

Analysis of Wheat Grain Varieties Using Image Processing-A Review

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Abstract: *Globally, wheat is the leading source of vegetable protein in human food, having a higher protein content than other major cereals, maize (corn) or rice. In terms of total production tonnages used for food, India is currently second to wheat as the main human food crop and ahead of maize. Determining the quality of wheat is critical. Specifying the quality of wheat manually requires an expert judgment and is time consuming. Sometimes the variety of wheat looks so similar that differentiating them becomes a very tedious task when carried out manually. To overcome this problem, Image processing can be used to classify wheat according to its quality. This inspection approach based on image analysis and processing has found a variety of different applications in the food industry. Considerable research has highlighted its potential for the inspection and grading of wheat. Image processing has been successfully adopted for the quality analysis of rice, cereal grains, fruits and vegetables. Likewise wheat grain quality and characteristics have been examined by this technique. This paper presents the significant elements of the image processing technique coupled with a review on the research work carried out by various researchers in the field of quality information of wheat varieties.*

Keywords: Computer vision; Image processing; Image analysis; Grain; Wheat; Classification; Grading

1. Introduction

WHEAT is one of the most important cereal grain crops. The quality of wheat has distinct effect on the yield of wheat, so the proper inspection of wheat quality is very important. During grain handling operations, information on grain type and grain quality is required at several stages before the next course of operation can be determined and performed. The varietal purity is one of the factors whose inspection is more difficult and more complicated than that of other factors. In the present grain-handling system, grain type and quality are rapidly assessed by visual inspection. This evaluation process is, however, tedious and time consuming. The decision-making capabilities of a grain inspector can be seriously affected by his/her physical condition such as fatigue and eyesight, mental state caused by biases and work pressure, and working conditions such as improper lighting, climate, etc. Also, the farmers are affected by this manual activity. Hence, these tasks require automation and develop imaging systems that can be helpful to identify wheat grain images, rectify it & then being analyzed. This process uses digital images to measure the size. In the case of crops such as wheat, where end use and shape related information from the images is dependent on use of a specific variety, identification. The shape, size and color of grains are normally of that variety is crucial. Variety identification is employed to identify wheat varieties. Digital image analysis offers an objective and accuracy quantitative method for estimation of morphological features. Zayas *et al.* (1989) applied the digital image analysis parameters technique to discriminate wheat classes and varieties.

devices in order to obtain information or to control processes. The core technique in computer vision is always related to image analysis/processing, which can lead to segmentation, quantification and classification of images and objects of interest within images. Computer vision has proven successful for online measurement of several food products with applications ranging from routine inspection to the complex vision guided robotic control (Gunasekaran, 1996). The application of computer vision in certain foods such as bakery products, meat and fish, vegetables, fruits, grains, prepared consumer foods and in food container inspection analyzed by Sun *et al.* (2003). Image processing system involves changing the nature of an image with a computer and suitable software in order to either improve its pictorial information for human interpretation or render it more suitable for autonomous machine perception (McAndrew, 2004). Image processing helps in the accurate, fast and objective quality determination of important characteristics of food products (Velioglu *et al.*, 2011). In recent years, image processing technology has become a powerful tool in determining the quality characteristics of agricultural products. It can be used safely throughout the process for determining the quality characteristics of the product without touching or damaging it. The general methodology used in image processing is as follows: image acquisition, image preprocessing, segmentation, measurement and interpretation. This paper presents the research work carried out by various researchers in the field of wheat and recent advances of computer vision in the grain industry.

Computer vision is a novel technology for acquiring and analyzing an image of a real scene by computers and other

2. Analysis of WHEAT grain varieties using Image Processing

Studies have been done on classification of wheat using machine algorithms and image processing. These studies have used different machine classifiers and have performed feature extraction for carrying out their work. Some studies extracted two classes of features while others extracted more than two classes of features. In a study (Arefi et al. 2011), four varieties of wheat were identified by integrating machine vision and artificial neural network using Matlab software. Different colour and morphological features of wheat were extracted for carrying out the process of identification. Given these features, testing of ANN was performed. It was concluded that colour features or morphological features alone could not recognize wheat so a combination of both was used. The overall accuracy was found to be 95.86%. Another study (pazoki et al. 2011) classified the rain fed wheat grain cultivars using Artificial Neural Network. For this purpose, colour features, morphological features and textural features were extracted. These features were fed to multilayer perceptron neural network. The classification accuracy was concluded to be 86.58%. After using UTA algorithm for feature extraction, the accuracy was increased to 87.22%. A study by Douik et al. (2008) used Discriminant Analysis and K Nearest Neighbor for classification of wheat and barley grain kernels. The system training was performed with only morphological features, only colour features and combination of morphological features, colour features as well as textural features. It was concluded that accuracies higher than 99% can be achieved when morphological, colour and textural feature types are used together as compared to using them alone.

