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Research Article

Application of thresholding algorithms for brown bread porosity evaluation

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Abstract

Bread is one of the most popular foods in Bulgaria. Its quality is regulated by approved standards. This paper presents a computer-based approach for evaluation of bread porosity which is one of the physicochemical parameters of bread quality. The proposed approach includes image processing techniques. A Java program is developed to binarize images of bread and calculate the ratio of white pixels to all (coefficient of diversity). This coefficient corresponds with the physicochemical parameter bread porosity. It is used an open-source plugin Auto_Threshold for image binarization. This plugin implements seventeen different algorithms to find the global threshold value of a grayscale image. Developed program uses also a global thresholding algorithm named HisAnalysis which is not included in Auto_Thresholding plugin. Four brands of brown bread are used by experiments. The results show that global thresholding is appropriate for evaluation of brown bread porosity. Practical applications: The use of image processing accelerates the process of bread porosity evaluation. Presented research proves a practical benefit to apply image processing for evaluation of physicochemical parameter- bread porosity. The results show that seven algorithms which are included in Auto_Threshold plugin and the HisAnalysis algorithm are suitable for brown bread porosity evaluation. The fastest algorithm of among them is the HisAnalysis and it could be used in practice for fast evaluation of the physicochemical parameter bread porosity (in real-time processing).

Keywords: bread porosity, image processing, global thresholding, Auto_Threshold plugin, HisAnalysis

Abbreviations:

GUI - Graphical User Interface; Kdiv - coefficient of diversity; ROI - Region of Interest

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Introduction

Chronic as one of the most important staple nutrition products for Humanity, the bread is widespread food product in many countries in Europe and more precisely in Turkey where the average consumption for 2013 is around 104kg. per capita per year, followed by countries like Bulgaria, where the average consumption is 95kg. per capita per year, Ukraine – 89kg., Greece – 68kg., Italy – 62kg. and others ([AIBI Bread Market Report 2013, 2015; Dumitraşcu 2015](#)). Based on the statistics the trends of bread consumption for those countries are relatively stable ([Eglite and Kunkulberga 2017](#)). On average the European consumer eats around 59kg. bread per year. Although the bread consumption is in stable trends for many European countries it is still important to analyze and improve both bread production technologies and bread quality in order to satisfy consumer preferences and tastes. These factors are in direct dependence on type and quality of the raw materials used for bread production. The main raw materials for bread production are the following - wheat flour, bread yeast, iodized cooking salt, drinking water, technological additives such as sugars, fats and so on ([Approved Standard "BULGARIA" - №04/2011](#)). According to the different types of raw materials used for bread production various types of bread are produced all over the world. Raw materials such as flour, bread yeast, water and different additives can affect either the quality of the bread, its structure and its taste. There are many different types of flour used for bread production, such as whole wheat flour, brown flour, oat flour, corn flour and others. As statistics show, Bulgaria is one of the European countries where most bread is consumed. According to the research made in 2016 it is important to note that Bulgarian children are consuming large quantities of bread and in particular white and Dobrudzha type of bread. Statistics show that 30,2% of Bulgarian students between 6 and 19 years suffer from overweight and this is a result mostly from consumption of harmful food products and the lack of consumption of whole grain bread ([Licheva](#)

[2016](#)). All these facts prompt scientists from whole world to look for different ways to improve either the quality of bread and the technologies for its production. Different scientific researches are made in terms of the additives and the presence of beneficial or harmful substances in bread. In order to obtain high quality of bread produced in the European countries over the last few years, raw materials are used and tested such as oat, composite wheat-sweet potato flour, tomato seed flour, legumes fortified flour, composite flour made from pumpkin seeds and golden flaxseed and various additives ([Flander 2012; Londoño 2014; Codina et al. 2017; González et al. 2014; Hedkvist 2009; Mironeasa et al. 2016; Moldovan 2016; Stefanova 2017](#)). In order to increase the biological value of bread and to overcome the deficiency of mineral substances in human body in many countries, including Bulgaria, breads enrichment with biologically active substances and minerals such as zinc and selenium is applied ([Sauvola et al. 2000](#)). For bread quality improvement, different scientific researches and investigations are made of technological, nutritional and sensorial characteristics of wheat bread influenced by different strains of *Saccharomyces cerevisiae* ([Heitmann 2017](#)). Another scientific research about enhancement of the nutritional value of bakery products is made ([Dumitraşcu 2015](#)). It relied on the use of two sources of nutrients - Jerusalem artichokes (*Helianthus tuberosus L*) tubers and partially defatted hemp (*Cannabis sativa L*) seeds, by-product from the cold pressing production of oil. Researches on bread products are not only relevant to the additives used in the process of bread production. Many scientific researches are made relevant to improve the production technology and to control the quality of bread. In 2009 a scientific worker made a thesis over developing molecular biological methods for gluten-free controlling of bread ([Némedi 2009](#)). Different methods for controlling bread contamination with harmful bacteria and substances are developed and tested.

