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Identification of Different Food Grains by Extracting Colour and Structural Features using Image Segmentation Techniques

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Abstract

Objectives: This paper proposes a method of identifying the different food crops which is automated. Identification of food crops can be automated using image segmentation techniques which reduces manual work. **Method:** Images of various food grains like wheat, paddy, cereals, barley and many more are captured using high resolution camera. Grab Cut algorithm helps in extraction only the part of image that the user is interested in. The colour features and outer boundaries of the food grains are extracted using Watershed algorithm and Canny detect detection. **Findings:** Extracting only the required part of an image i.e. the food grains, have made the processing easier as less features will be extracted. This reduction becomes very important when large data-set is considered. Many of the techniques used for segmenting grains consider only one feature, either colour or structural feature. The proposed system uses both colour and structural features which makes segmenting more accurate. Canny edge detection and Watershed algorithm takes less time for computation when compared with other techniques. **Applications:** An electronic hardware component can be built and the software part which identifies the grains can be embedded with it and used in the agricultural fields for separating food grains.

Keywords: Canny Edge, Detection, Feature Extraction, GrabCut Algorithm, Image segmentation, Watershed Algorithm

1. Introduction

Image segmentation is a field in computer vision which involves partitioning an image into set of pixels of same features. Each pixel in an image will be assigned with a label and same labels are grouped which means they have some characteristics in common. Image segmentation is performed to represent an image in an easy manner so as to help for further analysis[1,2]. The two main objectives of segmenting an image are to divide an image into various parts and to change the representation of an image. When an image needs to be processed, an entire image may not be useful. The goal is to operate only on the meaningful part of an image such as food grains in the proposed work. The food grains will be considered for further analysis. The features of food grains like colour and structure are used to segment an image. The reason for considering these two features is that, two grains may have the same colour but their structure can be different. And if there is confusion in the structure of the food grains, their colours can be used to identify them. The structure of the grains can be obtained by detecting their boundaries. Edge grouping methods help to identify the outer linings in a digital image. Hence, such techniques are very useful and are used in fields like content-based image retrieval[3], machine vision, medical imaging[4,5], object detection, recognition tasks.

In the recent past, many researchers have used image segmentation techniques in the field of agriculture to identify different plants and crops[6] performed colour analysis of wheat grains using digital image processing. Wheat grains are discriminated considering video colorimetric and kernel type. The red, green and blue colours of an image are used to distinguish the wheat grains[7] have used shape

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properties along with concave curvature in shape boundaries to choose the split points to segment the rice grains from the other set of grains[8] carried out the process of segmentation in which eight type of rice varieties are identified considering the features like grain length and aspect ratio. Extracted features are evaluated using unsupervised clustering techniques[9], implemented Support Vector Machine (SVM) classifier to segment the regions of rice grains that have symptoms of rice diseases, such as rice bacterial leaf blight, rice sheath blight and rice blast.

The discussed implementations have basically considered only one type of feature such as colour, shape and texture. Each of these features is considered separately. The proposed work considers combination of features, colour and structure of the food grains to segment them. The work on combining these features and identifying the food grains is minimal. In the above discussed algorithms, more data is required for processing. With the use of Canny edge detection, data processing can be reduced and Watershed algorithm requires low computation times when compared with other segmentation methods[10].

2. Proposed Work

The proposed work involves the steps namely, image preprocessing using Grab Cut algorithm, segmentation of structural features using Canny edge detection, segmentation of colour features using Watershed algorithm.

The data-set comprises of images containing food grains like wheat, paddy, cereals, barley and many more. A single image contains all these grains and the images are captured using a high resolution camera. Firstly, Grab Cut algorithm is used to extract only the important part of an entire image. Here, the part of an image containing the grains is extracted and used for further processing. Grab Cut algorithm is used as a part of image pre-processing phase. The image obtained from pre-processing phase is utilized to segment structural features using Canny edge detection. This algorithm helps to detect the edges or the outer boundaries of the grains. The outcome of this phase provides the images in which the boundaries of the food grains are obtained. In the next phase, output of Canny edge detection is passed to the Watershed algorithm wherein, the images are coloured. The different grains will be coloured differently based on the colour features of a particular grain. Now, the output images obtained from Canny edge detection and Watershed algorithm are both considered to identify a particular grain. Both, structural and colour segmentation is carried out because sometimes colour segmentation of an image will yield an output in which different crops may be identified with the same colour. In such cases, structure of the food grains can be used to identify a particular grain and if the structure is same then, colours of good grains can be compared. By considering two of the features (colour and structure), misidentification of food grains from

