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HOG AND STATISTICAL FEATURES OF POTATOES USING MATLAB

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Abstract: Image processing of rotten, crack, good, sprout and skin damage potatoes for extracting Histogram of Oriented Gradients (HOG) is given that in rotten image, rotten part and the areas subjected to initial sprouting are showing good gradients having cell size 18×18, compared to non defect areas of potato. The smooth areas of histogram of oriented gradients (HOG) may be formed due to not using light diffuser while capturing. HOG of cracked and good potato images observed that gradients are rotating in anti clockwise direction. HOG of skin damage shows that gradients at top of the image are weak than other parts of image but initial sprouting images have high gradients. Similar trend observed for sprout images. Contrast of skin damage potato is higher for sprout, rotten, good and crack potato. Rotten and sprout specimen images are equal in correlation values followed by good and skin damage potato. Crack and sprout specimen images contains equal energy values. Rotten, crack and good specimen images contains equal homogeneity values followed by skin damage and sprout potato.

Keywords: Potatoes, Textural features, HOG.

1. INTRODUCTION

Image processing includes operations like segmentation, thresholding, edge detection, filtering etc., (Prabha and Kumar, 2015). It is the application of mathematical and optical rules to find the solutions in the field of quality inspection of agricultural and horticultural products (Razmjooy et al. 2012). Image processing carries excellent verification of agricultural commodities and its usage will be high in food stuff manufacturing (Unay et al. 2011). It involves the exploitation and analysis of images and it is a wide area under discussion (Lillisand et al. 2015). Potato (Solanum Tuberosum L.) is one of the popular crops in the world, which is widely consumed in the form of raw or processed. Almost 80 per cent of the countries are involved in potato cultivation. It is the most important crop in India after rice, wheat, and maize. There is a large demand of potato for making processed products rather than raw usage. Thus, high-quality potato is raising the demand of the market (Rani and Prasoon, 2013). India occupies the third position in the production of potato in the world (Anonymous, 2017) cultivating 486 lakh tones in 2016-17 (Anonymous, 2018). In India, during last six decades, potato production increased significantly. Statistics given that during last decade the potato yield and production increased at 1.10 and 5.98 per cent per annum respectively. This paper fills up the gap of lack of modified information on potato image acquisition and Histogram of Oriented Gradients (HOG) and surface features of cracked, rotten, sprout, good and skin defect specimen image. Through this paper a comparison between surface features of skin damage, sprout, good, rotten and crack potato has been furnished.

2. MATERIALS AND METHODS

2.1 Textural Features of Image

Properties like contrast, correlation, energy and homogeneity are measured based on the pixels of an image. Contrast also known as variance and inertia is a measure of intensity between a pixel and its neighbor in all over the image and it is expressed in the following expression (MATLAB R2018b).

$$\text{Contrast} = \sum_{i,j} |i - j|^2 p(i,j)$$

Correlation is a measure of correlation between a pixel and its neighbor, in a whole image. Range of correlation is between 1 and -1 and for constant image it is zero (MATLAB R2018b). Correlation is expressed as

$$\text{Correlation} = \sum_{i,j} \frac{(i - \mu i)(j - \mu j)\, p(i,j)}{\sigma_i \sigma_j}$$

Energy also known as uniformity and it is a squared sum of elements in gray level co-occurrence matrix. Its range is between 0 and 1. Energy of a constant image is one (MATLAB R2018b). It can be expressed as

$$\text{Energy} = \sum_{i,j} p(i,j)^2$$

Homogeneity gives the measure of close elements distribution of elements in the gray level co-occurrence matrix to its diagonal. Its range is between 0 to 1. For diagonal gray level co-occurrence matrix, homogeneity is one (MATLAB R2014b). Homogeneity can be expressed as

$$\text{Homogeneity} = \sum_{i,j} \frac{p(i,j)}{1+|i-j|}$$

2.2 Image Acquisition

Images are captured by the setup developed as shown in Figure 1. A 40×40×40 cm box was developed using GI sheet of 20 gauge thickness. Four Quantum PC Camera, (Model no QHM495LM equipped with inbuilt six lights and potentiometer) are installed on four sides at the top of the box. A door was provided at the front to place and remove potatoes. Sample of thousand potatoes were selected and placed on a 6 cm raised platform made with polystyrene and covered with black cloth to reduce the effect of shade. Four images were captured at the top and again four images by rotating potato at 180°. Light intensity is adjusted by potentiometer. Images captured are in the size of 640×480 pixels. The four ends of cameras are connected to laptop through USB Hub. These images have been processed by using Matlab software (MATLAB, R2018b). Images are croped manually according to the edges of potato. The procedure for textural properties of rotten, crack, skin, sprout and good potatoes are given in the following flow diagram.