Previous research on application of two thresholding algorithms for brown bread porosity evaluation are done (Danev, Andreeva, Bosakova-Ardenska, Kostadinova-Georgieva 2016; Danev, Andreeva, Bosakova-Ardenska 2017; Bosakova-Ardenska, Danev, Andreeva, Gogova 2018). The results show that using elliptical ROI (Region of Interest) for thresholding a better correlation with physicochemical porosity is achieved in comparison with processing of rectangular ROI. Computer vision (particularly, image thresholding) is successfully used for bread dough quality evaluation by count and distribution of pores (Wang 2015). The aim of the current research is to evaluate application of computer vision (most of known thresholding algorithms) in evaluation the porosity as a physicochemical parameter of bread's quality.

Materials and Methods

Materials

Four different brands of brown bread are bought from the marketplace. The brands of bread are: "Castello", "Lozana", "Trakiiski Fines" and "Trakiiski". The breads "Castello", "Lozana", "Trakiiski Fines" have weight 650g. and only bread "Trakiiski" has weight 500g. According to the information given by the producer all breads contain: wheat flour type 1150, water, salt, yeast, additives (ascorbic acid, enzymes i.e.). For evaluation of bread's porosity two methods are used- physicochemical one (according to BDS 3412-79) and computer based one (using images processing).

Experimental setting. For determining the porosity of the brown bread through image processing twenty images are taken– ten slices from the middle of each bread are captured, each one from both sides. Several elements build up the experimental setting: digital camera - OLIMPUS PEN mini E-PM1; the analyzed slice of bread; a pad with black color (it is used for unification the background color of the image); a tripod for locking the camera in a stable position.

Thresholding algorithms. In terms of digital image processing thresholding is a simple but effective

technique to separate objects placed in the foreground from the background of an image. In most cases, thresholding techniques operate with grayscale images where the gray level values of the pixels belonging to the foreground objects are considerably or slightly different from the gray level values of the pixels in the background. There are many different types of thresholding applications such as: map processing, document image analysis, image processing in terms of quality inspection of materials, scene processing, segmentation of various image features for nondestructive testing, ultrasonic images evaluation, biomedical image analysis, food inspection and others (Oh 1999; Sezgin et al. 2004 Srikanthan et al. 2001; Nikolova et al. 2008). There are two main groups of thresholding algorithms– local and global ones (Sezgin et al. 2004). The algorithms in the group of local thresholding have a threshold value that can be changed smoothly through the entire image and the original grayscale image is divided into regions and a threshold value is calculated locally for each of these regions. The group of local thresholding algorithms contains several well-known algorithms such as: Mean thresholding method (Mean) (Gonzales and Woods 1992; Jain 1986); Sauvola algorithm for adaptive document image binarization (Sauvola 2000) (Sauvola); Bernsen's algorithm for locally adaptive binarization (Sezgin et al. 2004) (Bernsen); Median and MidGray methods for thresholding (Gonzales and Woods 1992; Jain 1986); Niblack's method (Niblack 1986; Rais et al. 2004) and others. Global thresholding algorithms use global thresholding value. In this group are the algorithms such as: thresholding algorithm based on histogram analysis named HisAnalysis (Bosakova-Ardenska et al. 2018), Otsu's approach (Otsu 1979), Tsai moment-preserving algorithm (Tsai 1985) (Moments), Kittler and Illingworth's algorithm for minimum error thresholding (Kittler et al. 1986) (MinError), Mean thresholding method (Glasbey 1993) (Mean), Kapur et al.'s method for gray-level thresholding using the entropy of the histogram (Kapur et al. 1985) (MaxEntropy), Ridler and Calvard's algorithm for thresholding using an iterative selection method (Ridler et al. 1978) (IsoData), Huang's method (Huang et al. 1995) (Huang), Li and Tam's method for minimum

