touching seeds might be found after the vibration.

With image processing software, while extracting features there might be variation in size (length, width, breadth) and color.

IV. Size Measurement

There are different measurement standards for all organization. After calculating the seed size, classification is done. Based on ARSO (CD-ARS 464:2012(E)) – African Rice Standard Organization, grain seeds are divided into head, broken and chip seed. Broken seed is further classified in long broken, medium broken and small broken as shown in figure1 [8].

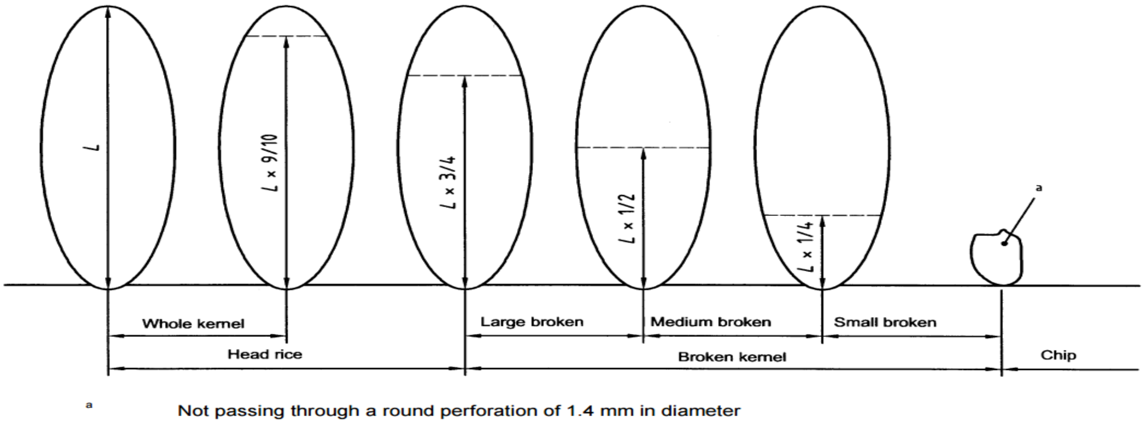

Fig. 3: The African Organisation for Standardisation [8]

With CODEX STAN 195-198 standards, the grain seed is classified in long grain, medium grain and short grain. Classification of seeds depends on the option selected. With different options range is provided for particular measurement unit. Three options are provided with this standard.

1. Based on seed length / width ratio
2. Based on seed length
3. Based on a combination of the seed length and the length/width ratio

Moreover these all measurement options are provided for husked rice and milled rice as well. [9]

Summaries, the classification can be done based on the measured length and width of the seed. But size difference is measured for the below scenarios:

1. Same sample analysed again with different resolution (without changing seed position).
2. Same sample analysed again with same resolution but with seed position changed

Size variation is because of the resolution of the image and angle of the grain seed. So size of rice required to be calibrated. The simple calibration can be done as given below for the first mentioned scenario.

Size of grain = Software measured size of grain +/- Deviation

But this formula doesn't work while experiment is made for the second scenario. The reason behind that is, the size variation also depends on the angle of the seed position with reference to tray edges. If all the seeds are placed with same angle then the discussed formula can be applied. The angle based size measurement algorithm (Aforge Imaging Library [10]) is as given below:

1. Find the angle between points P1(x1, x2) and P2 (y1, y2) based on dy (y1-y2) and dx (x1-x2).
2. Find the radiant angle by (-angle * pi /180) and based on that find the sine angle (sa) and cosine angle (ca).
3. Get the halfwidth (hw) and half height (hh) of image.
4. Rotate corners of four points (cx1, cy1), (cx2, cy2), (cx3, cy3) and (cx4, cy4) using below equation:

i. cx1 = hw * ca;

ii. cy1 = hw * sa;

iii. cx2 = hw * ca - hh * sa;

iv. cy2 = hw * sa + hh * ca;

v. cx3 = -hh * sa;

vi. cy3 = hh * ca;

vii. cx4 = 0;

viii. cy4 = 0;

5. Re-Calculate halfwidth and half height as below:
   i. hw = Max(Max(cx1, cx2), Max(cx3, cx4)) - Min(Min(cx1, cx2), Min(cx3, cx4));
   ii. hh = Max(Max(cy1, cy2), Max(cy3, cy4)) - Min(Min(cy1, cy2), Min(cy3, cy4));
6. Return original size by doubling height and width.