Image acquisition → Cropping → Filtering → Textural properties using MATLAB

Fig. 2.1 Image Processing Setup Developed for Potatoes

3. RESULTS AND DISCUSSION

3.1 Histogram of Oriented Gradients (HOG)

Pre-processed images are run through different operations like noise removal, segmentation and feature extraction. From HOG image of rotten potato, it is observed that rotten part and the areas subjected to initial sprouting are showing good gradients of cell size 18×18, compared to non defect areas of potato. The smooth area of histogram of oriented gradients (HOG) may be formed due to not using light diffuser while capturing the specimen image. However, HOG features failed to extract strongest corner points in rotten image, because of some limitations in algorithm. It detects one point twice in a result, with nearest distance, while the other point has been detected only once.

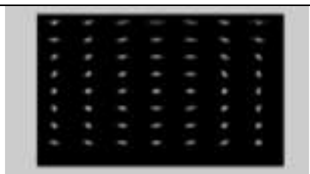
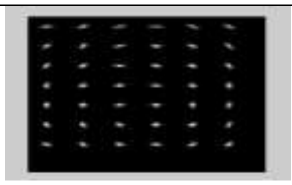
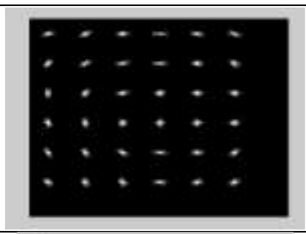
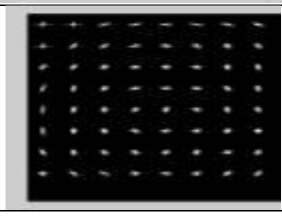
HOG feature of crack potato resultant image of cell size 32×32 indicated that gradients rotating in anti clockwise direction. In HOG feature of strongest corner points of crack potato, one point is identified twice and another is identified once. The point identified twice on the top portion of potato is due to little darkness at that point.

Histogarm of oriented Gradients (HOG) of good potato with cell size of 32×32 indicated that all the gradients are equally spaced and moving in the anticlockwise direction, while the Histogram of Oriented Gradients (HOG) features of strongest corner points of good potato is showing less accuracy.

The Histogram of Oriented Gradients (HOG) with cell size of 18×18 of skin damage potato indicated that the portions at the skin peel are good at gradients compared to no skin areas, and gradients are stationary at the resultant HOG image boundary and gradients are rotating in clock wise direction with respect to centre.

HOG feature of strongest corner point for skin damage specimen image indicated that in resultant image strongest point is observed at the initial point of skin peel. The HOG features of sprout potato indicated that at the top gradients were found weak than other parts of image but initial sprouting images have high gradients compared to other type of potato images. The HOG feature of strongest corner points for resultant image identified twice at the one initial sprout and one is identified as mislead.

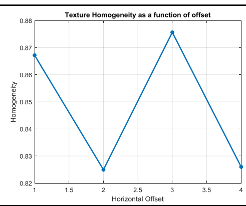
Table-3.1 Comparision between Different Potato Specimen Image with HOG Features

S. No.	Type of Specimen Image	HOG Feature	HOG Feature at strongest corner point
1	Rotten 		
2	Crack 		
3	Good 		
4	Skin damage 		
5	Sprout 		