cross entropy thresholding (Li et al. 1998; Sezgin et al. 2004) (Li). Based on a taxonomy developed in 2004 by Sezgin and Sankur (Sezgin et al. 2004) all of the algorithms mentioned above can be organized in six categories (described below) according to the information used by thresholding methods for processing the images:

1) Histogram shape-based thresholding algorithms. The methods used by the algorithms in this group achieve thresholding based on the shape of the histogram. They are characterized by analyzing the peaks, valleys and curvatures of the smoothed histogram. Some of these algorithms are based on analyzing the concavities of the histogram. Such algorithms are named convex hull algorithms. Other thresholding algorithms are based on analyzing explicitly peaks and valleys or implicitly the overlapping peaks. These algorithms are called peak-and-valley thresholding algorithms.

One representative algorithm of this group is the so called HisAnalysis thresholding algorithm. It is based on histogram analysis. For determining the threshold value a heuristic approach is used based on experimental founding that the optimal threshold value is close or equal to the gray level value which has the biggest amount of pixels in the histogram data. The algorithm can be described in three steps:

- building a histogram of grayscale image;
- finding gray level value which has the biggest amount of pixels, i.e. Color_Max;
- set threshold value to be equal to Color_Max.

2) Clustering-based thresholding algorithms. In this group of algorithms a clustering analysis of the gray-level data is performed and the clusters are always two. Riddler's thresholding algorithm is a representative of this group of clustering-based algorithms. The threshold function used by this algorithm is:

$$T_{opt} = \lim_{n \rightarrow \infty} \frac{m_f(T_n) + m_b(T_n)}{2} \quad (1)$$

$$\text{where} \quad m_f(T_n) = \sum_{g=0}^{T_n} gp(g) \quad (2)$$

$$\text{and} \quad m_b(T_n) = \sum_{g=T_n+1}^G gp(g) \quad (3)$$

Otsu's thresholding algorithm is another representative of this group of algorithms. His thresholding function is:

$$T_{opt}(T) = \arg \max \left\{ \frac{P(T)[1-P(T)][m_f(T) - m_b(T)]^2}{P(T)\sigma_f^2(T) + [1-P(T)\sigma_b^2(T)]} \right\} \quad (4)$$

Another example of this group of thresholding algorithms is Kittler's method for thresholding. In contrast to the other algorithm falling within this group (Lloyd), Kittler's algorithm removes the equal variance assumption and, in brief, addresses a minimum-error Gaussian density-fitting problem (Sezgin et al. 2004). Kittler's thresholding function can be calculated as follows:

$$T_{opt} = \arg \min \{ P(T) \log \delta_f(T) + [1-P(T)] \log \delta_b(T) - P(T) \log P(T) - [1-P(T)] \log [1-P(T)] \}, \text{ where} \quad (5)$$

$\delta_f(T)$, $\delta_b(T)$ are foreground and background standard deviation.

3) Entropy-based thresholding algorithms. In this class the thresholding algorithms exploit the entropy of the distribution of the gray levels in a particular scene. Several algorithms are representatives of this class – Kapur (Kapur et al. 1985) where the thresholding function is as follows:

$$T_{opt} = \arg \max [H_f(T) + H_b(T)] \quad (6)$$

$$\text{where} \quad H_f(T) = - \sum_{g=0}^T \frac{p(g)}{P(T)} \log \frac{p(g)}{P(T)}, \quad (7)$$

$$H_b(T) = - \sum_{g=T+1}^G \frac{p(g)}{P(T)} \log \frac{p(g)}{P(T)} \quad (8)$$

Yen (Yen et al. 1995), which thresholding function can be calculated as follows:

