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Separation of Wheat Seeds from Junk in a Dynamic System Using Morphological Properties

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Abstract: Wheat is the main food source of the humankind. After its harvest, it goes through many procedures from its separation from chaff to its packaging. With the development in technology, many of these procedures are realized with automatic systems which saves the manufacturer the cost of labour, time and provides the customer with more quality food. One of the main concerns of quality food production is to provide a customer with the product in its purest form which means the product must be separated from all foreign matters. In this study, type-1252 durum wheat seeds have been separated from junk using the morphological properties of wheat seeds through the uncompressed video image taken with the camera Prosilica GT2000c. The main references for the quality measurement of wheat seeds are the shape and the dimensions of a wheat seed. Aiming for high quality wheat grain storage with no junk, this article has adopted various image processing techniques from image preprocessing to feature extraction. The image processing has been realized in a computer environment and the results show that the image processing is successful and the detection of wheat seeds from junk was accurate.

Keywords: *BlobAnalysis, Feature Extraction, Image Processing, Junk, Morphological Properties, Segmentation, Wheat Seed*

1. Introduction

Food supply is one of the most essential materials for the survival of human beings. Wheat, which is the most fundamental material of amylaceous products like bread and pasta, is also one of the main food supply for human beings. It is important for the food industry to provide quality goods which includes wheat grains. After its harvest, wheat seeds go through many procedures from its separation from chaff to its packaging and they are stored in warehouses to be sold at specified intervals [1]. The inspection and the classification of good quality wheat grains can be done by manually through a series of instrumental or chemical analysis. Obtaining good quality wheat product through these tests and analysis is subjective, time consuming, less efficient, costly and the safe inspection of food without damaging its structure is nearly impossible[2, 3].

In recent years, it has become imperative to use automatic systems in the inspection and classification of wheat seeds to eliminate all those adverse conditions mentioned. With rapidly developing computer technologies, machine vision systems and image processing techniques have become one of the most popular research areas in wheat inspection and classification, because they have the ability to visually characterize wheat grains by their physical attributes and the process is objective, speedy, most efficient, cheap, repeatable and harmless to wheat seeds [2, 3].

Through the last years, many researchers have evaluated machine vision and image processing techniques if they really meet the expectations for the inspection and classification of the quality of wheat. There have been many studies about the determination of the properties of single wheat seed, separation of one type wheat from another or identification of damaged wheat seeds, but there have not been many researches about separating the wheat seeds from non-wheat seeds [1]. In a study conducted by Pourreza et al., nine different wheat classes growing in Iran have been classified according to their textural properties extracted from Gray Level, GLCM (Gray Level Co-occurrence Matrix), GLRM (Gray Level Run-length Matrix), LBP (Local Binary Pattern), LSP (Local Similarity Pattern) and LSN (Local Similarity Numbers) matrices and classified using LDA (Linear Discriminate Analysis [4]. Xia et al. classified a single type wheat with regards to its quality by accounting its 7 morphological properties and 6 colour properties [3]. In an article written by Güneş et al., it is explained the varieties of wheat growing in Turkey are classified according to its textural analysis using GLCM and LBP methods and k-Nearest Neighbour type classifier [5]. In a study conducted by Babalik et al., variety of wheat classes are identified with 9 morphological and 3 colour features using M-SVM (Multiclass Support Vector Machines) and BPSO (Binary Particle Swarm Optimization algorithm [6]. In another study, Farahani tried to determine the best potential morphologic features to classify 5 different types of durum wheat [7]. Manickavasagan et al. tried to measure the ability of a machine vision system with a monochrome camera to classify the different types of western Canadian wheat types by using bulk sample analysis [8]. Williams et al. have evaluated two different digital image analysis (DIA) approaches to quantifying wheat seed shape for exploring trait correlations and QTL (Quantitative Trait Loci) mapping [9]. All these studies generally have been made with the purpose of classifying different types of wheat. However, there is also a small number of studies about purification of wheat from

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its chaff and other impurities. One of these studies is made by Ebrahimi et al. to propose a machine vision automatic grading system which separates the wheat from the impurities within [1]. The objective of another study conducted by Paliwal et al. is to develop an algorithm which classifies 5 different types of Canadian wheats and also differentiates the wheats from non-wheat materials [10]. In another study, FN Chen et al. have developed an image processing algorithm which determines black germ wheat [11]. It can be seen from these examples that so few of the studies are about purification of wheat from non-wheat materials. Also, all of these studies are conducted in stationary environment and the possible outcomes are not known for a non-stationary environment.

In this study, our objective is to obtain good quality type-1252 durum wheat grains by separating the impurities from wheat grains in a dynamic system using image processing techniques.

2. Proposed Methodology

In this study, image acquisition, image preprocessing, segmentation, feature extraction, classification processes have been carried out. The process stages we used in this study are shown in (Figure 1).

