Model of Software System for automatic corn kernels Fusarium (spp.) disease diagnostics

TSVETELINA DRAGANOVA, PLAMEN DASKALOV, RUSIN TSONEV
Department of "Automatics, information and control engineering"
University of Rousse
8 Studentska Str., 7017 Rousse, BULGARIA
cgeorgieva@uni-ruse.bg   http://www.uni-ruse.bg/faculties/ef/automation/site/index_en.htm

Abstract: An information model of software system for automatic corn kernels Fusarium (Spp.) disease diagnostics, based on digital images analysis is presented in the paper. The model combines image processing methods, statistical approaches for colour and texture features usefulness, classifiers based on probabilistic neural networks (PNN) and Fuzzy logic rules. The model was tested with three kind corn kernels: corn seeds lines XM 87, 26A and hybrid Kneja 613, certificated from Institute of corn in Kneja, Bulgaria. The best classification accuracy of 98% is achieved by using the classifier based on PNN in combination of color and texture image analysis of corn kernel.
A software system is developed in a form of Graphical user interface, based on the presented model, using MATLAB@7.1 GUIDE Template editor and systems functions.

Key-Words: Corn Kernels, Fusarium (Spp.) disease, Colour image and texture analysis

1 Introduction

Contemporary agriculture is characterized by extremely increasing complexity of farming systems and transition to precision agriculture in which are combined as one whole agricultural, information, computer and communication technologies together with new approaches, methods of organization and production management. Precision agriculture uses geographic information systems, global positioning systems and specialized microprocessor systems for collecting, storing, visualizing and analyzing large amounts of data, build databases and expert systems, which are implemented by new management approaches and strategies for sustainable development of modern farms for agricultural production. These characteristics of modern agriculture and interrelated areas justify the construction of new software tools to characterize agricultural production.

Maize is one of the main cereals in the world. Quality of maize seeds is determined by a number of quality indicators, regulated in Bulgarian Standards [1]. One of the main quality indicators is *Fusarium disease (spp.)* - the most economically significant and toxic for both people and animals. For Bulgarian conditions the most important variety is *Fusarium Verticiloide*. According to Bulgarian Standards [2] in our country disease diagnose is carried by three methods: macroscopic, centrifugation and biological (Fig. 1c), allowing up to 3% infected seeds in a sample. The most often applied method for detection of the disease is the macroscopic method. It is based on examination of sample seed by an expert eye using magnifying glass or microscope.
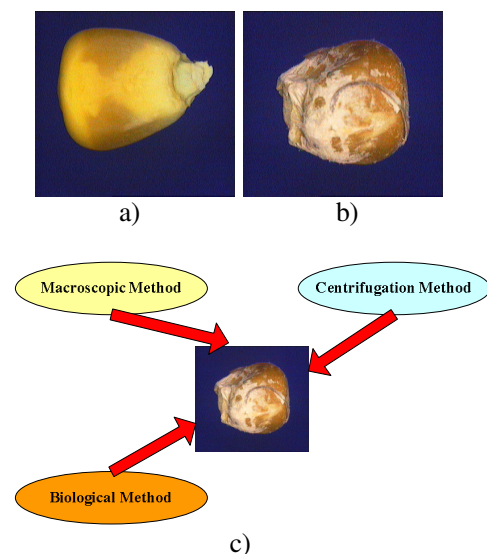

Fig. 1. Digital images of maize seed: a) healthy b) infected by *Fusarium Verticiloide* and c) methods for detection of Fusarium

This method is objective and requires large processing time of seeds samples treatment. Recognition accuracy of diseased seeds depends on the expert's routine. Fusarium disease is recognized mainly by external features - color coating and the surface of the seed. Methods based on analysis of digital images are very close to human vision and often used to assess the

external quality features on a wide products variety [9].

New software tool for automation of processing, analysis and identification of Fusarium disease in maize seeds was developed in MATLAB. MATLAB [8] allows the creation of a Windows - based window applications, which use different means of handling 2D and 3D objects. Together with them MATLAB offers a large set of components used in the design of graphical user interfaces. It has high computing power and is suitable for operations with matrices. Advantage of the programming environment is the possibility to create standalone applications, which launching does not require MATLAB.