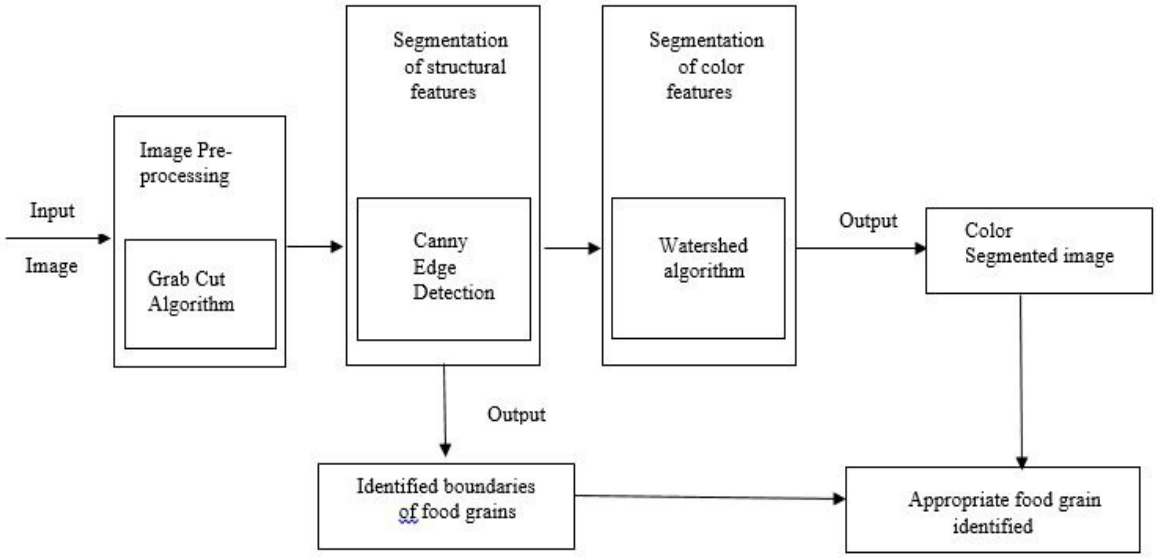

Figure 1. Steps involved in the proposed system.

the image segmentation techniques can be reduced. The workflow of the proposed work is shown in the Figure 1. Algorithms in our Experiment

3. Grab Cut Algorithm

The basic idea of this algorithm is to use the concepts of graph theory to partition an image into foreground and background pixels[10] the user draws the rectangle to separate foreground and background pixels.

Consider a simple image as shown in the Figure 2. Let us draw a horizontal line across an image for illustration and that line is represented as the set of pixels. An entire image can be mapped to a graph. Every pixel will be a node on a graph. The black circles in the Figure 2, represents the pixel. Each pixel represents a node in an image. Later, two nodes are added, one called the sink node that represents the background pixels and another one representing the foreground pixels. Once the nodes are created, these nodes need to be connected through the edges. First, the connection is made between the nodes representing a pixel with the foreground source and background sink. The edges are assigned with the weights connecting the pixels to the source node. Probability is calculated for each pixel being foreground or background. Pixel similarities are used to define the weights for the nodes. Pixel differences are computed for the neighbouring nodes and if the difference is more, an edge existing between them will be assigned with the low weight value.

In the next step, graph is segmented using min cut algorithm. Considering the minimum cost function, the graph is divided into two separating source node and sink node. The sum of all the weights of the edges forms the cost function. With this, all the pixels attached to the source node become foreground and those attached to the sink node becomes the background.