Computer Vision (CV) is the process of applying a range of technologies and methods to provide imaging-based automatic inspection, process control and robot guidance in industrial applications. While the scope of CV is broad and a comprehensive definition is difficult to distil, a generally accepted definition of computer vision is 'the analysis of images to extract data for controlling a process or activity' (Relf Christopher G, 2004). Computer vision is a novel technology for acquiring and analyzing an image of a real scene by computers to control machines or to process it. It includes capturing, processing and analyzing images to facilitate the objective and non-destructive assessment of visual quality characteristics in agricultural and food products (Timmermans AJM, 1998). Size, which is the first parameter identified with quality, has been estimated using machine vision by measuring either projected area by Tao et al. 1990 and Varghese et al. 1991, perimeter by Sarkar et al. 1985 or diameter by Brodie et al. 1994. Size measurement is important for determining produce surface area. The shape is one of the important visual quality parameters of fruits, vegetables, etc. Currently human sorters are employed to sort fruits based on shape. Shape is a feature, easily comprehended by human but difficult to quantify or define by computer. Most of the machine vision shape detection work has been done on industrial objects, which have definite structure. Agricultural and biological products are unique in nature and the growing environment causes

various boundary irregularities which influences their shapes. Image processing offers solution for sorting of fruits based on their shape. The colour of an object is determined by wavelength of light reflected from its surface. In biological materials the light varies widely as a function of wavelength. These spectral variations provide a unique key to machine vision and image analysis. Throop et al. 1993 used a color difference between bruised and non-bruised regions on 'Golden Delicious' apples. Daley et al. applied color imaging techniques to on-line poultry quality grading.

Application of computer vision to food processing fields evolved first in 1989 for grain quality inspection (Zayas et al. 1989). Huge post harvest losses in handling and processing and the increased demand for food products of high quality and safety necessitates the growth of accurate, fast and objective quality determination of food and agricultural products (Narendra et al. 2010). The method used by the farmers and distributors to sort and grade agricultural and food products are through traditional quality inspection and handpicking which is time-consuming, laborious and less efficient. Manual sorting and grading were based on traditional visual quality inspection performed by human operators, which is tedious, time-consuming, slow and non-consistent. Harvesting traditionally was done by manual sensory observations. The quality attributes often used for deciding on the harvest maturity were color, appearance, texture and odor (Sun et al. 2003). A first and an important step in the post harvest chain was sorting and grading of harvested produce. Commercially human senses were employed to sort or grade. Francis et al. (1980) found that human perception could easily be fooled. It is pertinent to explore the possibilities of adopting faster systems, which will save time and more accurate in sorting and grading of agricultural and food products. One of such reliable method is the automated computer vision system for sorting and grading. A study by Gujjar et al. (2013) in which Nine morphological features and six color features of each image acquired with a color machine vision system were extracted. A neural network was used to classify the rice seed. In the test dataset, the classification accuracies were 90.00%, 88.00%, 95.00%, 82.00%, 74.00%, 80.00% respectively. Many studies have been reported on application of artificial neural networks (ANNs) in agriculture (Chen *et al.* 2010).

Image processing and image analysis are recognized as being the core of computer vision (Krutz et al. 2000). Image processing involves a series of image operations that enhance the quality of an image in order to remove defects such as geometric distortion, improper focus, repetitive noise, non-uniform lighting and camera motion. Image analysis is the process of distinguishing the objects (regions of interest) from the background and producing quantitative information, which is used in the subsequent control systems for decision making. Image processing/analysis involves a series of steps, which can be broadly divided into three levels: low level processing, intermediate level processing and high level processing (Gunasekaran & Ding, 1994; Sun, 2000). Low level processing includes image acquisition and pre-processing. Image acquisition is the transfer of the electronic signal from the sensing device into a numeric form. Image pre-processing refers to the initial processing of