The purpose of this article is to develop an information system model and to describe a software tool, based on this model, for automatic identification of Fusarium disease in maize seeds.

2 Materials and methods

2.1 Information model for automatic identification of Fusarium disease in maize seeds

Methods which use analysis of digital images are based on object information obtained as an image. From receiving of information to the final assessment of seeds' kind - healthy or infected, are executed several procedures described below.

Digital images of maize seeds were acquired by computer system [3], consisting of a color video camera, personal computer and a special videoblaster for receiving signals from the camera. Each image (Fig. 2) is characterized by a certain quantitative characteristics. It is a combination of a number of constituent rectangles of pixels that form the image matrix. Color images with 352 lines and 289 columns of pixels are used for the disease study,i.e approximately 102,000 pixels form an image of a corn seed. Components R, G and B could be used as color features in the recognition process. The variety of existing color models RGB, Lab, HSV, XYZ, etc.., that a digital image can be described with, requires the use of additional color models together with the basic one. The transition from one color model to another (Fig. 3) is performed by linear or nonlinear transformations [7]. This requires calculation of values of the model components for each pixel of the image. Reduction of the time for the mathematical calculations can be obtained through prior "removal" of pixels of the background image. Thus only the pixels belonging to the

seed image area, which are representing about ½ of the total number of pixels, are processed.

Texture features were used to determine the condition of the maize seed surface. The most often used methods for extracting the texture attributes are classical statistical Haralik matrix and wavelet transforms with Haar functions [6].
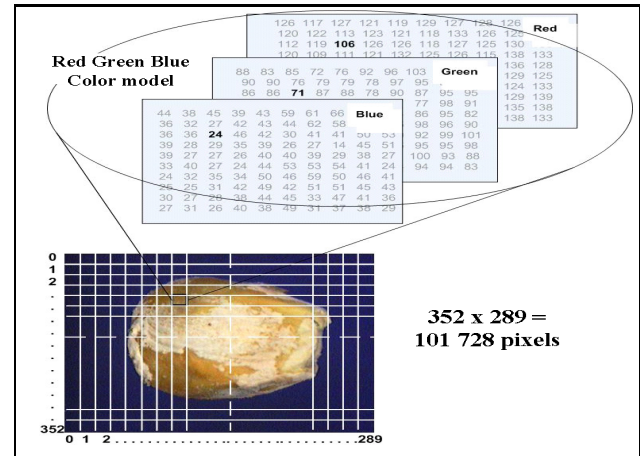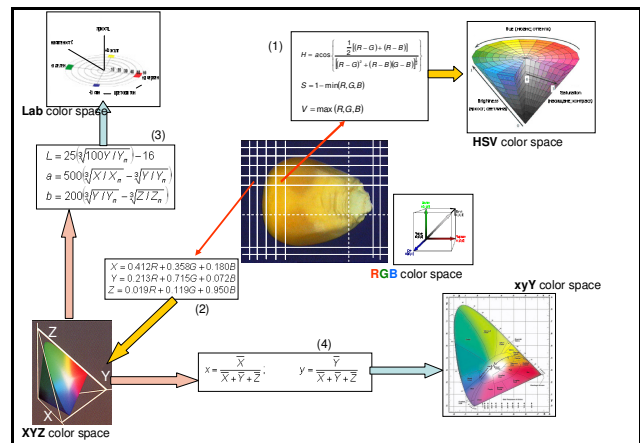

Fig. 2. Color maize seed

Fig. 3. Color digital image of maize seed produced by the computer vision system and transformations in color models

Appropriate classifier is necessary to determine the infected area of maize seed. The approaches used in industry as benchmarks and models of flat objects do not show satisfactory results in the classification, diagnosis and control of agricultural production. Therefore, self-learning techniques and approaches such as probabilistic neural networks (PNN) and Fuzzy Logic are more suitable to be used in similar studies. Creating and configuring classifiers with different informative signs is also a demanding task. The receiving of the final grade for the type of seed is related to the definition of criteria based on the outcome of the used classifier. They are

often logical conditions which classify the seed to one of the two types.