4. Canny Edge Detection

Edge detection is an image processing technique for finding the boundaries of objects within the images. It is used for image segmentation and data extraction. There are mainly three types of edge detection which are, Sobel method, Fuzzy logic method and Canny method. In the proposed work, Canny edge detection is used. It was developed[10-12] Steps involved in Canny edge detection are as follows:

Filter out any noise in the original image before trying to locate and detect any edges using Gaussian filter. Once a suitable mask has been calculated, Gaussian smoothing can be performed. An example of Gaussian kernel of size 5 that might can be used is

$$K = \frac{1}{154}\begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix}$$

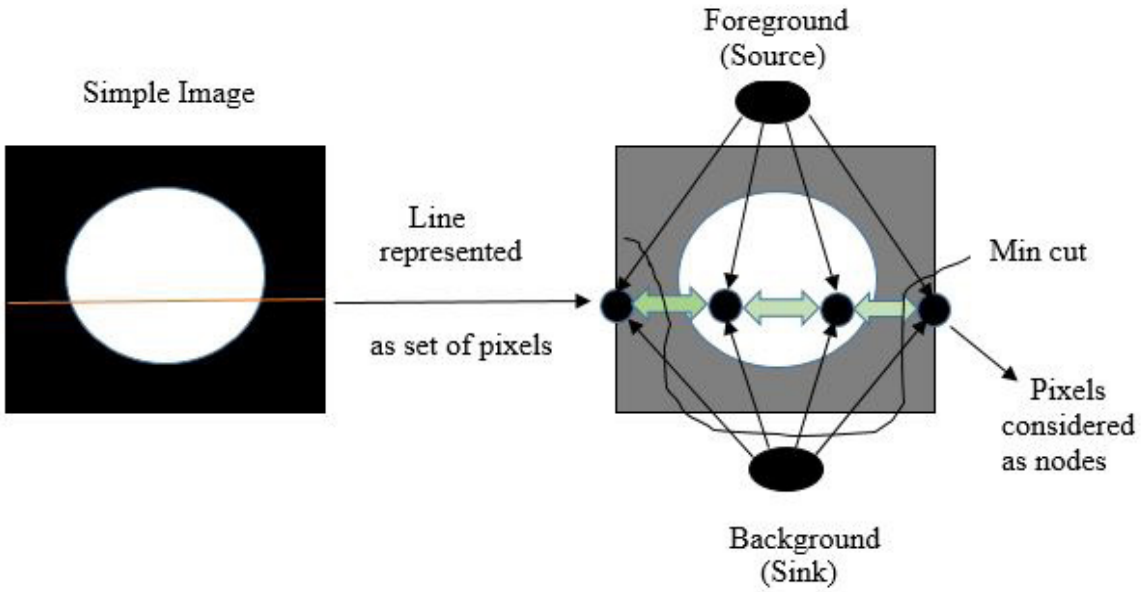

Figure 2. Representation of Grab Cut Algorithm.

Finding the intensity gradient of the image. After smoothing the image, Sobel kernel is used to get first derivative in the horizontal direction (G_x) and vertical direction (G_y). Edge gradient and direction for each pixel can be calculated as follows:

$$(G) = \sqrt{G_x^2 + G_y^2} \quad (1)$$

$$(\theta) = \tan^{-1} \frac{G_y^2}{G_x^2} \quad (2)$$

Non-maximum suppression is applied which removes pixels that are not considered to be part of an edge, results in a binary image with thin edges and trace along the edge in the edge direction and suppress any pixel value that is not considered to be an edge. This will give a thin line in the output image.

Hysteresis, where Canny does use two thresholds (upper and lower). If a pixel gradient is higher than the upper threshold, the pixel is accepted as an edge. If a pixel gradient value is below the lower threshold, then it is rejected. If the pixel gradient is between the two thresholds, then it will be accepted only if it is connected to a pixel that is above the upper threshold.

5. Watershed Algorithm

The idea of using Watershed algorithm is to identify the watershed lines in an image so as to disparate the distinct regions. The transformation provided by the watershed algorithm considers an image like a topographic map. Watershed algorithm is widely used in image processing and especially in the field of image segmentation.

Consider the topographic surface as shown in the Figure 3. Water would collect in one of the three catchment basins. Water falling on the watershed ridge line separating the three basins would be equally likely to collect either of the three catchment basins. Watershed algorithms then find the catchment basins and the ridge lines in an image.