$$T_{opt}(T) = \arg \max \{ C_b(T) - C_f(T) \} \quad (9)$$

where

$$H_f(T) = - \sum_{g=0}^T \frac{P(g)}{P(T)} \log [\mu_f(g)] \quad (10)$$

and

$$H_b(T) = - \sum_{g=T+1}^G \frac{P(g)}{1-P(T)} \log [\mu_b(g)] \quad (11)$$

Li (Li et al. 1998) where the threshold function is:

$$T_{opt} = \arg \min \left[\sum_{g=0}^T gp(g) \log \frac{g}{m_f(T)} + \sum_{g=T+1}^G gp(g) \log \frac{g}{m_b(T)} \right] \quad (12)$$

where

$$\sum_{g \leq T} g = \sum_{g \leq T} m_f(T) \quad \text{and} \quad \sum_{g \geq T} g = \sum_{g \geq T} m_b(T) \quad (13) \quad (14)$$

and Shanbag (Shanbhag 1994) whose threshold function look as follows:

$$T_{opt} = \arg \min \{ |H_f(T) - H_b(T)| \} \quad (15)$$

where

$$H_f(T) = - \sum_{g=0}^T \frac{P(g)}{P(T)} \log[\mu_f(g)] \quad (16)$$

$$H_b(T) = - \sum_{g=T+1}^G \frac{P(g)}{1-P(T)} \log[\mu_b(g)] \quad (17)$$

4) Object attribute-based thresholding algorithms. The algorithms from this group select the threshold value depending on some object attribute quality or using similarity measure between the original image and the binarized version of the image. As an example of thresholding algorithms assigned to this class of algorithms are moment preserving thresholding algorithm such as Tsai and fuzzy similarity thresholding algorithm such as Huang (Tsai 1985; Huang 1995; Sezgin et al. 2004).

5) Spatial thresholding algorithms. The algorithms from this class use both gray value distribution and dependency of pixels in a neighborhood, as an example, in the form of correlation functions, context probabilities, 2-D entropy, local linear dependence models of pixels and others.

6) Locally adaptive thresholding algorithms. In the group of locally adaptive thresholding algorithms are Niblack (Niblack 1986), Sauvola (Sauvola et al. 2000), Bernsen (Eyupoglu 2016), Oh (Oh et al. 1999) and others. In this group of algorithms, the threshold value is calculated for each pixel, which depends on some local statistics like range,

variance, or surface-fitting parameters of the pixel neighborhood. Niblack and Sauvola use the local variance, while Bernsen and Huang use the local contrast. These type of algorithms are time expensive because the number of threshold values is approximately equal to the number of all pixels in the image.

Software for bread porosity evaluation by image analysis. A Java application is developed in order to evaluate bread porosity by image analysis. The GUI (Graphical User Interface) of developed application is presented in Figure 1.

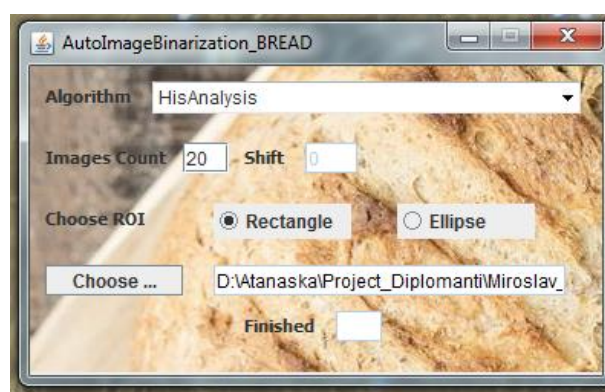


Figure 1. The main window of the application – AIB_BREAD_SETTINGS

The main window of the application (AIB_BREAD_SETTINGS) is designed for initial settings of image processing. The user should choose:

- number of images for processing;
- algorithm for processing (one of 18 algorithms for binarization);
- type of ROI (Region of Interest): rectangular or elliptical;
- directory which contains images with specific ROI

The used algorithms are thresholding algorithms for grayscale images and because of this every image is converted to grayscale before processing. Seventeen of them are implemented in Auto_Threshold plugin for ImageJ (Landini and Rueden 2017) and only

one- HisAnalysis (Bosakova-Ardenska et al. 2018) is implemented in the developed software.

The results of processing are displayed on AIB_BREAD_RESULTS (Fig. 2).

