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UNEXPLORED IDEA TO EXAMINE GRAIN SPECIMEN QUALITY BY UTILIZING IMAGE PROCESSING INTELLIGENCE

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ABSTRACT

The significance of measurement of grain quality has been felt since way back to a century old. However it is tedious, but very important measurement is to measure the individual kernel's qualitative analysis. Analyzing the grain sample manually is more time consuming and complicated process, and having more chances of errors with subjectivity of human perception. In order to achieve uniform standard quality and precision, machine based techniques are evolved, solely on its prime advantage of reproducing the same qualitative result efficiency again and again. Recent developments in the field of image processing, has opened up wide scope of its use for sample analysis too. Various applications of Image processing are seen in the field of agriculture, biomedical engineering, food and drug industry and many others. Food application mainly caters the qualitative aspect of various food and dairy products.

In this article, an attempt is made to investigate techniques used for the quality analysis. The main attempt is to compare relative applicability of human v/s machine based approach of analysis. Machine based techniques can be further classified as, offline grain analysis technique and online grain analysis technique. Both techniques are having their own limitations. Offline techniques consumes more time for sample preparation. On the other hand, online techniques suffer from less processing speed and kernel missing part while processing. Research gaps are identified with respect to the both techniques' limitations and new intelligent and accurate grain analyzer technology is evolved to enhance speed and accuracy by removing deficiency of the existing systems. Moreover offline and online grain image analyser features can be combined and enhanced to prepare a fully automated grain analyser to deal with different kind of grain varieties.

KEYWORDS: Feature Extraction, Grain Analysis, Image Acquisition, Image Processing, Quality Analysis

INTRODUCTION

Grain quality is very important aspect for human beings as it affects health and development of human body. It is require to measure quality of grain for identifying adulteration and presence of non-quality elements. So forth, measurement of grain quality and cereal research is wide research areas now a days. Techniques are evolved to measure grain sample's quality based on it; samples can be classified in terms of productivity and price. Sample quality has also proven its significance in cereal breeding. Classification may vary, based on consumer preferences. Grain quality depends on individual kernel features. Kernel's features can be measured by either structural analysis or compositional analysis. *Compositional analysis* is done for measuring internal aspects of kernel. For compositional analysis generally, near-infrared (NIR) technologies and chemical analysis based technologies are used.NIR technologies are used for detection of protein, fat, starch and water in rice (Yang *et al.* 2015). Research is made to check sugar, fructose and glucose level in fruits using NIR technology (Bellon *et al.* 2014). NIR technology is also useful for indicating freshness level (Huang *et al*. 2015; Lin *et al.* 2011). Structural analysis focuses on the outer part analysis. *Structural analysis* includes measurement of size (length, width, and height), color and glossiness. Image analysis techniques are useful and effective for structural analysis.

Length and width of grain are critical parameters for grain samples classification. Grains are classified as short grain, medium grain and long grain. Based on ARSO (CD-ARS 464:2012(E)) (The Africanorganisation for standards) – 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. For CODEX STAN 195-198 (Codex standards for rice) standards the grain seed is classified in long seed, medium seed and small seed. Classification of seeds depends of the options selected i.e. based on seed length / width ratio, based on seed length, based on a combination of the seed length and the length/width ratio. The length and width of a rice grain are important attributes that determine the class of the rice. The ratio of the length and the width is used internationally to describe the shape and class of the variety. The other important aspect of length and width is uniformity, i.e. all the grains in one sample must look the same. According to research thin kernel breaks while milling, this needs to be separated out. A trend is set for improved milled rice yield and head rice yield based on the above concept. When cooked, *long-grain* brown rice fluffs up readily and tends to separate when cooked. Therefore, 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 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 look in size but different in weight. These discussed features of rice are useful for agricultural breeding and categorization of grain for market delivery.

Texture is important characteristic for the every grain types. It defines as the common repetitive patterns. It has some tonal primitives which are common across many seeds. Image texture can be calculated based on one or more of the properties of fineness, coarseness, smoothness, granulation, randomness or irregularity. Rice research and development programs in Louisiana and Arkansas, in the USA, are attempting to identify instrumental methods that correlate well with scores reported by sensory panels for the different textural characters. (International Rice Research Institute 2006).