The algorithm works as follows: Suppose a hole is punched at each regional local minimum and the entire topography is flooded from below by letting the water rise through the holes at a uniform rate. Pixels below the water level at a given time are marked as flooded. When the water level increases, the flooded regions will grow in size. Eventually, the water will rise to a level where three flooded regions from separate catchment basins merge. When this occurs, the algorithm constructs a one-pixel thick dam that separates the two regions. The flooding continues until the entire image is segmented into separate catchment basins divided by the watershed ridge lines[13].

6. Results and Discussion

In this part, the results of the proposed work is discussed which includes the results of Grab Cut algorithm, Canny edge detection and Watershed algorithm.

Consider the Figure 4, where the rectangle is drawn by the user. The food grains present inside the rectangle forms the foreground pixels and background pixels are ignored. The output image contains only the food grains on which further analysis will be carried out.

In the Figure 5. (a), food grains are given numbers for convenience to analyze and the Figure 5. (a), is the image obtained from Grab Cut algorithm. This image is subjected to Canny transformation and the result after applying Canny edge detection is shown in the Figure 5. (b).

From the Figure 5, boundaries of the food grains are identified but this information is not enough to identify a particular food grain. When observed carefully, grains numbered as 1 and 5, though are different, structurally they appear to be same. In order to eliminate this confusion colour segmentation is performed.

The Watershed algorithm is used to segment an image as shown in the Figure 6. (b). From Figure 6, different food grains are coloured differently. Grains labelled as 1 and 5 as shown in the Figure 6. (a), almost have the similar structure and there is confusion in identifying them. But after performing the segmentation using Watershed algorithm, based on the colour features it is now possible to differentiate grains numbered as 1 and 5.

The reverse condition is also possible which is, if same colour is given to different grains, then their structure can be used to identify a grain properly.

Many other images of the food grains are considered to verify if the proposed model works well. Figure 7, shows the application of proposed system for certain sample of images.

7. Conclusion

The use of image segmentation techniques in the field of agriculture is being utilized very efficiently and rapidly. With the use of computer developed systems, no harm

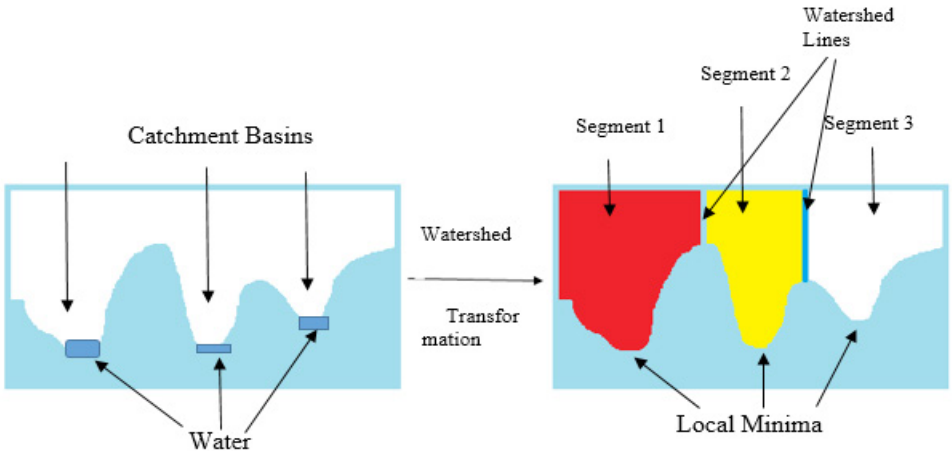

Figure 3. The concept of Watershed algorithm.

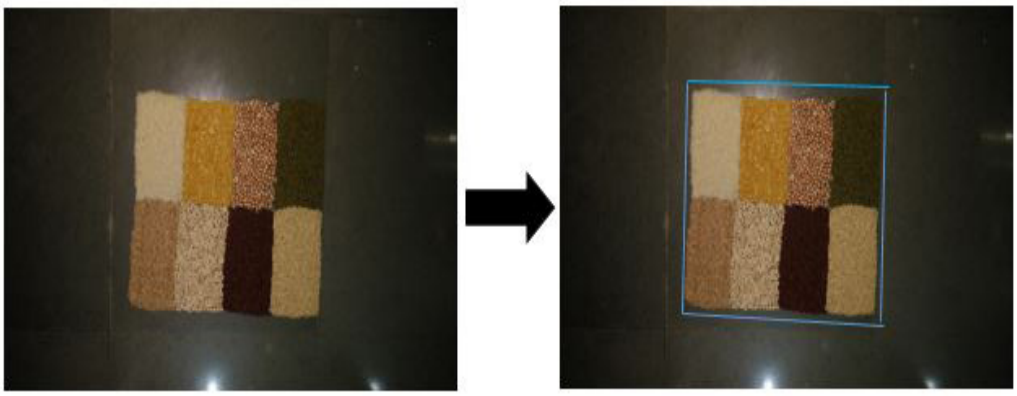

Figure 4. Result of Grab Cut algorithm.