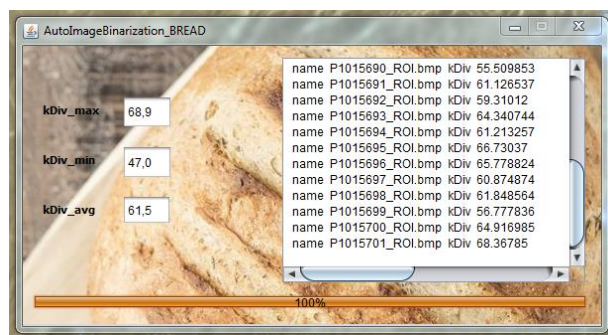


Figure 2. The results window of the application – AIB_BREAD_RESULTS

This window presents:

- a list with coefficient of diversity for every processed image (ratio of white pixels to all pixels in ROI);
- minimal, maximal and average values of coefficient of diversity (Kdiv) for processed images of bread.

Processed images are saved in special directory which is sub-directory of selected directory with input images. When rectangular ROI is selected then the result of processing is a binary image (which contains only two colors- black and white). When the ROI is elliptical then the resulting image has color background (magenta) and binary ROI. The example of original and processed images with rectangular and elliptical ROIs is presented on Figure 3.

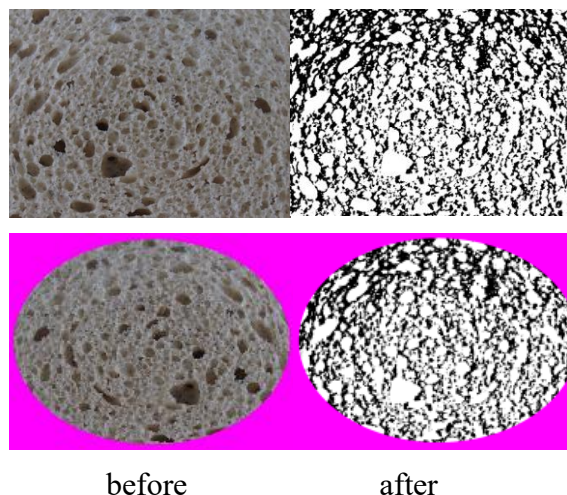


Figure 3. Rectangular and elliptical ROIs before and after processing with HisAnalysis algorithm

Results and Discussion

Bread porosity analysis by physicochemical method In order to verify accuracy of bread porosity evaluation by image analysis, a physicochemical evaluation by standard BDS 3412-79 is made too. According to the standard the procedure for physicochemical evaluation of bread porosity is made up of the following steps: taking samples from the middle of the bread; calculating the volume of the samples; compressing each of the samples manually to remove the pores (the compressed samples must have shape of a ball); measuring the weight of the taken samples; calculating the relative density of the bread by the formula: $RD = \frac{M}{V_1}$,

where RD – relative density of bread, M – weight of samples and V_1 - volume of compressed parts of samples; calculating the porosity (noted with X) of the bread's middle by the formula:

$$X = \left[\frac{V - \frac{M}{RD}}{V} \cdot 100 \right] \quad (18)$$

Physicochemical evaluation of bread porosity is done after slice's capturing. All of the tested brands of bread satisfy Approved Standard "BULGARIA"

for brown bread (i.e. their porosity is more than 65%). In Table 1 are presented results of physicochemical analysis.

Table 1. Bread porosity by physicochemical method

	Lozana	Trakiiski	Castello	Trakiiski Fines
Porosity, [%]	87.59	78.59	84.57	84.41

Bread porosity analysis by image processing. The developed software is used to process 20 images taken from four different brands of bread. A parameter called coefficient of diversity (*Kdiv*) is calculated by a formula:

$$Kdiv = \frac{C_{white}}{C_{all}} \cdot 100, \quad (19)$$

where C_{white} is the amount of white pixels in the binary image and C_{all} is the amount of all pixels in the ROI image. When *Kdiv* is calculated then the real porosity of the bread can be calculated by the formula:

$$P = \frac{\sum_{i=1}^{NP} Kdiv_i}{NP} + C, \quad (20)$$

where *P* is the porosity; *NP* – number of pictures; *C* – is a constant.

