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QUALITY EVALUATION OF GRAINS USING IMAGING TECHNIQUES

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Abstract: The production of grains in the world can be estimated to be in millions of tones every year. This paper focuses on major staple food grains consumed globally – The wheat, The quality and standard of the grains vary significantly due to differences in the physiological, growing conditions, crop management culture, grains management and different storage techniques. The grading of grains is based on their physical appearance and chemical characteristics. Thru the visual inspection the external features such as size, texture and color can be measured by comparing with the standards which are set by quality teams of individual countries every year.

The chemical properties can be moisture content and the amount of nutrients present in the grains. The moisture content can be measured by specified moisture meter. The amount of nutrients present in the grains, for example the protein content in the wheat can be determined using a near-infrared spectroscopy based instrument. It is necessary to develop a fast, accurate and automated system to monitor the grading factors. There may be a chance of the grain being infested (presence of insect inside the grain). This paper concentrates on different digital imaging techniques to evaluate the grains standards.

Keywords: Computer vision system, image processing, soft X-ray imaging, near-infrared spectroscopy, Spectral imaging, Thermal imaging.

1.INTRODUCTION

Agriculture industry is facing big challenge to give enough or adequate quantity of food grains in ever changing climatic conditions. There is a requirement to grow high-yielding crop types under different unpredicted situations. The grain quality is of at most important in the world because the nutrients present in them plays a major role in the good health and growth of the people, also in the agriculture industry good quality seeds will have significant effect on the yield of the crops. Grain quality depends on the seed health, its weight, purity and physical attributes which might lead to presence or absence of the disease, chemical components, insect infestation, and the presence or absence of weed seeds or other plant varieties. We know that nowadays people in the globe are very particular about the quality of the food they eat because human health is directly linked to the nutrients present in the grains. To achieve what has been quoted above in attributing to the quality of the grain, the traditional method of human inspection manually may not give accurate results because the human intervention can be biased and it might vary or change from person to person. When evaluating the seed quality one must keep in mind not to hamper or damage the grain. So in this paper to overcome the human interference and to achieve non destructive method to evaluate and measure the grain quality the concept of different imaging techniques are applied on the grains. The different image processing techniques that will be applied on the grains are namely, machine vision, spectroscopy, hyperspectral imaging, soft X-ray imaging and thermal imaging techniques.

Non-destructive techniques to grade the grains

1. Computer vision Technique

Computer vision or machine vision is the technique which uses both visible and non-visible part of the light spectrum which can be applied to measure the quality of the grains by just taking the images of the grains with a digital camera , it deals with object recognition and classification by extracting useful information about the object from its image**[1]**. Machine vision based inspection is already in commercial use in automotive, electronics and other industries. Many of the industrial objects being inspected are of defined size, shape colour and texture. Agricultural or biological objects, including grains are of various size, shape , texture and colour. The grains can be spread on a sheet of paper and a digital image can be captured , this technique is the most reliable and non destructive way to measure the quality of the seeds without intervention of the human beings which may not give the correct solution all the time. A digital image can be defined as a spatial representation of an object or scene . A monochrome image is a two-dimensional (2-D) light intensity function, denoted by I(x,y) where x and y are the spatial coordinates. The digital image processing combines mainly three main tasks that is, image acquisition, analysis, and recognition. The typical computer vision system

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consists of four basic elements such as an illumination system, a sensor or a camera, lens and a computer system with a digitizer(Fig 1). Most applications of computer vision system addresses the visible spectrum in the range (380–780 nm) [2]. The machine vision system after capturing the image, it should be capable enough to measure the external features of the grains such as its geometrical attributes like size, weight, shape etc, the texture, colour and morphological features.

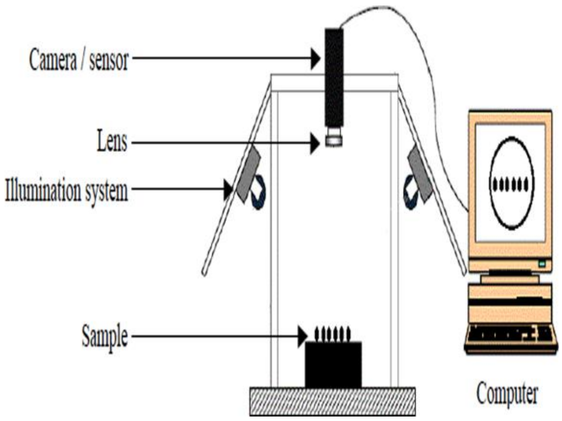

Fig 1: Machine vision system.