3.2 Textural Features of Cracked Potato

The surface properties such as homogeneity, contrast, energy and correlation of potatoes giving the complete information about its distribution and as well as repetetion of pixels. Mainly it gives the information about the neighborhood of pixels. In case of cracked potato, homogeneity of specimen image was decreased linearly from 0.867 (offset 1) upto 0.825 (offset 2) and on the other hand it was increased linearly from 0.825 (offset 2) upto 0.875 (offset 3) and finally homogeneity of specimen image decreased from 0.875 (offset 3) upto 0.826 (offset 4). In case of contrast of cracked specimen image potato, it was raised from 0.55 (offset 1) upto 0.97 (offset 2) and also lowered linearly from 0.97 (offset 2) to 0.75 (offset 3) and finally it was slightly increased from 0.75 (offset 3) upto 1.03 (offset 4). In case of third surface property of cracked potato specimen image i.e. energy, it was observed that it is decreased little bit from 0.0643 (offset 1) upto 0.056 (offset 2) and raised from 0.056 (offset 2) upto 0.0682 (offset 3) and finally as shown in Table 2, it is decreased from 0.0682 (offset 3) upto 0.0567 (offset 4). Finally, we analyzed correlation property of specimen image and noticed that it was decreased from 0.989 (offset 1) to 0.9816 (offset 2) and slightly increased from 0.9816 (offset 2) to 0.985 (offset 3) and finally decreased from 0.985 (offset 3) to 0.9793 (offset 4).

Table-3.2 Graphical Representation of Textural Features of Specimen Crack Potato Image

S. No.	Feature	Graph
1.	Homogeneity	

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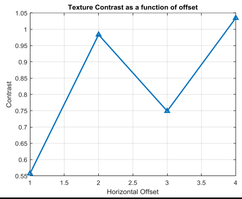
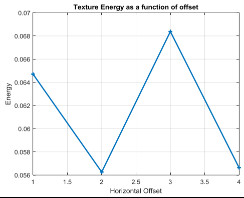
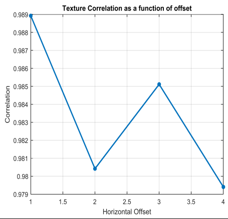
2.	Contrast	
3.	Energy	
4.	Correlation	

Table-3.3 Statistical Features of Different Types of Potato

S. No.	Specimen Image	Statistical Features
1.	Rotten Potato 	Contrast = [0.83 1.46 1.02 1.49] Correlation = [0.98 0.97 0.98 0.97] Energy = [0.08 0.07 0.08 0.07] Homogeneity = [0.87 0.83 0.87 0.83]
2.	Crack Potato 	Contrast = [0.55 0.98 0.75 1.03] Correlation = [0.99 0.98 0.98 0.97] Energy = [0.06 0.05 0.07 0.05] Homogeneity = [0.87 0.82 0.87 0.83]
3.	Good Potato 	Contrast = [0.82 1.44 1.01 1.44] Correlation = [1.00 0.97 0.98 0.97] Energy = [0.09 0.08 0.09 0.08] Homogeneity = [0.87 0.83 0.87 0.83]
4.	Skin damage Potato 	Contrast = [2.35 4.01 2.98 4.27] Correlation = [1.00 0.95 0.96 0.94] Energy = [0.04 0.04 0.04 0.04] Homogeneity = [0.84 0.79 0.84 0.79]
5.	Sprout Potato 	Contrast = [1.47 2.21 1.33 2.15] Correlation = [0.98 0.96 0.98 0.96] Energy = [0.06 0.05 0.06 0.05] Homogeneity = [0.84 0.79 0.85 0.80]

The following obsevations are inferred from Table 3 that the contrast of skin damage potato is higher (2.35) followed by sprout (1.47), rotten (0.83), good (0.82) and crack potato (0.55). Some times the contrast of specimen image is depend up on light intensity available at the time of capturing i.e time taken to allow light to settle on potato surface and the genetical type of potato. Correlation of sprout, rotten, good and crack potato specimen images are almost equal and less than one which satisfies the correlation condition that the range of it is between 1 and -1. Energy of specimen image of good potato is higher (0.09) followed by rotten (0.08) and skin damage (0.04), but crack and sprout specimen images contains equal energy values (0.06). Energy values of all the specimen images satisfies the condition that energy values should be in the range of 0 to 1. Homogeneity of three specimen images (0.87) are equal (rotten, crack, and good potatoes) followed by rest of two (0.84), which are again equal.

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CONCLUSIONS

Histograms of oriented gradients are very strong in rough texture surfaces like crack, rotten, sprout and skin damage. A comparision has been made between good and bad potato (rotten, sprout, skin damage and crack). Corners and strongest points need to be more identified than presented. Main problem associated with external defect extraction properties is overlapping of sprout and crack, rotten and sprout, skin damage and sprout, sprout and rotten etc.

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