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THE USE OF MORPHOLOGICAL ANALYSIS IN THE WHEAT QUALITY FEATURE EXTRACTION

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ABSTRACT

In the paper, an attempt towards morphological analysis implementation into grain physical features extraction, with the use of APR software, has been presented. The main objective of the research is to determine the physical characteristics of wheat grains in order to assess the automatic grain quality review. Photographic macro images of wheat grains were taken for the purpose of this study, and then they were processed using the APR application. Properly prepared graphic material has been subjected to segmentation and morphological analysis. Parameters derived from morphological analysis are presented synthetically and form the basis for further research focused on statistical analysis.

Introduction

Grain quality is important for economic reasons and has a direct impact on whether products manufactured from it will have an appropriate quality in terms of both taste and health. From an economic point of view, a reasonable estimate of the grain quality allows correct determination of the price it should be sold for. A grain quality assessment is carried out on the basis of the existing PN-R-74013: 2012 norm in terms of the initial quality control and testing of the organoleptic characteristics of the grain, the PN-R-74015:1994 norm for the determination of contaminants and in accordance with the PN-R-74016:1969 norm for the determination of the content of pests, pollution and grains smut in the sample. Current methods rely on mechanical methods of grains selection. These methods are not only tedious, but in fact they boil down to a series of manual steps and a subjective assessment of the person making the selection. As a result, the process is long, arduous, little repetitive, costly and burdened with the danger of a human error. It is not suitable for mass, continuous verification of grain quality, both during its acquisition from producers and cyclic verification of the quality during storage. Therefore, this is a sufficient evidence to raise the project of automation and objectification of parameters in grain quality evaluation methods. This is an issue of such importance that it has an impact not only on the economic aspect associated with a proper assessment to be adopted for the purchase of grain, but also has a

direct link to health security. During the evaluation of the sample it is important to properly diagnose microbial pest infestation of grain, which can in turn have a negative impact on the health benefits of derived products, e.g. too high toxin content in the final product.

One of the grain parameters group which can be automatically and non-invasively determined is the morphology in terms of a seed shape as well as the morphology of anomalies covering the seed, also in terms of a geometric shape. Due to the assumption regarding a low cost of testing the study will be based on:

– visual analysis of the grain,
– surface test in 2D space,
– color images acquisition.

The following section presents the methodological basis in respect of the acquisition and processing of images. The next section focuses on the analysis of samples taken. It is followed by the section presenting the preliminary results of the application of the morphological analysis on the kernel of wheat image. As a conclusion, the authors presented the aspect in which the suggested method can be used in order to study the physical characteristics of the grain, and to find out what impact can the results have on the grain quality testing.

Methodology

The suggested method is based on the automatic images analysis. Therefore, basic issues related to the research involving graphic images as input information should be considered. The first step is referred to the definition of the research objectives and further selection of methods and tools to support their implementation. In this respect, it has been specified that the set parameters describing grains will be assessed just to be used in evaluation of their quality. The paper focuses on parameters of two kinds. The first group comprises the parameters based on the shape of a grain and any anomalies associated with it. The second group consists of the parameters based on the analysis of the distribution of colors on the surface of the object (grain). It should be noted that there are known studies involving the use of color distribution in a sample, which mainly concerned determination of the share of grains of different cereals in heterogeneous mixtures (Tukiendorf et al., 2006). A more detailed description of parameters and their importance in the proposed method will be presented later in this paper. However, the possibility of parameters reading from the image, rely mainly on proper image acquisition.