2. Soft X-ray imaging technique

There have been many researches on the non-destructive methods for quality evaluation of the grains over many years. Soft x-ray imaging and computer tomography are few of the non-destructive techniques which are gaining popularity now days in the various fields of agriculture and food evaluation industry.

These techniques we all know that were mostly used in the medical field in the hospitals for medical applications, besides medical imaging there are many applications of X-rays such as baggage checking at airports, inspecting industrial components, generally when a digital image of an object is captured in the visible spectrum, only its external features such as its size, colour, texture are visible and one cannot grade the grain quality based on only these features, there is a possibility of the grain being infested which cannot be visible in the external layer of the grain sample also there is a possibility of presence of a crack in the grain. So to gain access to the internal layers of the grain samples, the soft X-ray image samples has to be taken without damaging the grain. This technique finds a wide application on any agricultural products.

An X-ray image is formed by penetrating, high energy photons of 0.1-100 nm wavelength passing through an object. Mainly agriculture industry practices two types X-ray imaging: soft X-ray imaging with a wavelength of 1-100nm, of low energy and less penetrating power and hard X-ray imaging (or X-ray computed tomography) with a wavelength of 0.1-1 nm, of high energy and greater penetrating power, which are restricted to use in high-density objects. The X-ray technique provides images based on object density differences, A soft X-ray imaging system includes a fluoroscope which produces soft X-rays and real time images, a computer system and a digitizer (Fig 2). Current X-ray systems require that grains be placed manually on the platform between the X-ray tube and detector [3]Automation of this technology which scans a single layer of bulk sample moving on a conveyer belt would be ideal for use in the grain industry. Real time hard X-ray imaging systems are available for continuous food production. The shielding of low energy X-rays and development of an X-ray detector to detect soft X-rays fast enough in a continuous system are the hurdles in the development of a X-ray machine.

However industries at present are working towards creating such a system where these machines would be able to scan singulated grains to detect insect infestation [4]. these machines can scan grain kernels at the rate of 60g/min, like a continuous machine vision system that captures colour images of grain for identification. X- ray images can be obtained at different voltage and current settings. For grain images, a 15-kV potential and 65 -µA current works best [3]. Images formed on the detection screen are captured by a charge coupled device monochrome camera and digitized into 8-bit gray scale images at a spatial resolution unique to the system. A computer system is used for image acquisition and post processing

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Fig 2: Soft X-ray imaging system

3. Soft X-rays for insect infestation in the grains

Image processing allows measuring the external geometrical features of the grain samples which are spread uniformly on a sheet of paper, In spite of extenive research work happening since many decades, bulk grain is still not routinely inspected by X-ray. The reason for this is dual: the size of grain kernels restricts the inspection of speeds beyond the capability of even the fastest computers plus the inability of current high speed X-ray systems to detect larvae at their earlier stages. it is still a challenge to the researchers to evaluate the geometrical features for the bulk quantity of the grains through machine vision technique, there is another important thing to be worried about is what if the grain is infested that is it might have a larvae in it. This cannot be seen with the normal digital image, because the visible rays has to penetrate through the grains to find out whether the grain is infested or not. With all these challenges to the researchers, X-rays has been finer in penetrating through the grains irrespective of their small size. To achieve this grains has to be X-rayed at 15 kV and 65 -µA. Fig 3 [5] show the sample digital X-ray images of various stages of the larvae being infested in the wheat kernel.