V. Color Calibration

Color calibration is important as all organization following different measurement standards and have different color batch/category name. Efforts are not made for changing original pixel color at any stage of image processing. It provides the way to identifying the same seed color with different name according to different organisation. Same seed can be classified into different color group with the different organisation standards. To make generalised grain analyser, customisation mechanism should be developed. With this mechanism any seed can be classified in particular color batch/category according to organisation provided standards. Either of two approaches can be followed for that mechanism, discussed in subsequent paragraphs.

A. Approach 1:

While discussing at granule level, imaging software measures the individual pixel color. It identifies maximum no. of color pixel with same RGB combination in particular seed and provides that RGB combination color as seed color. For calibration utility, method can be provided for customising this group color name according organisation choice. So different possibilities of RGB combinations in each seed is identified by the imaging software and facility is provided for categorising and naming each combinations as shown in workflow figure 4. It also gives the information about the total numbers of pixels have same RGB values, which helps in deciding the importance of that RGB value combination. This data is saved as calibration file and acts as input data for measuring other sample as shown in workflow figure 5. Calibration file contains RGB combinations values and associated color group name with it.

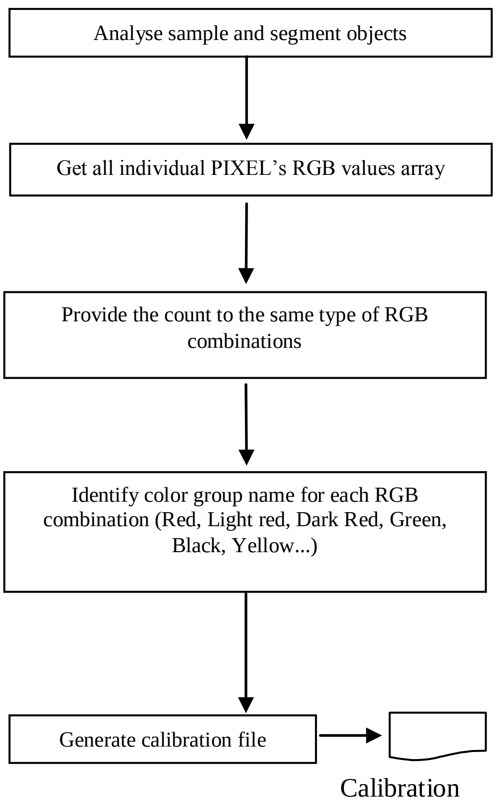

Fig. 4: Color calibration with individual pixel

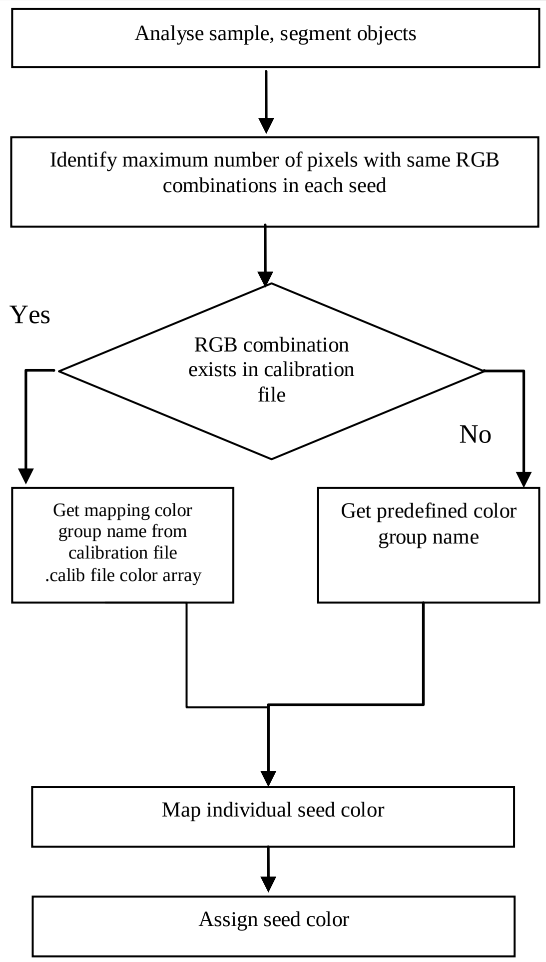

Fig. 5: Color calibration with individual pixel