the raw image data for correction of geometric distortions, removal of noise, grey level correction and correction for blurring (Shirai, 1987). Pre-processing aims to improve image quality by suppressing undesired distortions or by the enhancement of important features of interest. Averaging and Gaussian filters are often used for noise reduction with their operation causing a smoothing in the image but having the effect of blurring edges. Also through the use of different filters fitted to CCD cameras images from particular spectral regions can be collected. Rigney et al. (1992) used a 400–620 nm interference filter to examine contrast between defect and good asparagus tissue. A multi-spectral camera system with six band pass filters for the inspection of poultry carcasses was used to achieve better classification of abnormal carcasses (Park & Chen, 1994). Algorithms such as neural networks, fuzzy logic and genetic algorithms are some of the techniques of building knowledge bases into computer structures. Such algorithms involve image understanding and decision making capacities thus providing system control capabilities.

Cereal quality requirements differ with respect to the end users such as the preparation of varieties of bread, cakes, cookies and pasta products. The current visual classification procedure is demanding, even for trained inspectors because of the wide variation in visual characteristics caused by contrasting class, varietal and environmental effects. Zayas et al. (1996) found that the physical characteristics of wheat could be used as the basis for the development of an objective wheat classification method. By the use of computer vision and crush force features, differentiation rate between hard and soft wheat was 94% for the varieties tested. A feature selection method based on an orthonormal transformation was used to discriminate digitised wheat cultivars (Uthu, 2000). Recognition of durum wheat cultivars and bread wheat cultivars was 82% and 81% respectively for the samples examined. In a comprehensive study Majumdar and Jayas (2000a, 2000b, 2000c, 2000d) investigated the use of morphology models, colour models, texture models and a combined model of all three for the classification of cereal grains. A total of 23 morphological, 18 colour, 25 textural features were tested on the training data set of 31,500 kernels. High accuracies were recorded for all the models examined ranging from 76% to 100%. The mean accuracies of the combined morphology–texture–colour model were 99.7% and 99.8% when tested on the independent and the training data sets of CWRS(Canada Western Red Spring) wheat, CWAD (Canada Western Amber Durum) wheat, barley, oats and rye. Similar research investigated the classification of dockage components from cereal grains and found that a morphology– colour model could classify test sample with a mean accuracy of 90.9% (Nair et al. 1997). A prototype machine vision system for automatically inspecting corn kernels was designed and tested by Ni et al. (1997). Blur due to the motion of the kernels was eliminated by the use of a strobe light and successful classification rates of 91% and 94% were achieved for classification of whole and broken kernels. Other studies using computer vision have been successful in the measurement and classification of corn whiteness, and mechanical and mould damage in corn (Liu & Paulsen, 1997; Ng, Wilcke, Morey, & Lang, 1997).

Grain visible features, related to the object surface color and texture characteristics are evaluated in this study. The grain sample elements are distributed in the following main quality groups: grains whit inherent for the variety color, heat-damaged grains, green grains, mould grains, smutty grains, infected (with *Fusarium*) grains, sprouted grains and non grain impurities. The grain sample characteristics presented above have visible symptoms on the grain surface. They are related to the specific grain appearance, surface color and surface texture and they are assessed by an expert on the basis of visual estimation only. This method for assessment presumes a computer vision system to be used for evaluation of a big part of these quality features (Brosnan and Sun, 2003; Liu and Paulsen, 2000; Luo et al., 1999; Mladenov et al., 2011). There are many materials published, in which color characteristics analysis is used to assess some particular quality features like authenticity (Liu and Paulsen, 2000; Majumdar and Jayas, 2000a), variety (Paliwal et al., 2003a; Paliwal et al., 2003b), infections (Ning et al., 1988; Mladenov et al., 2011), germination (Mladenov and Dejanov, 2008), etc. Morphological features, related to the grain shape and geometrical parameters are used for assessment of variety (Majumdar and Jayas, 2000b), purity (Paliwal et al., 2001; Mladenov et al., 2004), different injuries (Schneider and Kutzbach, 1999) and other similar grain properties. Some preliminary investigations (Mladenov et al., 2011) showed that the analysis of object color images could not give sufficiently precise assessment of some grain sample elements, like infected grains, mould grains and non grain impurities. This was determined by the fact that in comparison with the normal grains, not only color features of such objects are changed, but the surface texture are changed too.