MATERIALS AND METHODS

Manual Techniques and Their Limitations

In manual techniques, grain sample is analysed with necked eyes. For measuring dimensional parameters, usually micrometer screw and vernier calipers are used. The results with these technologies are very subjective and also depend on expertise level and mind set of analyser. Results might be varying with same analyser based on analyser's experience level and mood. For same sample and for same analyser there is chance of different results with repetitive measurement of same sample. So results would not be more reliable. Moreover, if we are interested in individual seed's parameter then it is very time consuming and tedious in manual measurement with micrometer screw and optical inspection. It is very difficult to measure quality parameters and remember every seeds' features individually. Average features like length, width, color and no. of broken seeds are generally measured with this method. The centered white color part called rice's chalkiness is also sometimes distinguished with the manual technique. There is also possibility of material damaged and deformation. It becomes more tedious when many samples need to be analysed. Inexperienced human analyser may provide results in unacceptable range. Therefore, it is inefficient way to measure rice appearance using manual techniques. Manual analysis is highly subjective and affected by physiological conditions of human and other environment configurations which results in erroneous results.

Traditional Image Based Techniques

Recent technological development in the field of Image processing has made it more adoptable and accepted method for feature extractions in grain quality analysis. In image based grain analysis, grain seeds are put/spread over grain tray or conveyer belt. Grain sample image is taken either by scanning (using scanner) or by capturing (with different types of cameras). This image is processed for feature extraction of every seeds. To get better results pre-processing is performed on captured image. Based on each seed's extracted features of grain sample image, the sorting is performed.

Image based grain analyzers can be classified in following two categories:

- *Online grain analyzers*
- *Offline grain analyzers.*

In both the techniques grain sample image is captured for processing. In online grain analyzer the grain would be in moving condition while capturing the grain sample image. While in offline grain analyser the grain would be in steady condition while capturing the grain sample image.

Different offline/online image based grain analysers are studied. Subsequent section discuss about the methodology and limitations associated with each type of grain analyzers.

Offline Image Based Grain Analyser

Digital image analysis (DIA) – 'SeedCount' 324(Armstrong *et al.* 2005)

SeedCount 324 DIA (Digital Image Analysis) system – developed by SunRice, through the Rice Appraisals Laboratory in Leeton NSW, does the careful placement of grains sampled with a vacuum based positioning funnel. After capturing the image, it is analyzed using algorithms to measure the kernel length, width and related parameters.

In this technique, grain seeds need to be put in one grain tray. Grain tray is having slots in rows and columns like structure. Grain sample is gently spread on grain tray, and then all kernels are separated to fit one kernel in one single slot of grid tray. Each slot must accommodate only one kernel while capturing image, as every slot is directly mapped with particular address for image analysis. (Figure 1(a)) shows the grain tray which needs to be filled by grain seeds. Grain seeds are fit in different grid kind structured slots. (Figure 1(b)) shows the SeedCount scanner.

Figure 1: (a). Seed Count Tray Preparation (Armstrong et al. 2005)

Figure 1: (b). Seed Count Tray in Scanner Cabinet (Armstrong *et al.* 2005)

Limitation with this technique is that it does not deal with the connected seeds. It requires separating all kernels manually, taking much time for sample preparation. It doesn't measure the real length and breadth but it measures a diagonal approximation. The DIA system is useful for examining larger samples, as up to 1350 rice kernels can be examined per tray. This data is useful for comparing the dimensional distributions within and between grain lots and to briefly examine the effects of milling on rice. It is very tedious to arrange all 1350 kernels at particular place to get accurate result. Angular position of seed is one of the affecting factors to results. This method is difficult to apply when huge amount of samples needs to be measured and there is a possibility of kernel damage.

Rice image is captured from top; it could give different results if angels of camera are varied. Weight of seed is not considered while analysis. As weight also affects the quality, there should be few techniques to categorize seed based on individual weight. Image smoothing could be used before extracting features. Cut rice identification needs to be made to improve quality results. More specific development methods are required for various rice types such as Basmati, lachkari etc. Chalkiness (Guangrong *et al.* 2011) of rice one of the important factors for measuring rice quality might be considered for better results.

Image acquisition system (Guzman *et al.* 2008)

Image acquisition system deals with the parameters sizes, shapes, and variety of samples. Five varieties Philippines rice is considered. Technique is developed using multilayer neural networks and sample is classified using thirteen grain features extracted from each sample image.

While capturing image, grains arranged in a singulate non-touching pattern for each rice variety as shown in (Figure 2). So here there is limitation of arranging all seeds at particular location which is tedious task if many samples need to be analyzed. With this method classification needs to be improved more by combining it with machine vision system. Sampling methods, sample processing and sample size should be standardise according to rice industry standards.