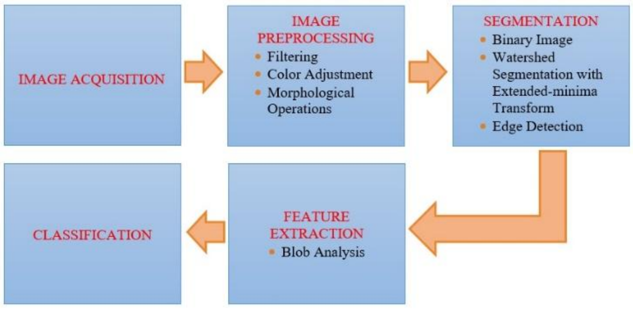

Figure1. The process stages that were followed in the study

2.1. Image Acquisition

The system used consists of a band-wheel system where the durum wheat grains are moving upon, image acquisition camera Prosilica GT2000C, and illumination apparatus with a shady box stand for preventing the shadow formation on the background.

Prosilica GT2000C camera is a 2.2 megapixel, RGB camera with 2048 x 1088 resolution, CMOS type sensor, 53.7fps maximum frame rate at full resolution and efficient operation temperature range between -20 °C and +65 ° C [12]. The camera has been placed atop the illumination apparatus and daylight coloured illumination apparatus there is a ground glass around the camera lens so that the light can refract uniformly. The camera and the light illumination apparatus has been placed above a shady box so that the outside light does not affect the wheat grains and shadow formation can be prevented.

The camera views a 8 cm x 10 cm area inside the box and the 5 sec uncompressed video obtained from the camera is transmitted to the image processing computer software with an ethernet cable. The system used for this study is shown in (Figure 2). Also, a frame sample of the video acquired is shown in (Figure 3).

2.2. Image Preprocessing and Segmentation

The obtained video has been separated into frames and all the frames have been subjected to same processes. First the colormap of the images adjusted suitably after several trials so that the image segmentation is successful. The image with adjusted colormap is shown in (Figure 4).

After adjusting the colormap, the images are turned into gray images and subjected to a 5 x 5 median filter. Median filtering is a non-linear filtering process which offers an effective noise reduction without blurring the image [3]. After the filtering process, the background is subtracted from the image with "top-hat" operation so the background noise does not affect the image processing. The median filtered image with background subtraction is shown in (Figure 5). Then, morphologically "open" and "close" operations have been applied to the images to smooth the boundaries of the objects and the images have their contrast values adjusted to reduce edge detection error. The final state of the frame sample after several morphological operations is shown in (Figure 6). Lastly, they were converted to binary images using an appropriate threshold value. The binary image of the frame sample is shown in (Figure 7).

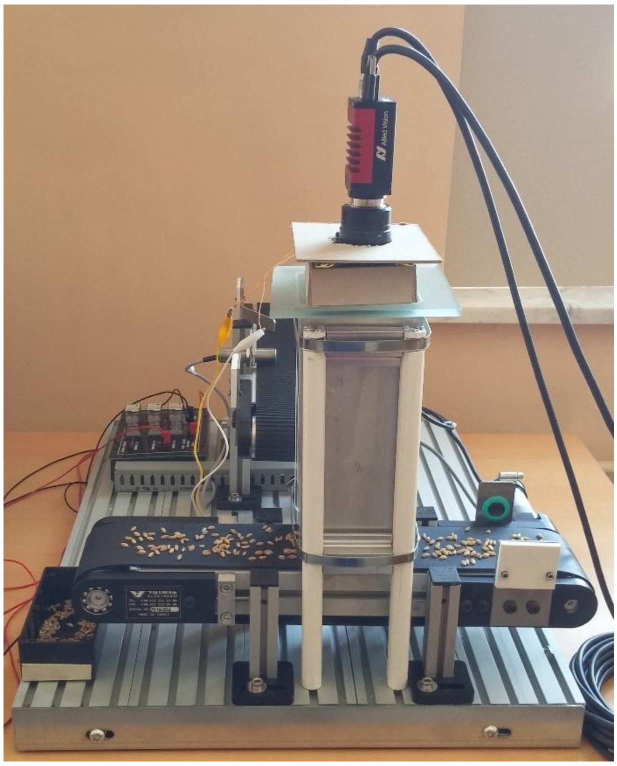

Figure 2. Dynamic system used for acquiring video sample of durum wheat grains with impurities

Figure 3. Frame sample of the video visualizing durum wheat grains with impurities