Lai et al.(1986) suggested some pattern recognition techniques for identifying and classifying cereal grains. The same researchers (Zayas et al., 1986) also applied the digital image analysis technique to discriminate wheat classes and varieties. Luo et al.(1999) used a color machine vision system to identify damaged kernels in wheat. Substantial work dealing with the use of different morphological features for classification of different cereal grains and varieties was reported (Draper and Travis, 1984; Keefe, 1992; Myers and Edsall, 1989; Neuman et al., 1987; Sapirstein et al., 1987; Symons and Fulcher, 1988a; 1988b; Travis and Draper, 1985; Zayas et al., 1986). Some investigations were carried out using color features (Hawk et al., 1970; Majumdar et al., 1996; Neuman et al., 1989a; 1989b) for classification of different cereal grains and their varieties for correlating vitreosity and grain hardness of Canada Western Amber Durum (CWAD) wheat.

Durum wheat (*Triticum Durum* L.) is used by semolina millers and producers of pasta products and couscous worldwide. Approximately 100 million bushels are grown in the United States and 1.2 billion bushels are produced worldwide. Vitreousness of durum wheat is a measure of its quality and is related to the protein content. Nonvitreous (starchy) kernels are opaque and softer, and result in decreased yield of coarse semolina (Dexter et al 1988). In comparison, vitreous kernels appear hard, glassy and translucent, and have superior cooking quality and pasta

color, along with coarser granulation and higher protein content. Thus, the vitreousness of durum wheat kernels is an important selection criterion in grain grading. Various grading systems using different morphological features for the classification of different cereal grains and varieties have been reported in literature (Barker et al., 1992a, b, c, d; Majumdar and Jayas, 2000; Myers and Edsall, 1989; Sapirstein and Bushuk, 1989; Sapirstein et al., 1987; Symons and Fulcher, 1988a, b; Zapotoczny et al., 2008). Huang et al. (2004) proposed a method of identification based on Bayes decision theory to classify rice variety using color features and shape features with 88.3% accuracy. Majumdar and Jayas (2000) developed classification models by combining two or three features sets (morphological, color and textural) to classify individual kernels of Canada western red spring (CWRS) wheat, Canada western amber durum (CWAD) wheat, barley, oat and rye. Image analysis based on texture, morphology and color features of grains is essential for various applications in the grain industry including discrimination of wheat classes, to assess grain quality and to detect insect infestation (Tahir et al., 2007). Several researchers have worked on the development of machine vision systems for class and variety identification of grains (Neuman et al., 1987, 1989a, b; Manickavasagan et al., 2008). Zayas et al. (1986) classified three classes of wheat from the USA (hard red winter, soft red winter and hard red spring) and their varieties, using kernel length, width, length ratio, tangent, sine and arc length of parabolic segment with 77 to 85% accuracy. While classifying five Australian wheat varieties using size and shape features attained 44 to 96% accuracy (Myers and Edsall, 1989).

The GrainCheck 310 (FOSS Tecator, Höganäs, Sweden) is an image processing and ANN based instrument for assessing grain quality using color and shape information. This technology can provide real-time wheat quality inspection for every shipment of grain between producers, receiving stations, mills, and breweries (Svensson et al., 1996). Liu-yen et. al(2005), classified the six paddy varieties using digital image analysis based on colour and morphological features. They obtained the images in the steady illumination by mounting the stable supported camera with flexible vertical movement. After image acquisition seven colour and fourteen morphological features were used to discriminate the paddy varieties. An algorithm was developed in window environment using MATLAB programming language to extract the colour feature and morphological features such as Area, major axis length, minor axis length and roundness.

3. Conclusions

After going through the research work reported by various researchers in the field of quality inspection of wheat varieties and applications of image analysis in grain industry, it has been concluded that Image processing technique has the potential to become a vital component of automated food processing operations as increased computer capabilities. Image processing is recognized as being the core of computer vision with the development of more efficient algorithms assisting in the greater implementation of this technique. The automated, objective, rapid and hygienic

inspection of wheat grains can be achieved by the use of image processing and greater processing speed of algorithms are continually developing to meet the necessary online speeds. Image analysis based on texture, morphology and color features of grains is essential for various applications in the grain industry including discrimination of wheat classes, to assess grain quality and to detect insect infestation. Image processing modifies pictures to improve them (enhancement, restoration), extract information by analysis, recognition, and change their structure i.e. Composition, image editing.

4. Future Scope

This study can be carried forward by using Image Processing technique for Classification and Grading of different varieties of wheat grains and other cereal grains. Matlab programming can be used for determining morphological and color parameters which have better accuracy and has less computational cost. Moreover, research can be done on different variety of wheat and different feature set can be used.

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