Acquisition is a process that involves loading of a digital representation of the object into the computer application. The most common method is based on the use of visible radiation (light) to illuminate the sample, and detecting reflected light by an appropriate sensor. A physical aspect, including the issue of optics and optoelectronics, due to the nature of this article lies outside the area of the authors' interest. However, what is important and worth emphasizing is the need to respect the principles of correct acquisition of digital images, in particular, the proper illumination of the sample. Appropriate means, in this case, the proper selection of light intensity, the angle of light rays incident on the sample and the temperature of the light spectrum. Any errors made at this stage are fateful in terms of the accuracy

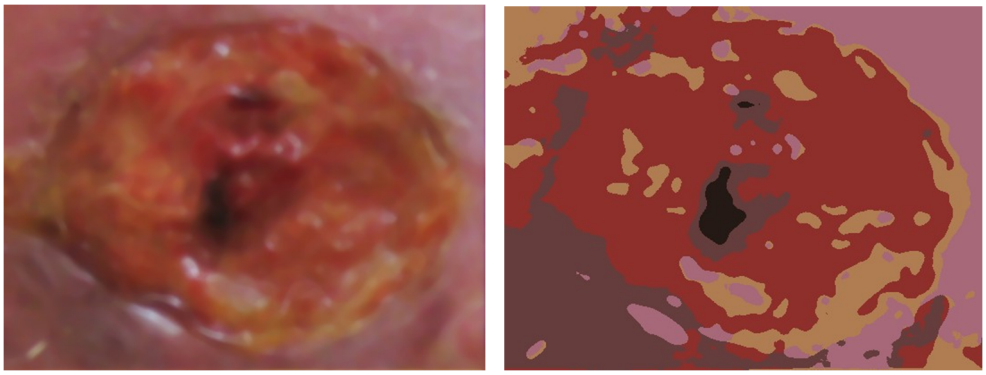
and amount of information that can be extracted from the image. Particular attention should be paid to the repeatability of the measurement, which is crucial for the presented method and an absolute condition for metrological validation of measurements. An attention should also be paid to the optimal usage of the light sensor brightness levels characteristics, so that the resulting picture could be characterized by the highest possible rate for all levels of brightness for achromatic images and RGB intensity levels for chromatic images. It is very important for the illuminated sample not to generate additional artifacts in the form of e.g. shadows or areas of high brightness (blinks) so that the analysis could not distort the image and suggest the existence of additional elements or change the shape of the observed object. In the aspect of shadows, multipoint scattered lighting is suggested with possibly homogeneous distribution of light sources throughout the observation area (Szwedziak and Krótkiewicz, 2006). Emerging local light flashes result from the optical phenomenon consisting of the light reflection from the relatively smooth surface. However, such a surface has to have a degree of curvature at which clear brightening peaks occur associated with the accumulation of light rays on a relatively small area. The other aspects of the acquisition include:

– frequency of image acquisition,
– resolution, the number of pixels corresponding to their actual body size,
– color depth.

After the acquisition, the image requires processing. Image processing is an operation in which both the input and the output are images. The processing can be performed for a variety of reasons. In the described issue one of the first steps is to prepare the image in the way to eliminate any interference (Tadeusiewicz and Korohoda, 1997).These disturbances can have a very wide variety of sources and may be characterized by different features. A description of all potential distortions resulting from imperfect acquisition methods is beyond the scope of this article.

The main task is to separate the object from the background. This operation is called segmentation. Due to the nature of the proposed method, that assumes the use of morphological analysis (Krótkiewicz and Wojtkiewicz, 2009), the image needs to be binarized, i.e. converted from color to a binary one. In addition to the trivial threshold method the applied APR software offers more sophisticated segmentation algorithms implemented, i.e. one based on selection of any number of areas in the image (Fig. 1).

Each area is represented by the specified rectangle in which pixels are averaged within the range of each of the color components. The result is a single pixel value which then is used as the basis for determination of the distance between the pixel color, and all the pixels of the analyzed area. The APR software allows selection of the metrics which is used to calculate the pixel distance. After making this choice the automatic segmentation of the image occurs producing as many areas as reference areas had been assumed. Following the simple segmentation methods available in the APR it is possible to remove all the pixels except for the pixels having a specific component values. Binarization is the next step. An image processed that way becomes an input to the process of morphological analysis (Krótkiewicz and Wojtkiewicz, 2009).