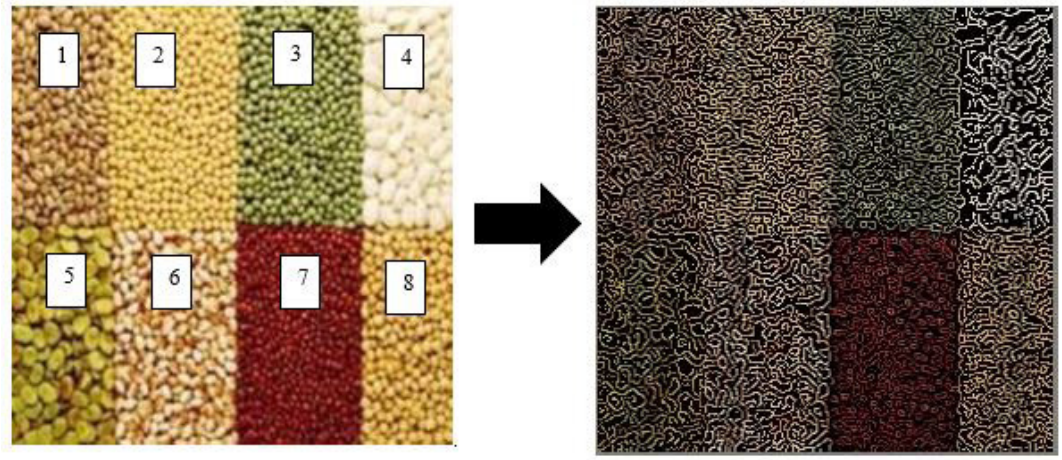

Figure 5. Result of Canny edge detection.

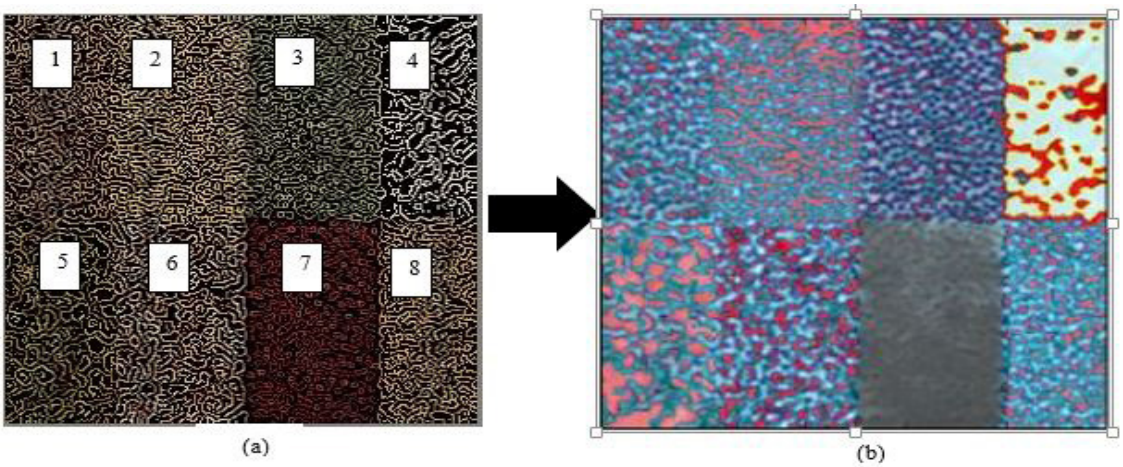

Figure 6. Result of Watershed algorithm.