Fusarium disease recognition requires the preparation of reference images, seeds of "training" sample, to obtain representative limits signs of healthy and infected seeds. Then the same mathematical calculations are applied to the matrix of images of seeds from the control sample to determine the percentage of infected seeds. All these procedures are associated with more time for information processing, batch operations and the need for automation process.

Procedures described here are basic steps in the identification of Fusarium disease in maize seeds by analyzing digital images. They could be incorporated into an information modeling software system for automatic identification of Fusarium disease in maize seeds (FDMaize). Fundamental data blocks forming the model are presented in Fig. 4.
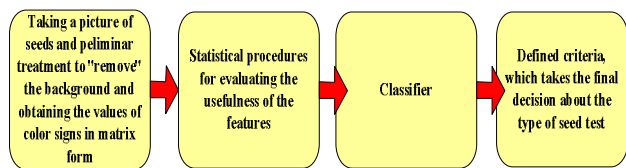

Fig. 4. Functional diagram of an information model FDMaize

The procedures included in the individual building blocks are presented in details in Fig. 5. Block 1 includes procedures for taking a picture of seed, preliminary treatment to "remove" the background and obtaining the values of color signs in matrix form [4]. In block 2 are set statistical procedures for evaluating the usefulness of the features [5]. Creating and setting the parameters of the classifiers are implemented with block 3 [5]. In block 4 are set defined criteria, according to which the final decision about the type of seed test is taken [5]. According to the defined information model the following demands are placed on the programming environment, into which will be implemented: possibility for image processing, possibility for serial and parallel execution of many computing operations, possibility for building modules that can be modified or complemented; possibility for the above described functions, to visualize graphically the results obtained, allowing the operator to ask the necessary data for identification of disease through dialogs.

Comprised information model is applied to the identification of Fusarium disease in maize seeds from three species - inbred lines 26a and XM 87, and a hybrid Knezha 613. Achieved accuracy of identification is presented in Table. 1.

Table 1   Achieved accuracy of identification

Corn variety	% healthy seeds correct recognition		% diseased seeds correct recognition	
	PNN classifier	Fuzzy logic classifier	PNN classifier	Fuzzy logic classifier
XM 87	100	100	98,00	94,00
26A	98,57	98,57	97,14	95,71
Kn - 613	85.00	80,00	90,00	90,00

Comprised information model requires a programming tool to be built from individual modules that can be adjusted, to allow the user to set the necessary data using dialogs, to perform appropriate operations and calculation and to display the received data in an appropriate manner. A software system for automatic identification of Fusarium disease in maize seeds (FDMaize), which includes six main modules (Fig. 6), is presented.
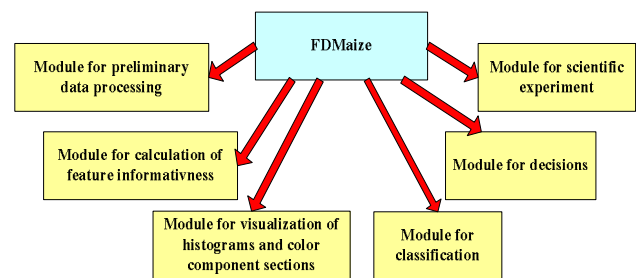