Durum wheat grains and other non-wheat materials reside on the band in a random order so the grains can touch other grains or the other non-wheat materials. While the morphological operation "erode" can shrink the objects, thus maybe separate them. However, if the objects are touching each other they can still be connected despite the touching area is really small. In such conditions, a watershed algorithm is needed. The watershed transform is a segmentation algorithm that can divide the image into multiple regions where the darker colours represent a region with lower altitude and lighter colours represent a region with higher altitude topologically [13]. Thus, a watershed segmentation algorithm used for properly segment all the objects from each other. To apply watershed transform efficiently for segmentation, the first step is to apply the distance transform which labels each existing pixel according to the distance with the nearest boundary pixel in a binary image [13]. Although the distance transform is successful for segmenting round and simple touching objects, it is not successful for kernels with irregular shapes [13]. The reason why it is not successful to segment kernels with irregular shapes is because large number of local minima occur due to large clusters of objects which causes over-segmentation [14]. So, in our study, we used a watershed segmentation algorithm with extended-minima transform to segment the durum wheat grains where the extended-minima transform can produce markers for objects where local minima with greater depth than h which represents a depth value specified by the user of the algorithm are marked and where local minima with less depth than h are eliminated. By using minima imposition technique, we create minima at the specific locations associated with the markers [14]. After this procedure, watershed segmentation is applied which results in perfect segmentation for touching grains. The edge detected binary sample image after watershed segmentation with extended-minima transform is shown in (Figure 8).