	X	Y	Red	Green	Blue	Pixels	Share
	410	312	176	124	81	217745	46.353 %
	241	238	37	25	22	27013	5.750 %
	207	140	142	47	43	147608	31.422 %
	465	58	167	105	122	36898	7.855 %
	128	382	100	61	60	40490	8.619 %

Figure. 1. An example of multipoint segmentation by the use of APR software with the output chart

Morphological analysis in the study of kernels characteristics

The image analysis should be understood as a set of operations where input is an image, and the result is a set of values of the studied properties. This is an intermediate step between the processing and classification of images. However, it should be emphasized that the entire examination process may end up on the stage of the analysis, which will provide the necessary information about the object to which it is subject. The selection of the features determines the nature of the analysis (Sonka et al., 2014). One type of analysis is the morphological analysis. It concerns the structure and composition of the objects that are in the area of interest.

In respect to the APR application the morphological analysis is performed only for a binary scene and provides a set of attributes that can be divided into two subsets. In the first there are the features that characterize the scene as a whole (Tab. 1).The second subset contains a description property of individual objects, where the object is understood as a coherent area of white pixels (Tab. 2). If the coherent regions are included in each other, i.e. a coherent area is surrounded entirely by a different consistent area, the internal one is understood as an integral part of the external object (Fig. 2). In other words, the object is the pixel area consistent with all areas of coherent pixels located in its interior.

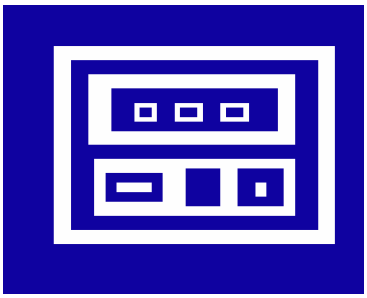


Figure 2. A figure that contains objects within object

Table 1
Features obtained from morphological analysis describing the scene

Number of pixels	The number of pixels on the scene
Width	The width of scene.
Height	The height of scene.
Filled field	Number of pixels that are assigned to objects
Empty field	The sum of pixels building holes in the objects on the scene
Length of external edge	The number of pixels that build external edges of objects
Length of internal edges	The number of pixels that build internal edges of objects
Length of all edges	The sum of two previous attributes
Number of edges	Number of all separable edges
Number of holes	Number of holes that can be designated on the scene
Number of objects	Total number of all objects on the scene

Table 2
Features obtained from morphological analysis describing the object

Object number	The unique number of the object
Filled surface	The number of the pixels filled by the object on the scene.
Empty surface	The number of pixels that describes size of holes in the object
Number of holes	Number of holes (empty spaces) that can be found inside the object
Edge adherent	Number of pixels that are assigned to the edge and at the same time build the frame of the scene
Centre of gravity	Coordinates of the centre of gravity that is computed for the object
Start pixel	Coordinates of the very first pixel found by the function FindNex-tObject
(X1, Y1)	Coordinates of top-left corner of the rectangle circumscribed on the object
(X2, Y2)	Coordinates of down-right corner of the rectangle circumscribed on the object
Length of external edge x	The number of pixels that build external edge of object.
Length of internal edge	The number of pixels that build internal edges of object.
Length of all edges	The sum of two previous attributes.
Number of edges	The number of all edges (external and internal) assigned to the object
Internal edges	The list of internal edges containing length of the edge and coordinates to its start pixel.