Fig. 6. Structure of the integrated tool modules FDMaize

For modules programming implementation are used system functions and tools of the editor GUIDE Templates. One of the main modules, implemented as self-use graphical (GUI) cmodel (Fig. 7), is the module for visualization of sections and histograms of color components. For the convenience of the user a command line is used - 1, including main menus and submenus, dialog boxes – 2, together with preview field – 3, fields for entering values - 4 and information fields - 5 and 6.
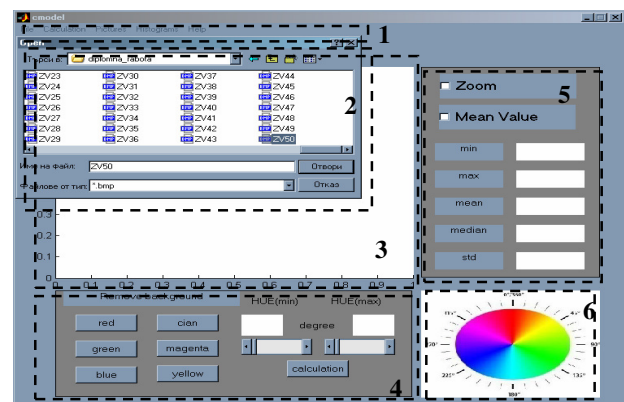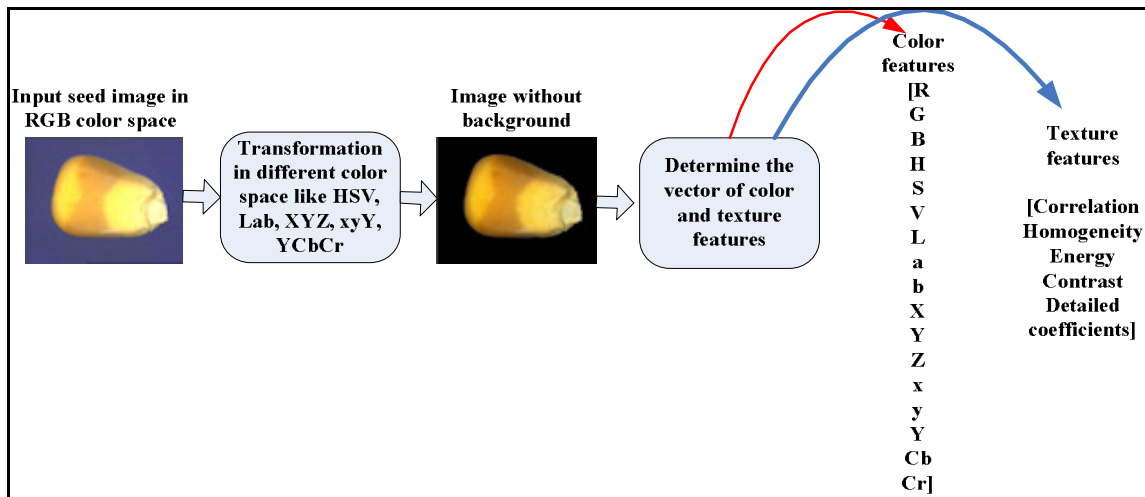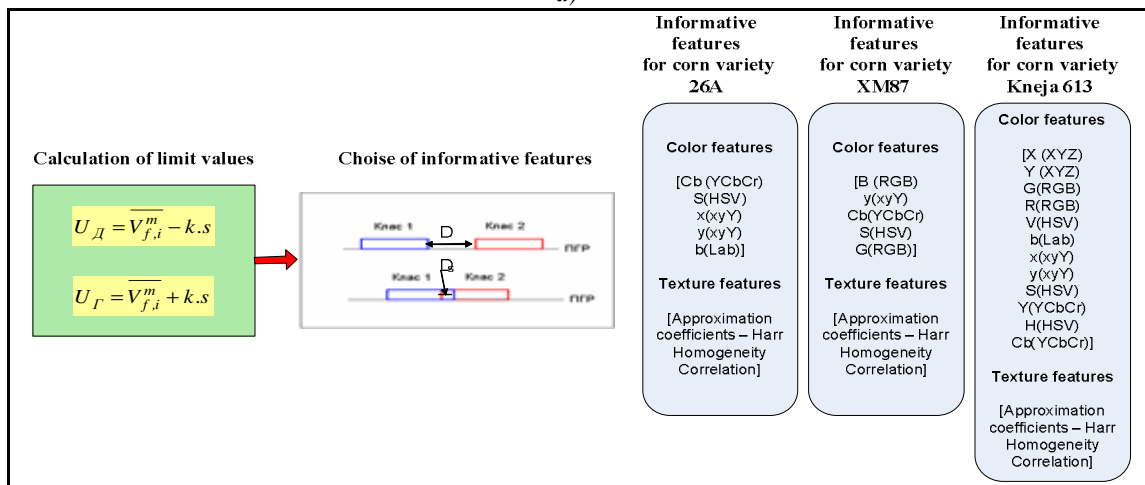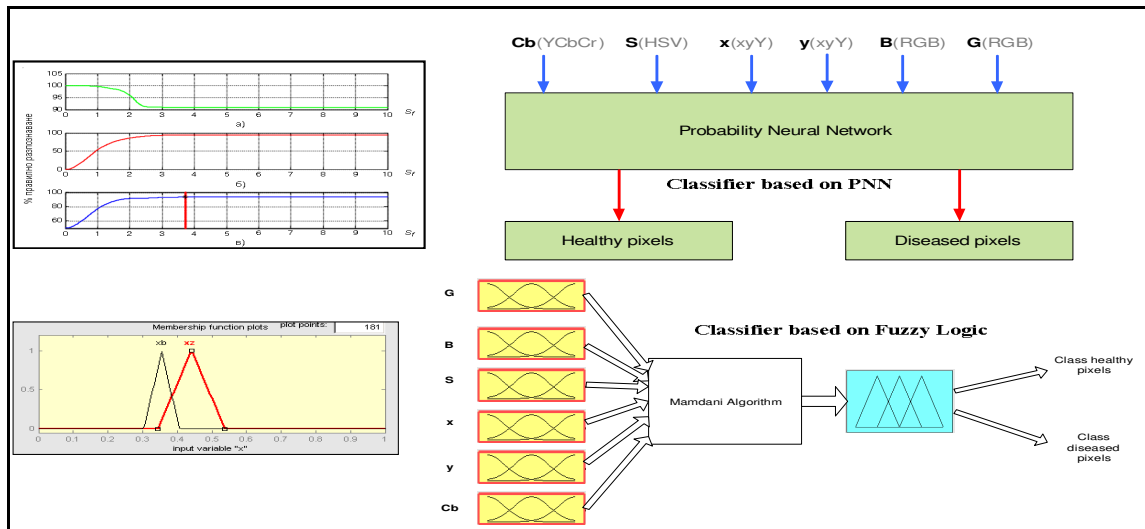