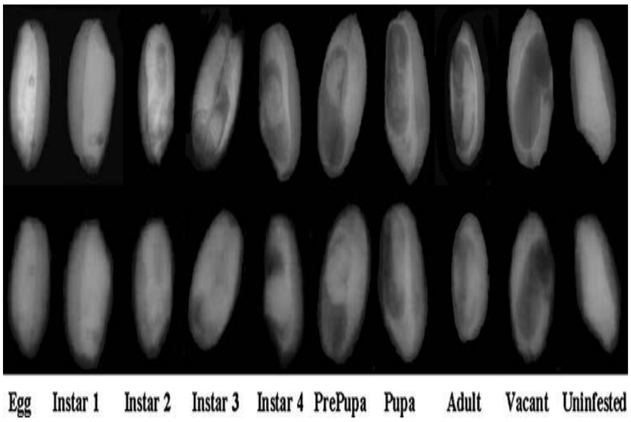

Fig 3 : X-ray image of wheat kernel with different stages of insect infestation.

4. Hyper Spectral imaging technique

Spectral imaging is one more advanced technique in the field of imaging which captures the digital image in the form of cuboids with more number of colour (spectral) information for each pixel than traditional colour cameras. The result of this can be viewed as a data cube which is a set of tens to hundred of picture frames with each successive frame representing its own spectral band or as a complete detailed curve for each pixel. It is a new technique that combines simultaneous skills of imaging and spectroscopy. HSI is an analytical method that together delivers chemical, structural and functional information from the sample. This technique can be used to verify both individual kernels and mass samples and simultaneously determine quality parameters of grains [6]. HSI acquires both spatial and spectral information together [7]. It is also known as chemical or spectroscopic imaging, it is an emerging technique that combines both traditional imaging and spectroscopy to get both spatial and spectral information of an object in general[8].

In comparison to a human brain, which uses only three primary colors seen by the human eye, computer vision systems can employ many more color channels. With this added spectral (or color) information, spectral machine vision systems often demonstrate greatly improved color differentiation as compared to predictable color imaging. Additionally, spectral imaging systems can access spectral regimes such as the infrared, which enables machine vision system to exploit reflectance differences humans cannot see. HSI was originally developed for remote sensing applications[9]. It has been used to study the geological features and composition of planets and stars in space exploration [10–13], mineral mapping, atmospheric composition analysis and monitoring, militaiy target detection or recognition , agriculture, pharmaceuticals and medicine. Industrial applications of hyperspectral imaging to identify different materials or chemicals have also been reported. As optical sensing and computer technology advance, applications of hyperspectral imaging to other areas are expected to emerge rapidly. One such important area is food safety inspection and quality evaluation, in which hyperspectral imaging can have great potential but has yet to be explored. Fig 4 is the sketch representing the HSI system.

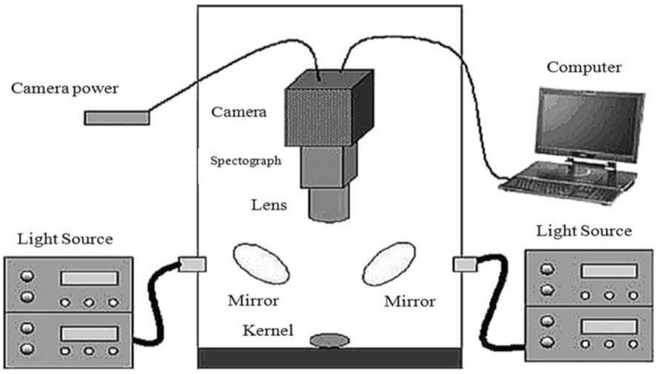

Fig 4: Diagram of Hyper spectral imaging system.

Spectroscopy has the potential to be used for measuring the hardness and vitreousness of kernels, for color classification, the identification of damaged kernels, the detection of insect and mite infestation, and the detection of mycotoxins Also, the feasibility of using reflectance characteristics for quick identification of bulk grain samples has been assessed. The spectroscopic method detects infested grain kernels based on differences in spectral reflectance. The cuticular polysaccharides (chitin content) of insects have a different spectral reflectance from that of water, protein, starch, or other chemical constituents in the grain. This method was successfully used to identify wheat kernels infested by the larval stages.Healthy, artificially created sprouted, and naturally midge-damaged wheat samples can be classified by acquiring the spectral images of wheat grains (Fig 5). In grain quality evaluation, hyperspectral imaging has been experimented with for detection of insect damage, moisture and oil content prediction.