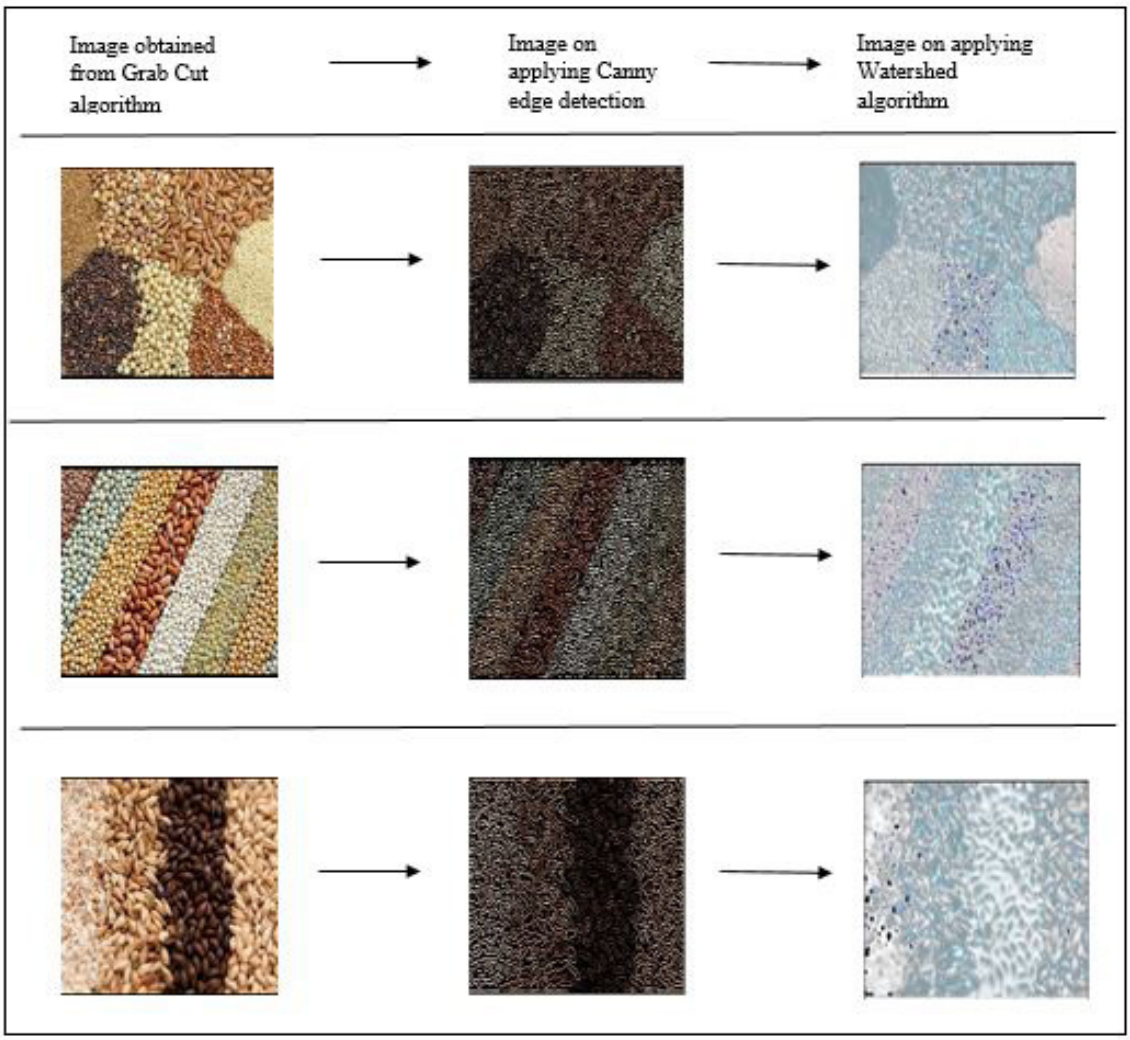

Figure 7. Results of proposed system using other sample images.

is caused to the agricultural plants. The emphasis of the paper is on the development of an automated system that identifies the different food grains from one another and separating them, reducing the human work. Many food grains are all together considered in a single image and grains are distinguished in terms of their structure and colour. Techniques such as Canny edge detection and Watershed algorithm are used to obtain the structure and colour of the grains. Further research and implementation may include developing an automated hardware system which could help in the separation of food grains from one another.

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