In Table 2 are presented average *Kdiv* of tested bread for all 18 thresholding algorithms. In order to evaluate results of images processing a correlation analysis is made too (Table 3). The results show that 9 algorithms could be useful for practical application when processed images have rectangular ROI (their correlation coefficient with physicochemical method is above abs(0.7) which is indicator about their significant relation) and 11 algorithms when the ROI is elliptical. An experimental evaluation of performance is done for selected algorithms with practical potential. The evaluation is made over a single image (it is randomly chosen and it is used for all measurements). A computer system with Intel(R)

Celeron(R) CPU E3300 @ 2,50GHz, RAM DDR2 3 Gbytes and JDK 1.8 installed is used for performance analysis. The results are presented in Tables 4 and 5. Measured time is performance time only for threshold finding (without time for histogram building). It is obvious that the slowest algorithm is Shanbhag because of its complex fuzzy logic and the fastest algorithm is HisAnalysis because of its simple heuristic approach.

Conclusions

Porosity, as one of the physicochemical parameters of brown bread quality, is tested for possible examination by image processing. Four brands of brown bread that are popular on the Bulgarian market are used for the experiments. The results show that:

- Seven algorithms which are included in Auto_Threshold plugin (Default, IsoData, Li, Mean, Moments, Otsu and Shanbhag) and HisAnalysis have good correlation with physicochemical porosity for both type of ROI (rectangular and elliptical).
- Shanbhag's thresholding algorithm achieved significant correlation with physicochemical porosity but it is very slow (average 3,84ms are needed for processing an image sized 1294x867 pixels).
- The thresholding algorithm HisAnalysis has good correlation with physicochemical porosity and it is appropriate for real-time tasks because of its good performance (average 0,003ms are needed for processing an image sized 1294x867 pixels).

Table 2. Average Kdiv [%] for tested bread and for two type of ROI

	Rectangular ROI				Elliptical ROI			
	Lozana	Trakiiski	Castello	Trakiiski Fines	Lozana	Trakiiski	Castello	Trakiiski Fines
Default	30,99	24,98	28,92	32,20	31,34	24,33	28,51	32,53
Huang	41,34	40,29	40,10	39,08	41,69	40,01	40,12	39,14
Huang2	42,14	40,95	39,82	39,17	41,83	39,86	40,38	39,66
Intermodes	40,10	10,51	10,58	9,33	20,82	3,50	11,40	17,87
IsoData	31,12	24,99	28,97	32,48	31,66	24,88	28,70	32,65
Li	30,73	27,06	30,35	31,09	31,28	26,09	29,94	31,22
MaxEntropy	7,11	5,14	6,13	12,04	8,17	5,54	6,80	13,20
Mean	43,18	42,19	42,96	42,76	43,04	41,91	42,50	42,83
MinError	64,36	58,94	60,16	44,70	61,20	60,63	59,71	45,00
Minimum	35,80	8,43	8,07	4,13	15,83	0,47	5,23	12,34
Moments	31,14	26,75	29,86	33,68	32,15	26,51	29,52	33,84
Otsu	32,56	27,66	31,03	33,46	33,16	26,77	30,51	33,49
Percentile	49,85	50,06	49,90	49,95	50,00	49,99	50,04	49,97
RenyiEntropy	9,03	5,45	6,73	13,93	8,68	5,65	7,53	14,09
Shanbhag	34,79	31,87	33,67	33,77	34,97	30,71	33,03	33,59
Triangle	5,73	5,88	5,89	6,92	5,44	6,29	6,43	6,54
Yen	8,98	5,39	6,77	14,31	8,28	5,59	7,65	14,34
HisAnalysis	62,45	63,94	61,48	63,00	62,09	65,39	62,53	65,22

Table 3. Correlation analysis – Coefficients of correlation of physicochemical method versus Kdiv for rectangular and for elliptical ROI

Thresholding algorithm \ Correlation coefficient	rectangular ROI	elliptical ROI
Default	0.85	0.85
Huang	0.23	0.49
Huang2	0.17	0.70
Intermodes	0.66	0.93
IsoData	0.84	0.85
Li	0.91	0.94
MaxEntropy	0.36	0.42
Mean	0.98	0.96
MinError	0.13	-0.09
Minimum	0.61	0.89
Moments	0.72	0.78
Otsu	0.86	0.89
Percentile	-0.98	0.24
RenyiEntropy	0.47	0.45
Shanbhag	0.99	0.98
Triangle	0.01	-0.53
Yen	0.46	0.41
HisAnalysis	0.70	-0.76