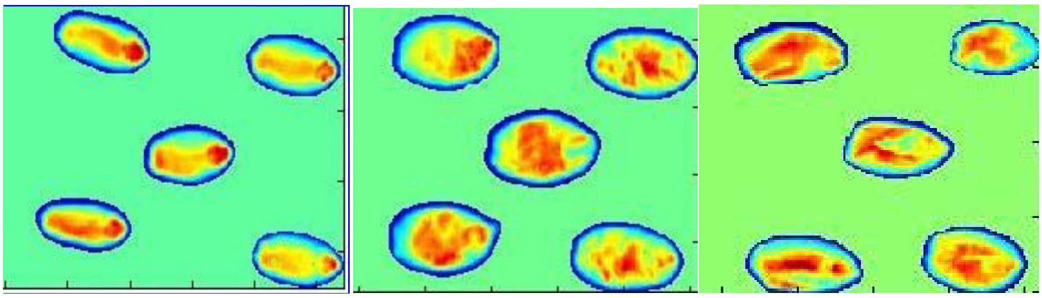

Fig 5 Healthy, germinated, midge-damaged samples

5. Thermal Imaging Technique

The temperature of the grains matter a lot because it plays a major role in the storage of the grains for long term usage by keeping it safe, The spoilage of grains occurs due to inadequate storage facilities, which leads to improper interactions between abiotic (temperature, moisture content, and gases composition) and biotic (grain itself, insects, fungi, moulds, and mites) factors. The storage life of grains depends on two factors mainly, the temperature and moisture content of grains.[14]

The thermal image is generated from the infrared radiation (700–1 nm) emitted from an object at a given temperature. In other words, thermal imaging provides a surface-temperature map of an object. The thermal imaging system (Fig 6) includes an infrared thermal camera (such as the Therma CAM TM SC500, of FLIR systems, Burlington, Ontario, Canada, an un-cooled focal plane array type camera capable of generating images of 310 × 140 pixels in the spectral range 7.5–13.0 µm) and a computer system. The thermal resolution of such camera is quite high (approximately 0.07°C at 30°C). Close-up lenses (for example, of 50-µm focal length) are usually attached to the original lens of the camera (FOV24° × 18°) to obtain magnified thermal images of a kernel. In thermal imaging, the emitted energy is represented as a two-dimensional image. This imaging technique is a non-contact type, but it requires the creation of temperature differences in an object, either by heating or cooling, to obtain internal information. By heating or cooling kernels of wheat which were initially at a uniform temperature, it is possible to show the differences between sound and infested

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kernels, or kernels of different classes. At present, thermal imaging is at research stage; however, it has already shown the potential to provide information associated with wheat quality degradation.

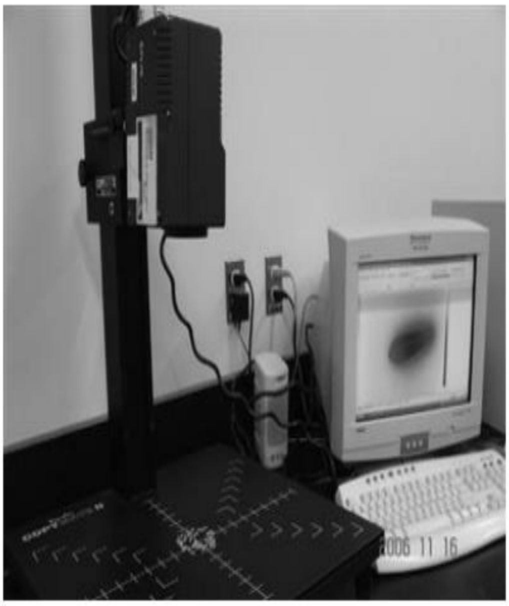

Fig 6: Thermal imaging system

CONCLUSION

The different image processing techniques which are discussed in this paper gives an idea that , it's not that the grains can be graded based on only the conventional images which are taken from a normal digital camera, it gives an insight into other imagine techniques which can be applied on the grains or any agricultural or food items to evaluate its quality by taking the quality detection into another superior level. Thus we can conclude that with these advanced techniques, the infested grains can be detected with the grain images taken at multiple frames(spectral images), the temperature measurement (Thermal images) of the grains to store the grains without spoiling it for long term usage can be achieved.

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