It is still require giving predefined color category, as all seed color doesn't fall under predefined customised color range and remain uncategorised. For predefined color category; range can be given instead of exact RGB combinations, to cover wide spectrum of possible RGB combinations as given below

Group 1:

minR1<actualRValue<maxR1; minG1<actualGValue<maxG1; minB1<actualBValue<maxB1;

Group 2:

minR2<actualRValue<maxR2; minG2<actualGValue<maxG2; minB2<actualBValue<maxB2;

…..

………

Group N:

minRN<actualRValue<maxRN; minGN<actualGValue<maxGN; minBN<actualBValue<maxBN;

B. Approach 2:

With above option the issue is, there is wide range of different RGB combinations required to be calibrated, as hundreds of different RGB combinations are found even when single seed image is captured and analysed. Out of them, there are many RGB combinations which are very nearer in look and have not significant different while seeing it with necked eyes. It is also not require to provide each combinations name, as we are not interested in individual pixel color rather we are interested in seed color as a whole. So instead of considering each RGB combination group color name we can narrow down our selection.

Instead of identifying each RGB combination group color, first find the maximum numbers of RGB combinations available in single seed. Repeat this exercise for all seeds and get maximum numbers of RGB color combinations for every seeds and prepare array of it. Remove duplicate records from this array. Duplication could exist because of same color's seeds present in the sample. In approach 1 the step for getting all individual PIXEL's RGB values array can be replaced by the getting individual seeds max RGB color combination.

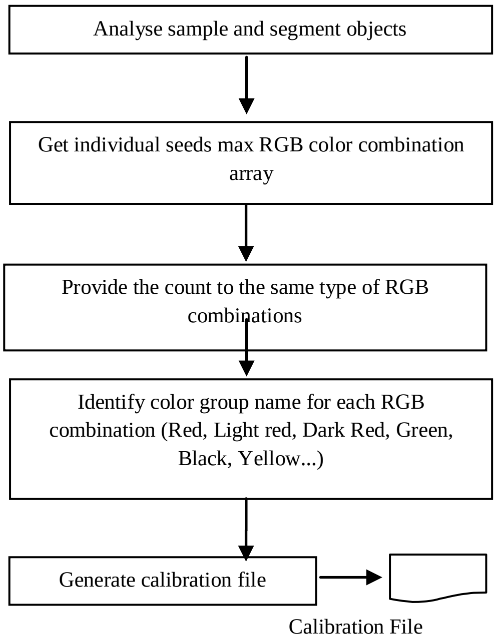

Fig. 6: Color calibration with individual pixel

VI. Comparison of Both Approaches

First approach requires many more numbers of RGB combinations to be calibrated while for second approach very less numbers of RGB combinations require to be calibrated. First approach gives accurate results but very time consuming, while second approach can be tried out with minimal time.