Fig. 7 Module for visualization of sections and histograms of color components.

Input seed image in RGB color space

Transformation in different color space like HSV, Lab, XYZ, xyY, YCbCr

Image without background

Determine the vector of color and texture features

Color features
[R
G
B
H
S
V
L
a
b
X
Y
Z
x
y
Y
Cb
Cr]

Texture features

[Correlation
Homogeneity
Energy
Contrast
Detailed coefficients]

a)

Calculation of limit values

$$U_{Д} = \overline{V_{f,i}^{m}} - k.s$$

$$U_{Г} = \overline{V_{f,i}^{m}} + k.s$$

Choise of informative features

Клас 1   D   Клас 2   ПГР
Клас 1   D   Клас 2   ПГР

Informative features for corn variety 26A

Color features

[Cb (YCbCr)
S(HSV)
x(xyY)
y(xyY)
b(Lab)]

Texture features

[Approximation coefficients – Harr
Homogeneity
Correlation]

Informative features for corn variety XM87

Color features

[B (RGB)
y(xyY)
Cb(YCbCr)
S(HSV)
G(RGB)]

Texture features

[Approximation coefficients – Harr
Homogeneity
Correlation]

Informative features for corn variety Kneja 613

Color features

[X (XYZ)
Y (XYZ)
G(RGB)
R(RGB)
V(HSV)
b(Lab)
x(xyY)
y(xyY)
S(HSV)
Y(YCbCr)
H(HSV)
Cb(YCbCr)]

Texture features

[Approximation coefficients – Harr
Homogeneity
Correlation]

b)

Cb(YCbCr) **S**(HSV) **x**(xyY) **y**(xyY) **B**(RGB) **G**(RGB)

Probability Neural Network

Classifier based on PNN

Healthy pixels

Diseased pixels

Classifier based on Fuzzy Logic

G
B
S
x
y
Cb

Mamdani Algorithm

Class healthy pixels

Class diseased pixels

Membership function plots   plot points: 181

input variable "x"

c)

Fig. 5. Structure of the information module:
a) preliminary data processing, b) assessment of features informativness, c) Seeds classification

The structure and operational algorithm of the module are represented in Fig. 8.