Figure 2: Pictorial of Image Acquisition System (Guzman *et al.* 2008)

Rice quality analyzer– kett – model RN300 (Rice quality analyser Model RN 300)

Rice Quality Analyzer– kett – Model RN300 grains works on reflected lights fundamentals. Measurement tray can accumulate 1148 grains in one tray. Tray contains 1148 holes; each hole in the tray has an address. Address is based on row and column position of the tray. It has color code for identification and verification. Tray fits into the scanner for further processing. The light is transmitted on sample and reflection of light by each seeds is measured. For every sample RGB signal is taken and processed by "Quality Scan" software. For every sample data is compared with pre-defined standards and each kernel is analysed. Based on that summary of sample quality is prepared and results are transferred to computer. It takes 24 seconds to complete this operation. (Figure 3) shows the mapping of kernel in pictorial representation computer system with the physical tray slot in tray.

It is required to make careful placement of each grain seeds before start processing. Result depends on transmitted light, so it depends on intensity of light source. Result might vary based upon the selected light source.

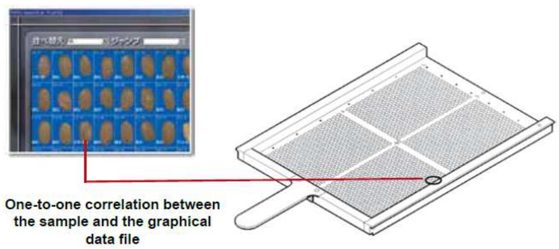

Figure 3: Pictorial of Image Acquisition System (Rice Quality Analyser Model RN 300)

Offline Image Based Grain Analyser Limitations

In all the offline grain analyzers, it is necessary to put grain kernels in particular positions, in grid kind structure. Grid contains slots in row and columns arrangement. Each slot can accommodate one seed at a time. All slots are mapped with particular address, which can be used to be located by image analysis software. With this methodology, it is required to separate all kernels manually before starting analysis. If huge amount of samples are there then sample preparation becomes too tedious task. If the seeds are not put in individual slots then there is chance of considering more than one seeds as one seed, which affects quality results. So, all seeds should be separated precisely. Offline grain analyzers deal with few rice varieties only. Reason is, to deal with different rice varieties the tray slots size should be variable, which is not possible with static frames. For such kind of method (by seed scan)(Armstrong *et al.* 2005) generally different frames are provided containing different size slots. Sample weight should be considered, which can be further mapped to quality parameters indirectly. It is also require setting configuration variables. If they are not set properly then results would vary for the same sample analysis. Chalkiness is one of the important factors for rice which is not considered with many offline grain analyzers.

Online Image Based Grain Analyser

HRY grain check system - GrainCheck310 (Wang *et al.* 2005)

In HRY grain check system - GrainCheck310, images of durum wheat kernels are analyzed from three conditions (reflected, side−transmitted, and transmitted).Based on their vitreousness artificial neural network model is develop to classify durum wheat kernels. It shows 100% classification results for non-vitreous kernels and 92.6% for mottled kernels based on trained models (Wang *et al.* 2005).

Milled rice from a laboratory mill and a commercial scale mill are evaluated for head rice yield using a shaker table and a machine vision system called the Grain Check. Comparisons are made for both medium and long grain rice varieties. For each variety, samples with different levels of broken kernels are analyzed to determine the performance of the two instruments over a range of head rice yields. In that Head rice yield for laboratory milled long – and medium – grain rice is measured for samples obtained from three drying conditions using a shaker table and a Grain Check system. (Guzman *et al.* 2008)

For calculating vitreousness it does the comparison of the effectiveness of transmitted and reflected kernel images. Based on position of kernels the quality results can differ. This deficiency should be eliminated while measuring grain quality (Wang *et al.* 2005).

In grain check system vibrator is used for separating kernels. So, it cannot be used if rice kernels are connected or overlapped. Only two varieties of rice are focused. With different varieties rice features affects differently to quality. (Guzman *et al.* 2008)

Automatic grain quality inspection (Wan *et al.* 2002)

The system is composed of two main parts, an inspection machine and an image-processing unit. In brief, the rice kernel handling procedure involves the following steps. First, rice kernels are scattered over a predetermined matrix positioned conveyer belt. Photograph of seeds on conveyer belt is taken by two CCD (charge-coupled device) cameras which are connected to the computer. First camera is a Sony XC-711 color CCD camera and other is A Sony XC-75 black and white CCD cameras. The computer segregates the kernel images from the background, provides a recognition process, and transfers the final sorting results to the machine controller. The controller signals each corresponding pneumatic valve to eject the kernels from the carrying holes into collection containers. An interface protocol is developed between the inspection machine and the image-processing unit to coordinate their concurrent activity.