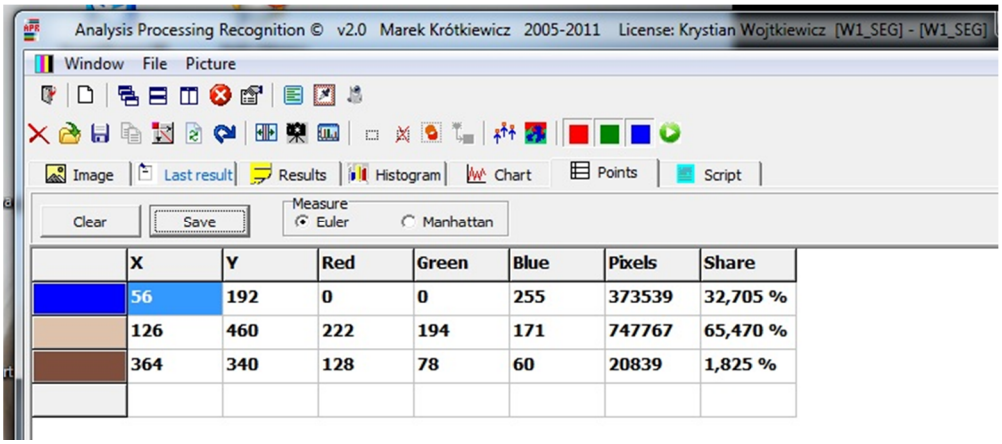
This paper presents an approach to the use of the morphological analysis results performed on the image that has one object, which is the wheat kernel. In order to do that, an image acquisition by means of Nikon D700 camera with Sigma Macro 105mm lens has been performed to give an image of 4288 to 2848 pixels size and 8-bit color depth for each of the three RGB components. The output image has been shown in Figure 3.

Figure 3. Macro image of wheat caryopsis

The obtained image has been subjected to processing by the use of average filter mask of 9x9 pixels size. Then, a median filter was used with the mask equal to the square on the side of 9 pixels. It reduced image noise without introducing significant blurring (Russ and Woods 1995).The next step was to use a multi-level segmentation based on an algorithm which consists in determination of reference pixel blocks, and then calculation of the distance in color space between them and all the pixels in the image. Each of the pixels in the image is assigned to one of the categories (represented by the reference pixel) according to the minimum distance algorithm. The study was performed for both the Euclidean and Manhattan metric. However, the difference in the results obtained from those two metrics is not essential for the analyzed images. The steps of actions are illustrated in fig. 4.

Figure 4. Effects of consequent steps of wheat caryopsis image processing.

Pixels in the scene have been segmented into three classes (Fig. 5). First class represents the background image, the second surface of the grain, and the third the groove. After segmentation, the APR application allows image to be binarized selectively choosing the class of pixels on the basis of their RGB values. As a result of binarization, i.e. transformation of the achromatic image to the binary one, pixels of the selected class are represented by white pixels. At the same time, all the pixels that do not belong to this class, thus are assigned to the other one, take the value of black color.



	X	Y	Red	Green	Blue	Pixels	Share
	56	192	0	0	255	373539	32,705 %
	126	460	222	194	171	747767	65,470 %
	364	340	128	78	60	20839	1,825 %

Figure 5. The table from APR with the statistics of chosen pixel classes.

In the binarized image minor artifacts have been removed successively by the erosion and closing operations. The operation of the so-called erosion is a minimum filter and operates on the basis of the algorithm consisting in replacing all the white pixels to black when they are adjacent to at least one black pixel. This operation is opposite to the dilation operation, which is known as the maximum filter and involves the replacement of all the black pixels to white, as long as they are adjacent to at least one white pixel. The closing operation is based on the sequence of the two operations in a specific order, namely the first dilation operation and then erosion (Tadeusiewicz and Korohoda 1997). As a result of the operations performed relatively, smooth areas, that are the right material for morphological analysis, were obtained (Fig. 6).

Figure 6. Binarized wheat caryopsis image.