The program starts by loading an image file of maize seed. Use the menu File -> Open a command line application (Field 1). The screen displays a standard windows box for opening files (Box 2). To "read" the digital image of maize seed an embedded MATLAB function *imread* is used. In the programming environment underlie a wide range of image formats like: BMP, CUR, GIF, HDF, ICO, JPEG, PBM, PCX, PGM, PNG, PNM, PBM, PGM, PPM, RAS, TIFF, XWD. Images of the seeds are obtained from a camera and videoblaster in BMP format [3]. To facilitate the user only files with extension *.bmp are seen during the opening.
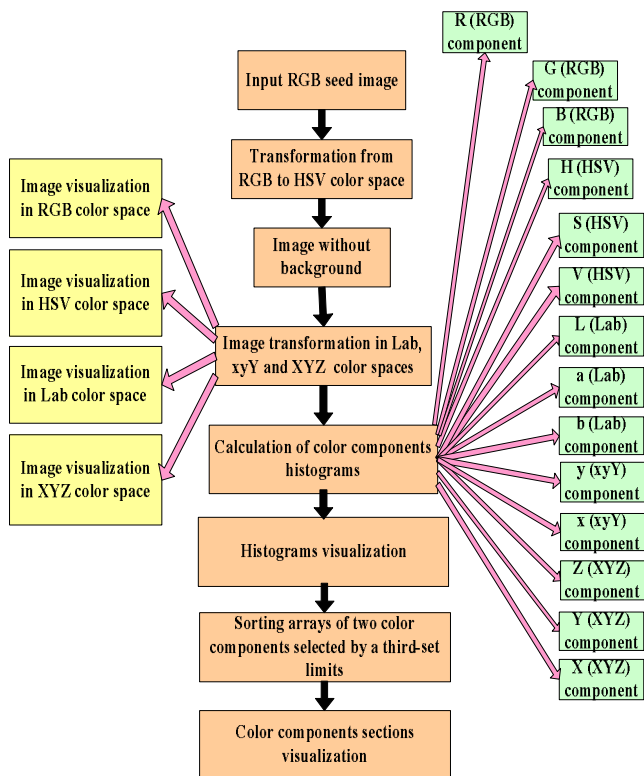

Fig. 8. Structure of Module for visualization of sections and histograms of color components.

The image is stored in three-dimensional array. Image dimensionality of the array corresponds to the image dimensions in pixels. The value of each component of the case is changed from 0 to 255 (8-bit representation).

In fields HUE(min) and HUE(max) are entered by the consumer the values of H component to remove the background image. This is due to the need to reduce the time for image processing. Removing the background is realized by threshold segmentation in component H of HSV color model [3]. In the data field, for ease of consumer, is shows the change of H component in

degrees for the pure spectral colors. From experimental conditions [3] were obtained and processed images of maize seed on a blue background, for which the values of the component H are between 210° and 270°. These pixels are recorded in an additional array D with value 0 and the rest ones (not belonging to the background) - with a value of 1. The result is an array of 0s and 1s, which represent a black & white image of the maize seed. An array containing the input image and the additional array multiply Image *. D.

Preview image in the seed color models HSV, Lab and XYZ be made by inverting the pixel from RGB image [7]. These transformations are performed by menu command line Calculation. Preview image seeds in different color models realize the menu Pictures. It is important to recognize the disease Fusarium signs of color histograms using the visualization of the individual color components (menu Histograms). In Fig. 9 shows the histogram of R component of healthy maize seed.
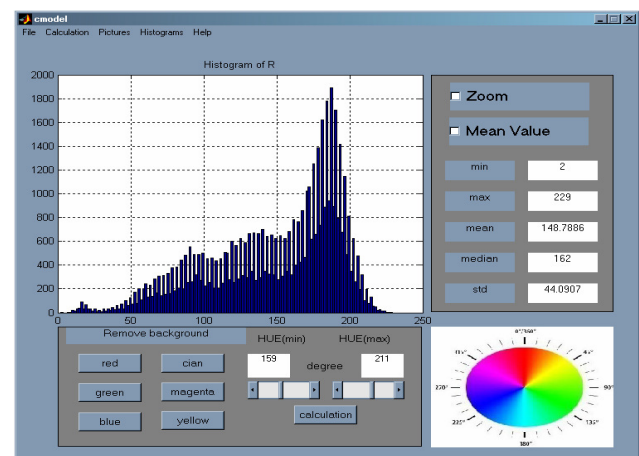

Fig. 9. Histogram of R component of healthy maize seed

Visualization of sections of color components is implemented as a software application to its own module for visualization of histograms and sections of the color components (Fig. 10).