Online Image Based Grain Analyser Limitations

In online grain analysis the grain would be in moving condition and for capturing particular kernel image there would be very little time. So with this approach, there is chance of missing current kernel while processing previous kernel; which affects final quality results. With this option, faster processor and high speed cameras are required which deals with image capture and processing part in parallel. Kernel shall be capable of handling major issues with online image based techniques, be it reflected, transmitted or side-transmitted. Chalkiness is also not considered with studied online grain analyzers, which is having much importance in quality measurement. It is also require dealing with complex issues like touching and overlapped kernels which uses rotating conveyer belt mechanism.

Offline / Online Image Based Grain Analyser Limitations

Comparisons are made for light and source dependency, processing mechanism, processing power and hardwre architecture of offline and online image based grain analyser features to identify their limitations depicted in Table 1.

Table 1; Grain Analysers' Features Comparison *NS, Not Specified

	Seed Count 324 (Armstrong *et al.* 2005)	**Image Acquisition System (Guzman *et al.* 2008)**	**Rice Quality Analyzer RN300 (Rice Quality Analyser Model RN 300)**	**HRY Grain Check 310 (Wang *et al.* 2005)**	**Automatic Grain Quality Inspection (Wan *et al.* 2002)**
Offline/Online	Offline	Offline	Offline	Online	Online
Chalkiness/ Vitreousness	No	No	No	Yes	Yes
Predetermined Matrix	Yes	Yes	Yes	Yes	Yes
Camera Angle Dependency	Yes	Yes	No	Yes	Yes
Light Source Dependency	Yes	Yes	Yes	Yes	Yes
Light Transmission	No	No	Yes	Yes	No
Consume more static sample preparation time	Yes	Yes	Yes	No	No
Grain should be fit in grain slot	Yes	Yes	Yes	NS*	Yes
Time	NS*	NS*	1 Sample / 24 Secs	NS*	1200 Kerenls/Min
Grain	Rice	Rice	Rice	Wheat	Rice
Maximum no.of Kernels	1350	110	1148	50	24
Software	NS*	CIAS 2.0, MS Excel, Neural Network	Quality Scan, matlab, Neural Network	Grain check	C Visual Basic
Vibration	No	No	No	Yes	No

DISCUSSIONS

After studying all the above discussed grain analysis techniques and based on literature review, we are proposing one solution where we have combined features of both online and offline image based grain analyzer techniques. Subsequent sections of this paper provide an insight to pros and cons related to proposed solutions.

With proposed solution, grain sample is spread gently over the flat conveyer belt and image of all static kernels is captured using camera. Then features are extracted for quality measurement. All kernels are classified based on extracted features and based on that overall sample quality is determined. The whole process is as depicted in (Figure 4).

Conveyer belt (Figure 5) used with this solutions having vibration mechanism which help in separating out overlapped kernels. However, touching kernels might be found after the vibration. Starting efforts can be made by using plain colored-background grain tray, which doesn't consist of any slots for accommodating grain kernels. Selection of tray background color depends on the presence of sample's elements color. Back-ground color should be powerful enough to distinguish it from sample particles. Mostly blue background is selected as there is very little chance of same color element present in grain sample. However, with different grain type and grain varieties tray background color can be changed. Static grain tray can provide one image of sample at a time and for next iteration it is require to first clearing it. So when sample is huge, time will be wasted in creating next iteration setup. To resolve that, static grain tray can be replaced by sensor based moving conveyer belt. Conveyer belt has sensor point which is useful for controlling the movement of conveyer belt. When sensor point comes the conveyer belt is stopped and image is captured by camera. Again conveyer belt move until next sensor point reach. This process is repeated until whole sample is passed through conveyer belt. There might be chance of touching and overlapped kernels even if you use vibration mechanism. Image analysis algorithms needs to resolve quickly the issue arise with this method.