The use of binary analysis

The proposed method of analysis assumes the possibility of the grain quality analysis based on the analysis of each grain in the sample independently. Assuming that in the first stage, image processing will be carried out in accordance with the procedure allowing obtaining the optimal input image, the morphological analysis can be carried out in order to determine the parameters of a grain and furrows independently. The following is a sample script that carries out binary analysis procedure in the APR:

```
apr.pathpictures()
apr.imload("ziarno_binar.jpg")
apr.imclearmorfologyinfo()
apr.immorfology()
t = apr.imgetmorfologyinfo(0)
n = t[11]
apr.print("Number of objects: "..t[11])
for i,v in ipairs(t) do
 apr.print("["..i.."] = "..v)
end
for i=1, n do
 t = apr.imgetmorfologyinfo(i)
 apr.print("--- Object number: "..i.." ---")
 for i,v in ipairs(t) do
  apr.print("["..i.."] = "..v)
 end
end
apr.immorfologyinfo()
apr.message("OK")
```

The analysis outputs a set of features describing the scene as well as sets of features describing all detected objects in the scene. The analysis led to the identification of five independent objects, 4 of which were rejected as artifacts due to the very small size (less than 100 pixels). The remaining object has been identified as a kernel whose value characteristics are shown in Table 3.

Table 3
Features obtained from morphological analysis for the object identified as caryopsis

Object number	2
Filled surface	740837
Empty surface	23059
Number of holes	7
Edge adherent	0
Centre of gravity	383.4258, 760.3822
Start pixel	377, 66
(X1, Y1)	29, 66
(X2, Y2)	748, 1463
Length of external edge x	3223
Length of internal edge	2322
Length of all edges	5545
Number of edges	8
Internal edges	90, 1027, 433, 246, 54, 391, 81

The values should be scaled (normalized) to obtain the values in SI units. Standardization issues are extremely interesting as such, but it goes far beyond the scope of this paper and will not be presented in it. This task, however, is only relevant for the calculation of the size and parameters that must be given in real units, i.e. for example the length and width of the kernel. But there are many indicators that are dimensionless, and at the same time allow the assessment of the object. Factors that can be identified in this group are among others: coefficient contour of the object, circuit coefficients, Malinowska factor, Haralicka factor or Danielsson factor.

Conclusion

This paper presents an application of the binary image analysis method to determine the characteristics of the grain. In the study, the wheat caryopsis image has been acquired, which was transformed, and then underwent the morphological analysis. The results obtained allowed stating clearly that this method enables precise determination of the basic parameters of kernels, which can then be used as an input element for the multi-criteria analysis based on the aspect ratio. The authors also pointed out that by the use of the APR software, information on the distribution of colors on the surface of the grain through the use of multi-point segmentation can be easily obtained.

In the future, the authors will focus on conducting a series of experiments in order to obtain statistical material to allow it to draw a hypothesis on the parameters characterizing the grain quality. This applies to both the parameters and the coefficients obtained based on the morphological analysis of the object, as well as the data on color characteristics of the surface of the kernel.

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ZASTOSOWANIE ANALIZY MORFOLOGICZNEJ W BADANIU CECH JAKOŚCIOWYCH ZIARNA

Streszczenie. W artykule opisano próbę zastosowania metody analizy morfologicznej do określenia cech fizycznych ziarniaka pszenicy przy wykorzystaniu aplikacji komputerowej APR. Głównym celem badań jest określenie cech fizycznych ziarniaków pszenicy pozwalających na ocenę jakościową ziarna w procedurze automatycznej. W ramach badań wykonano zdjęcia fotograficzne makro ziarniaków pszenicy, które następnie poddano przetwarzaniu przy użyciu aplikacji APR. Odpowiednio przygotowany materiał graficzny poddany został segmentacji i analizie morfologicznej. Parametry uzyskane z analizy morfologicznej zostały przedstawione w ujęciu syntetycznym i stanowią podstawę dalszych badań na gruncie analizy statystycznej.

Słowa kluczowe: komputerowa analiza obrazu, aplikacja komputerowa APR, analiza morfologiczna ziarno konsumpcyjne, cechy fizyczne ziarna