VII. Results and Discussion

A. Size Measurement:

Experiments are carried out for measuring the length of rice samples for the variety PR20 Basamati. Out of them little analysis is discussed here. First 20 seeds individual length is measured and compared with the manually measured length. For that experiment is done by arranging the rice kernel first horizontally and then by arranging all the rice seeds vertically. This is require to check the length difference while seed's angular position is changed. Same experiment is performed for 50 no. of rice seeds to get more accurate results. In addition to horizontal, vertical positions seeds are also arranged in crossed direction for getting better angular position based results. Length measurement results are taken for the broken seeds. Then broken seeds are mixed with normal seeds and analysis is carried out.

Below samples are taken for length measurement:

1. 20 no. of seeds are arranged vertically and then same seeds are arranged in horizontal direction and compared with manual analysis *[Table 1]*
2. 50 no. of seeds are arranged vertical, then horizontal and then same seeds are arranged in crossed direction and compared with manual analysis *[Table 2]*
3. 10 no. of only broken seeds length measured and compared with manual measurement. *[Table3]*
4. Broken seeds mix with normal seeds and length measurement is done - total 15 seeds *[Table 4]*

TABLE I Vertical and Horizontal Aligned Seeds Length Comparison with Manual Measurement (20 seeds)

Rice Id	M	V	H	Diff (V-M)	Diff (H-M)
1	7.11	6.22	6.73	-0.89	-0.38
2	7.28	6.73	6.86	-0.55	-0.42
3	7.37	7.24	7.24	-0.13	-0.13
4	7.61	7.24	7.37	-0.37	-0.24
5	7.65	7.49	7.37	-0.16	-0.28
6	7.67	7.49	7.37	-0.18	-0.30
7	7.72	7.62	7.49	-0.10	-0.23
8	7.72	7.75	7.49	0.03	-0.23
9	7.74	7.75	7.49	0.01	-0.25
10	7.82	7.75	7.62	-0.07	-0.20
11	7.85	7.75	7.62	-0.10	-0.23
12	8.06	7.75	7.62	-0.31	-0.44
13	8.06	7.75	7.87	-0.31	-0.19
14	8.23	8.13	8.00	-0.10	-0.23
15	8.25	8.25	8.00	0.00	-0.25
16	8.27	8.25	8.00	-0.02	-0.27
17	8.44	8.25	8.13	-0.19	-0.31
18	8.47	8.25	8.38	-0.22	-0.09
19	8.60	8.25	8.38	-0.35	-0.22
20	8.65	8.51	8.64	-0.14	-0.01
Avg	**7.9285**	**7.721**	**7.68**	**-0.20**	**-0.245**

* M – Manual, V-Vertical, H-Horizontal, Diff (V-M) – length difference measured vertically and manually, Diff (H-M) – length difference measured horizontally and manually.
Note: all measurement is in mm.

TABLE II Vertical, Horizontal and Crossed Aligned Seeds Length Comparison with Manual Measurement (50 seeds)

Rice Id	M	V	H	C
1	7.46	7.37	7.37	7.37
2	8.06	8.00	7.87	8.13
3	7.82	7.87	7.62	6.86
4	8.17	8.00	8.38	8.38
5	8.52	8.51	8.38	8.51
6	8.46	8.25	8.38	8.64
7	7.61	7.49	7.49	7.62
8	8.51	8.25	8.51	8.25
9	7.93	8.00	7.37	7.62
10	8.39	8.25	8.38	8.25
11	7.76	7.75	7.49	7.75
12	7.85	5.97	7.62	7.49
13	7.97	7.87	7.62	7.87
14	7.87	7.87	7.75	7.75
15	7.31	7.11	7.49	7.11
16	8.05	8.00	7.75	8.00
17	7.73	7.49	7.49	7.62
18	7.46	7.11	7.11	7.24
19	7.34	7.11	6.98	7.24
20	8.54	8.64	8.25	8.38
21	7.63	7.37	7.49	7.49
22	8.09	7.87	7.87	8.00
23	8.48	8.51	8.25	8.38
24	6.98	6.73	6.60	6.86
25	8.31	8.25	8.13	7.62
26	7.54	7.37	7.62	7.62
27	8.19	7.87	7.87	8.13
28	7.45	7.24	7.11	7.11
29	8.48	8.38	8.38	8.64
30	8.47	8.38	8.25	8.51
31	8.04	8.00	7.87	7.49
32	7.88	7.87	7.62	7.11
33	7.41	7.49	7.49	7.37
34	7.39	7.37	7.37	7.37
35	6.98	6.98	6.86	5.71
36	7.94	8.13	7.87	7.87
37	7.12	6.35	6.86	6.98
38	7.93	7.75	7.75	6.86
39	8.38	8.13	8.38	8.51