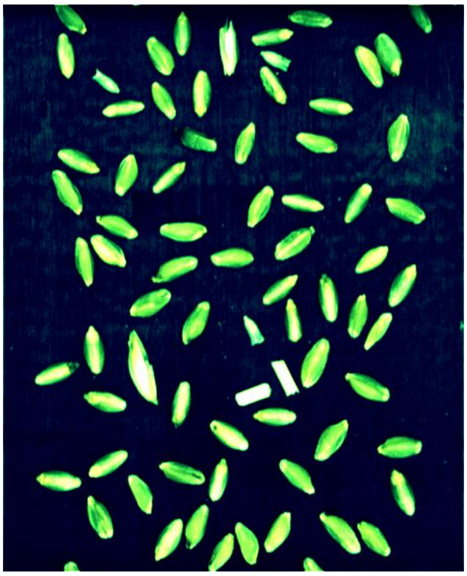

Figure 4. The frame sample of the video with adjusted colormap

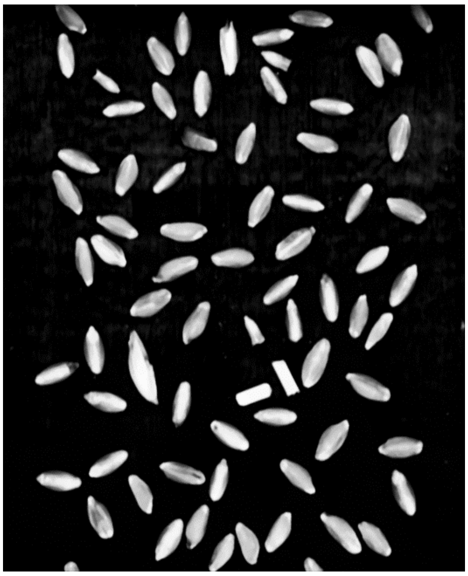

Figure 5. Median filtered image with background subtraction

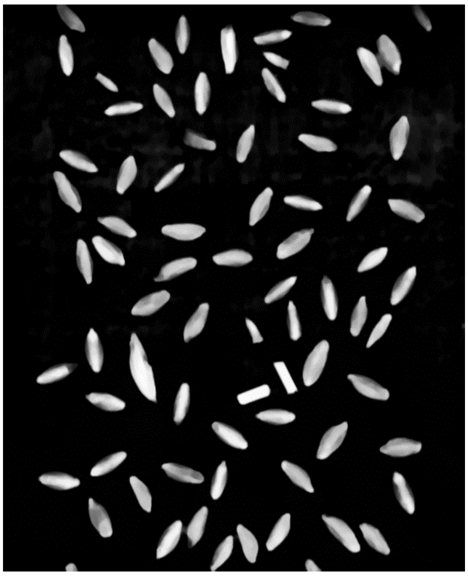

Figure 6. Frame sample after several morphological operations

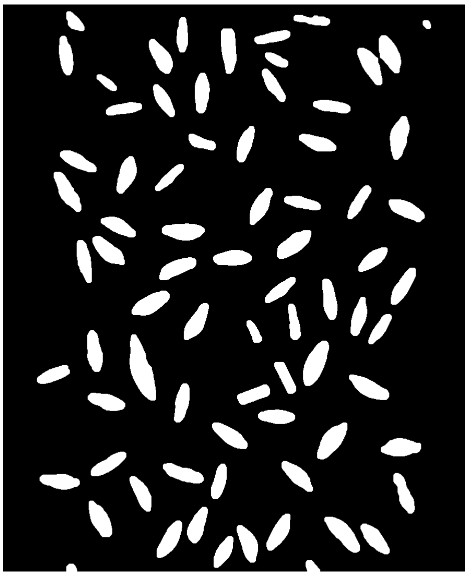

Figure 7. Binary image of the frame sample

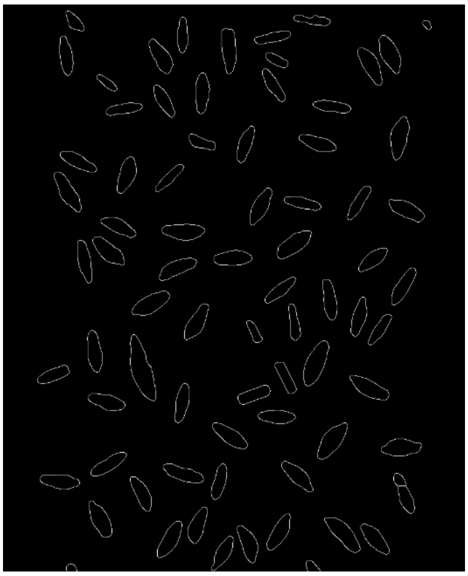

Figure 8. The edge detected binary image of the frame sample after watershed segmentation with local-minima transform

2.3. Feature Extraction

The blob is the region of connected pixels of an object and blob analysis is the method which investigates these regions and provides us the information about the regions' several properties. It is used for feature extraction processes [15]. The blob analysis algorithm distinguishes the pixels according to their values and labels them into 2 categories. The foreground category is generally the pixels with a non-zero value and the other category is the background where the pixels with a zero value belong. Thus, the blob analysis algorithm measures several properties of the object regions in the image [15].
After the segmentation process, blob analysis algorithm is used for the feature extraction process to measure the properties of wheat grain regions. In our study, 9 morphological features are used for the separation of durum wheat grains from impurities. These features which are extracted directly by blob analysis are area, major axis, minor axis, perimeter equivalent diameter, eccentricity. Features which can be calculated from the others are roundness, shape factor, compactness [6]. The features used for this study and their definitions are shown in the Table 1[6, 7, 16].

Table 1. Features used and their definitions

Feature	***Definition***
Area	Number of pixels in the region
Major Axis	The length(in pixels) of the major axis of the ellipse
Minor Axis	The length(in pixels) of the minor axis of the ellipse
Perimeter	The length(in pixels) around the boundary of the region
Equivalent Diameter	The diameter of a circle with the same area as the region
Eccentricity	The ratio of the distance between the foci of the ellipse and its major axis length
Roundness	$4.\text{Area}/\pi(\text{Major Axis})^2$
Shape Factor	$4.\pi.\text{Area}/\text{Perimeter}^2$
Compactness	$\text{Sqrt}(4.\text{Area}/\pi)/\text{Major Axis}$

3. Results and Discussion

After feature extraction, mean and standard deviation values of the properties have been calculated. Durum wheat grains are separated from the impurities by a simple algorithm which uses the calculated results as ranges. The mean and the standard deviation values of the properties is given in Table 2.
The algorithm determines the particles which are accepted as durum wheat grains by comparing the properties of every single object within a range specified using the mean values and standard deviation values of the properties. If all the properties of a single object is within the specified range, then the object is a durum wheat grain. If not, then the object is non-wheat material. The obtained result is 73.52% accuracy for the separation of non-wheat materials from durum wheat grains which is an optimistic result for image processing of a dynamic environment, because it is much more complex than image processing of a single image of a stationary environment. If a more complex and more efficient classification algorithm is used for the separation of durum wheat grains from impurities, than the accuracy result will be improved.

Table 2. Mean and standard deviation values of the features

Features	***Mean***	***Standard Deviation***
Area	151,151	33,585
Major Axis	88,590	17,901
Minor Axis	38,357	7,077
Perimeter	172,485	35,456
Equivalent Diameter	192,451	42,761
Eccentricity	0,892	0,056
Roundness	0,026	0,011
Shape Factor	0,068	0,023
Compactness	0,160	0,027

4. Conclusion

As it is shown in literature, previous studies conducted are not about the purification of wheat from non-wheat materials generally but about classification of wheat varieties. Also, the studies conducted in a dynamic environment are almost non-existing. In this study, the objective has been to obtain good quality type-1252 durum wheat by separating the impurities from wheat grains in a dynamic system using image processing techniques. These processes are image preprocessing for image enhancement, watershed transform with extended-minima transform for segmentation and blob analysis for feature extraction.In this study, after segmentation and feature extraction processes, a simple algorithm is used for the separation of non-wheat materials from durum wheat grains. The reason for using a simple algorithm is because it was a start for dynamic environments which is not the case for many researches in literature. However, the obtained result is not bad for a start. In future studies, we will use different and more efficient classification models to obtain perfect classification results.

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