Table 4. Time for processing one image with rectangular ROI by specific algorithm, [ms]

	Default	IsoData	Li	Mean	Moments	Otsu	Percentile	Shanbhag	HisAnalysis
1	0,098715	0,107317	0,008192	0,043828	0,040551	0,013927	0,127797	3,863	0,004096
2	0,145001	0,111003	0,009421	0,031949	0,04137	0,01106	0,126978	3,949017	0,004096
3	0,09462	0,150325	0,007373	0,03072	0,045876	0,013517	0,130664	3,809341	0,005325
4	0,095848	0,105679	0,009831	0,030311	0,039732	0,011059	0,128617	3,855627	0,002048
5	0,0938	0,106907	0,009421	0,030721	0,089294	0,014746	0,128206	3,807703	0,001639
6	0,097896	0,107727	0,009421	0,063489	0,044648	0,010649	0,12452	3,899045	0,005325
7	0,0938	0,103631	0,007373	0,04178	0,038093	0,013107	0,125339	3,806884	0,006963
8	0,095848	0,10445	0,00983	0,036455	0,043828	0,011879	0,125749	3,806884	0,001638
9	0,095848	0,108955	0,006963	0,049972	0,046695	0,015156	0,127388	3,804426	0,001639
10	0,101173	0,106088	0,01024	0,028673	0,039732	0,01024	0,125339	3,835556	0,002458
AVG	0,101255	0,111208	0,008807	0,03879	0,046982	0,012534	0,12706	3,843748	0,003523
MIN	0,0938	0,103631	0,006963	0,028673	0,038093	0,01024	0,12452	3,804426	0,001638
MAX	0,145001	0,150325	0,01024	0,063489	0,089294	0,015156	0,130664	3,949017	0,006963

Table 5. Time for processing one image with elliptical ROI by specific algorithm, [ms]

	Default	Huang2	Intermodes	IsoData	Li	Mean	Minimum	Moments	Otsu	Shanbhag	HisAnalysis
1	0,097485	0,330139	0,020071	0,106496	0,01024	0,006144	0,021299	0,040551	0,014745	3,812573	0,004915
2	0,096666	0,284263	0,02007	0,105677	0,010649	0,007782	0,0213	0,04137	0,013927	3,876471	0,004096
3	0,101172	0,286721	0,038503	0,106087	0,01024	0,006554	0,049562	0,04096	0,014745	3,810934	0,005325
4	0,099943	0,303105	0,019252	0,108954	0,009421	0,006554	0,024167	0,046285	0,013516	3,818307	0,005325
5	0,098714	0,284673	0,019661	0,108954	0,00983	0,007373	0,022118	0,043008	0,013517	3,812163	0,004915
6	0,096666	0,290408	0,021299	0,106497	0,012288	0,006963	0,021709	0,047924	0,015565	3,81544	0,004096
7	0,097485	0,283444	0,019661	0,106906	0,010649	0,007373	0,021299	0,045466	0,014336	3,88753	0,006554
8	0,099533	0,290817	0,019661	0,106087	0,01106	0,006144	0,063488	0,04178	0,014336	3,837149	0,004506
9	0,096666	0,291637	0,019661	0,106496	0,01024	0,006554	0,02048	0,042189	0,014337	3,813802	0,004096
10	0,096666	0,285083	0,020071	0,106496	0,012288	0,008192	0,021299	0,04096	0,013108	3,912515	0,005734
AVG	0,0981	0,293029	0,021791	0,106865	0,010691	0,006963	0,028672	0,043049	0,014213	3,839688	0,004956
MIN	0,096666	0,283444	0,019252	0,105677	0,009421	0,006144	0,02048	0,040551	0,013108	3,810934	0,004096
MAX	0,101172	0,330139	0,038503	0,108954	0,012288	0,008192	0,063488	0,047924	0,015565	3,912515	0,006554

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