40	6.48	6.22	6.10	6.60
41	8.37	8.13	8.25	8.25
42	8.44	8.13	8.38	8.13
43	8.20	8.25	8.13	5.25
44	7.49	7.24	7.24	7.24
45	8.45	7.49	8.25	8.51
46	7.26	7.37	7.24	7.37
47	7.39	7.24	7.11	7.37
48	7.04	6.73	6.86	7.24
49	8.35	8.25	8.00	8.25
50	8.26	8.25	7.87	8.25
Avg	**7.8646**	**7.685**	**7.6874**	**7.6434**
Diff	--	**0.1796 (V-M)**	**0.1772 (H-M)**	**0.2212 (C-M)**

* M – Manual, V-Vertical, H-Horizontal, Diff (V-M) – length difference measured vertically and manually,
Diff (H-M) – length difference measured horizontally and manually, Diff (C-M) – length difference measured crossed and manually.
Note: all measurement is in mm.

TABLE III Only Broken Seeds Length Comparison with Manual Measurement (10 broken seeds)

Rice Id	M	by GA	Diff
1	4.73	4.83	-0.10
2	3.20	3.05	0.15
3	4.69	4.70	-0.01
4	3.72	3.94	-0.22
5	4.04	3.17	0.87
6	4.12	3.81	0.31
7	4.00	3.94	0.06
8	6.89	6.60	0.29
9	3.95	3.68	0.27
10	6.41	6.35	0.06
Avg	4.575	4.407	0.168

* M – Manually, byGA – by Grain Analyser, Diff – Difference of length measured manually and by grain analyser.
Note: all measurement is in mm.

TABLE IV Broken Mixed Seeds Length Comparison with Manual Measurement (15 seeds)

Rice Id	M	by GA	Diff
1	8.39	8.64	-0.25
2	7.58	7.75	-0.17
3	4.73	4.70	0.03
4	7.72	7.87	-0.15
5	3.20	3.30	-0.10
6	7.66	7.87	-0.21
7	8.11	8.25	-0.14
8	9.18	9.14	0.04
9	8.44	8.51	-0.07
10	7.99	8.00	-0.01
11	8.32	8.38	-0.06
12	4.69	4.83	-0.14
13	7.78	7.75	0.03
14	7.97	8.75	-0.78
15	3.72	3.94	-0.22
Avg	7.0320	7.1787	- 0.1467

* M – Manually, byGA – by Grain Analyser, Diff – Difference of length measured manually and by grain analyser.
Note: all measurement is in mm.

For any grain sample's quality measurement it is require to measure average length of seeds. With above experiments we found that the length has not more than 0.25 mm difference with manual measurement which is in acceptable deviation range of rice standards.

B. Color Calibration:

Experiments are carried out for generating calibration files and which can be used for color analysis in of rice samples.

Four rice samples are taken as training data set as given below:

1. Only red colored rice (20 seeds)
2. Only green colored rice (20 seeds)

3. Only yellow colored rice (20 seeds)
4. Only black colored rice (20 seeds)
5. Only white colored rice (20 seeds)

For every sample, calibration file is generated containing all possible color of each seed. After generating the individual calibration files for the RGB combinations values are combined and single calibration file is generated. Experiment is repeated for second approach and calibration files are generated. Total two calibration files are generated, approach 1 calibration file and approach 2 calibration file. With both calibration files following rice samples are analysed and results are carried out. Samples are divided in two groups from top level.