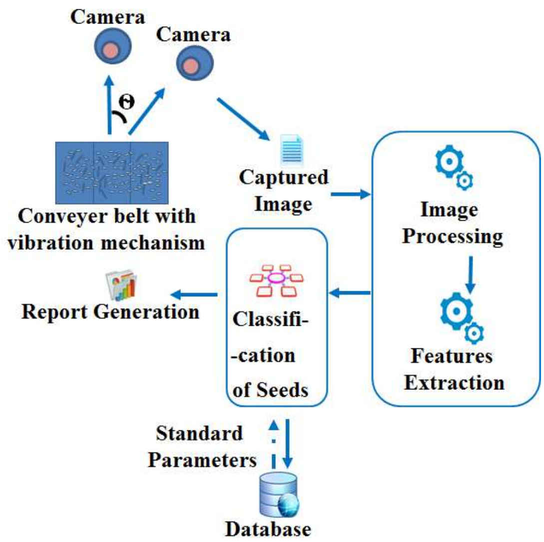

Figure 4: Proposed Solution Architecture

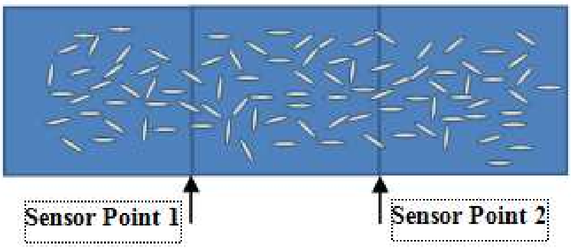

Figure 5: Conveyer Belt

With this proposed solution there is no need to arrange seed in particular manner, which overcome the main offline analysis technique's limitations. There is no chance of missing any single kernel, which provides the solution for online grain analysis techniques.

With this proposed solution, different rice varieties can be analyzed using same setup. Traditional techniques measure only four parameters length, width, thickness, and roundness. It does not incorporate even a three dimensional approach also. With this solution, more quality parameters can be added which can accommodate measurement quality by considering dimensional approach, like chalkiness of rice. Chalkiness (Guangrong *et al.* 2011) of rice is one of the important factors for measuring rice quality. Milling rice can be brittle if more chalkiness is there. While exporting rice it has great significance and must be added into quality measurement part. Sorting can be more robust in addition to it.

The only limitation to address is, if the camera angles are changed then how it will affect to quality. It is not addressed in this paper. Moreover light intensity is considered static. With change in light source image clarity would be changed, which leads to different quality results. With that we cannot exactly give conclusion for error rate with different samples. These are research gaps associated with conventional techniques which should be overcome. Weight of seed has direct mapping with quality parameters which is not considered with this conventional techniques. As weight also affects the quality, efforts should be made to map seed weight with based quality parameters. Image smoothing could be used before extracting features. In both type of techniques broken seeds are not identified. Broken seeds identification needs to be made to improve the analysis of quality results. Standards and guideline should be specified for different grain varieties.

Quality results can be improved by developing image processing algorithms for intelligent grain analyzer which could be independent from following:

- Camera angles
- Sample image backgrounds
- Light intensity
- Overlapped / Connected seeds
- Variety with specific standards
- Camera types

Other things that can be taken into considerations for providing robust solutions are: (1) Image data storage techniques (2) Analysis report generation methods (3) Broken grain analysis (4) Chalkiness measurement (5) Color calibration (6) Size calibration. Grain analyzer should deal with different varieties of grain.

Issues Resolved by Proposed Architecture

Following issues can be resolved with this proposed architecture:

- No need to arrange seed in particular manner
- Sample preparation time is reduced
- No chance of kernel missing
- More no. of rice samples can be analysed using same imaging setup
- More image based quality parameters can be added like chalkiness of rice
- Classification mechanism based on measurement standards can be provided
- Different types of grain varieties can be analysed without changing imaging setup
- Different types of grain can be analysed without changing imaging setup

Emerged Issues with Proposed Architecture

Following issues are emerged with this proposed architecture:

- Identification of touching kernel which are not separated by vibration
- Identification of overlapped kernel which are not separated by vibration
- Identification of each kernel’s individual address as there is no direct mapping for that
- Position of kernel which might be vertical, horizontal or angular
- Combinations and analysis of each iteration outcomes

- Boundary seed kernel appears in more than one iteration

CONCLUSIONS

With providing all the discussed features in one solution, many conventional grain analysis techniques' deficiencies can be removed and intelligent grain analyzer can be developed with enhanced speed and accuracy.

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