The possibility for formation of two classes of healthy and diseased seeds through the developed application is verified with a sample of 100 maize seeds (50 healthy and 50 infected by Fusarium). Using the Lab color model and selected limits of L component from 70 to 100, the averages of the other two components of the model a and b are calculated. Results for healthy and infected maize seeds are presented in Table. 2.
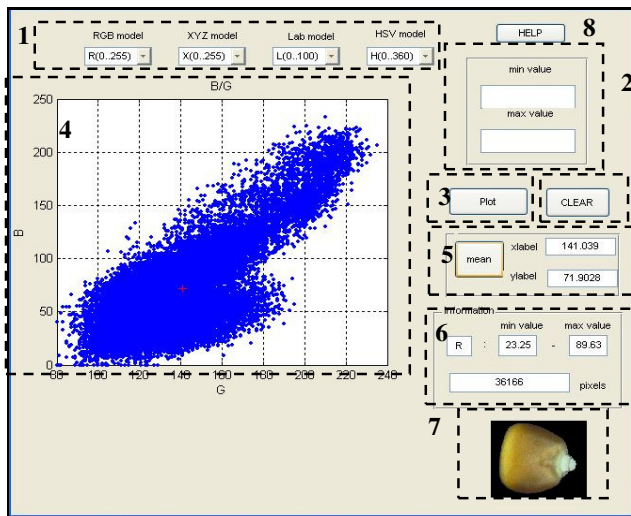
Fig. 10. Module for visualization of sections of the color components

Table 2   Experimental results

Corn seeds	L = 70 - 100		
	Mean value of **a** component	Mean value of **b** component	Pixels number
Healthy	11,14	30,42	17717
Diseased	-4,44	26,1	44091

4 Conclusion

An information model describes the complete procedure for identification of Fusarium disease in maize seed with sufficient accuracy for practical purposes stipulated in the BDS 14852-79.

Module has been developed for visualization of histograms and color sections of the components by a software system for automatic identification of Fusarium. The module is based on an information model of the recognition process of the disease and is designed with specialized tools for development of graphical interfaces from the programming environment MATLAB. Programming tool is created in a manner to facilitate maximum user-friendly usage. It allow adjustments at program level and addition of supplementary functions if necessary. The software application for visualization of sections of color components is a useful tool in determining the informative signs and limit values (for healthy and infected seeds).

References:
[1.] BDS 529-84. Cereal grains, 1985.
[2.] BDS 14852-79. Methods for determining the damage from pests and diseases., 1980.
[3.] Draganova Ts., R.Tsonev, P. Daskalov. Fusarium disease corn seeds assessment by color image analysis, *Proceedings of University of Rousse*, Vol 40, 1.1, 2003 , pp.25-32.
[4.] Draganova Ts., Research of features informativeness used for color identification of Fusarium in maize seeds., *Proceedings of University of Rousse*, 2005, pp. 106-112.
[5.] Draganova Ts., R. Tsonev, P. Daskalov, Corn seeds classification by neural networks and fuzzy logic, *International Scientific Conference "Energy efficiency and agricultural engineering"*, Rousse, 2006, pp. 681-688.
[6.] Draganova Ts., Fusarium disease corn seeds recognition by image analysis and spectral characteristics, PhD Thesis, 2007
[7.] Ford A., A. Roberts., Colour space conversions, 1998.
[8.] MATLAB Function Reference. The MathWorks, Inc., 2003.
[9.] Ng,H.F., Wilcke,W.F., Morey,R.V., Lang,J.P. Machine vision evaluation of corn kernel mechanical and mold damage. *Transactions of the ASAE*, Vol.41(2), 1998, pp.415-420.