Group 1: Colored rice seeds are same, which are used for generating calibration files

Group 2: Colored rice seeds are different and not used earlier for generating calibration file.

For above both approaches below types of samples are prepared and analysed.

1. White – red colored mixed rice (10 white, 10 red seeds)
2. White – yellow colored mixed rice (10 white, 10 yellow seeds)
3. White – green colored mixed rice (10 white, 10 green seeds)
4. White – black colored mixed rice (10 white, 10 black seeds)
5. Red – yellow – green colored mixed rice (10 red, 10 yellow, 10 green seeds)
6. Green – black – red colored mixed rice (10 green, 10 black, 10 red seeds)
7. White – red – yellow – green colored mixed rice. (10 white, 10 red, 10 yellow, 10 green seeds)

TABLE V Seeds Identified by Approach 1, Group 1

Color / Sample	White	Red	Yellow	Green	black	NI	Accuracy (%)
S1	10	10	0	0	0	0	100%
S2	10	0	10	0	0	0	100%
S3	10	0	0	10	0	0	100%
S4	10	0	0	0	10	0	100%
S5	0	10	10	10	0	0	100%
S6	0	10	0	10	10	0	100%
S7	10	10	10	10	0	0	100%

* NI – Not identified by grain analyser. S1-S7 – Sample range
Note: All numbers shows no. of seeds of particular color group.

TABLE VI Seeds Identified by Approach 2, Group 1

Color / Sample	White	Red	Yellow	Green	black	NI	Accuracy (%)
S1	10	10	0	0	0	0	100%
S2	10	0	10	0	0	0	100%
S3	10	0	0	10	0	0	100%
S4	10	0	0	0	10	0	100%
S5	0	10	10	10	0	0	100%
S6	0	10	0	10	10	0	100%
S7	10	10	10	10	0	0	100%

* NI – Not identified by grain analyser. S1-S7 – Sample range
Note: All numbers shows no. of seeds of particular color group.

TABLE VII Seeds Identified by Approach 1, Group 2

Color / Sample	White	Red	Yellow	Green	black	NI	Accuracy (%)
S1	9	9	0	0	0	2	90%
S2	10	0	9	0	0	1	95%
S3	10	0	0	10	0	0	100%
S4	10	0	0	0	8	2	90%
S5	0	10	9	9	0	2	90%
S6	0	10	0	10	10	0	100%
S7	10	9	10	10	0	1	95%

* NI – Not identified by grain analyser. S1-S7 – Sample range
Note: All numbers shows no. of seeds of particular color group.

TABLE VIII Seeds Identified by Approach 2, Group 2

Color / Sample	White	Red	Yellow	Green	black	NI	Accurac y (%)
S1	9	9	0	0	0	2	90%
S2	10	0	9	0	0	1	95%
S3	10	0	0	10	0	0	100%
S4	10	0	0	0	8	2	90%
S5	0	10	9	9	0	2	90%
S6	0	10	0	10	10	0	100%
S7	9	9	10	10	0	1	90%

* NI – Not identified by grain analyser. S1-S7 – Sample range
Note: All numbers shows no. of seeds of particular color group.

With experiment we can conclude that, if rice seeds which are used for preparing calibration files are used for color measurement then it shows 100% accurate color classification results with both the approaches. But if seeds are different than the seeds which are used for generating calibration file then it shows around 90% accuracy. It is because of the few seeds colors (RGB combinations) were not available while generating calibration file. If we add the not identified RGB color combination to particular group and analyses the same sample again then we are able to achieve 100 % accuracy.

VIII. CONCLUSION

With the discussed approach color calibration and sorting can be done effectively for different grains by considering different organisations standards. It gives more than 95% accuracy, as customisation is done by end-users only. New calibration file can be generated for the new grain type and grain varieties introduced. One time effort needs to be put for machine learning, then after same calibration file can give consistent result for the measurement of same type grain samples.

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