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OS-GLCM COMPUTER SYSTEM DESIGNED TO GENERATE A GLCM MATRIX FOR THE DIGITAL IMAGE OF OILSEED RAPE

Summary

The purpose of this paper is to produce original software for calculating the GLCM matrix and its properties. Application mechanics is based on two AForge.Net library for image segmentation, and the Accord.Net library for calculating the GLCM matrix. The application mechanics have included the ability to calculate the GLCM matrix at the given accounts. The application is equipped with functions that calculate the properties of the matrix as a full complement of the problem. Generated matrix properties are saved to a CSV file, or added to an existing one according to user preferences. Digital images of rape leaves constitute a research material used in the work.
***Key words**: GLCM matrix, diseases of oilseed rape*

SYSTEM INFORMATYCZNY OS-GLCM PRZEZNACZONY DO GENEROWANIA MACIERZY GLCM OPISUJĄCEJ TEKSTURĘ OBRAZÓW CYFROWYCH RZEPAKU

Streszczenie

Celem niniejszej pracy jest wytworzenie oryginalnego oprogramowania do obliczania macierzy GLCM, oraz jej właściwości. Mechanika aplikacji opiera się na dwóch bibliotekach AForge.Net do segmentacji obrazu, oraz biblioteka Accord.Net do obliczania macierzy GLCM. W mechanice aplikacji uwzględniono możliwość obliczania macierzy GLCM przy zadanych kontach. Aplikacja została wyposażona w funkcje obliczające właściwości macierzy, co pełni formę uzupełnienia zagadnienia. Wygenerowane właściwości macierzy zastają zapisane do pliku CSV, lub dopisane do już istniejącego wedle preferencji użytkownika. Materiałem badawczym wykorzystanym w pracy, są obrazy cyfrowe liści rzepaku.
***Słowa kluczowe**: macierz GLCM, choroby rzepaku*

1. Introduction

Rape (Brassicanapus L. var. Napus) is a varietal of rapeseed cabbage. Genetics points to a mixture of vegetable cabbage (Brassica oleracea) and cabbage (Brassica rapa). Rape is a one-year or two-year plant. It is sown in the second half of August. The collection takes place in the second year in July. The term largely depends on weather conditions [3]. The plant is cultivated in Poland in several directions. The first most commonly used direction – the production of oil where the final product is rapeseed oil, the second - the production of biodiesel [4]. The plant in its growth phase is exposed to many diseases resulting in a decrease in yield. According to data, rape disease accounts for about a dozen percent of the losses. However, in warm and humid weather the losses can reach about 50%. The occurrence of the disease, and its severity are mainly affected by weather conditions. The most common diseases of rape are: *Verticillium fungicola, Botrytis cinerea Pers, Alternaria brassicae* (Fig. 1) [10]. The process of automating the disease detection process using dedicated software can be a response to the difficulty of diagnosing a disease. For this purpose, a program for creating GLCM learning sets was created for the creation of artificial neural networks corresponding to the problem of disease interpretation. In the study, appropriate GLCM matrix and its coefficients gave the best results.

The GLCM matrix is used for texture analysis. Calculation of the GLCM matrix, and their calculated coefficients, were used by Harlick in his work.

Fig. 1. Rape leaves infected with diseases, from the left: Verticillium fungicola, Botrytis cinerea Pers, Alternaria brassicae [10]
Rys. 1. Liście rzepaku zarażone chorobami, od lewej: Verticillium fungicola, Botrytis cinerea Pers, Alternaria brassicae [10]

The method works on the principle of determining the pixel neighborhood dependence on a digital image. Arithmetic calculation consists in determining the components representing the number of occurrences of pairs of pixels of the same color at a given distance, in the specified direction at a specific area of the image, or on its whole. This matrix shows the pattern:

$$V_{l,\alpha}(i,j) = \left|\{((r,s),(t,v)) : I(r,s) = i, I = (t,v) = j\}\right|$$

Where:

$$\mathbf{i,j = 0,\dots,(N-1) i,j = 0,\dots,(N-1)}$$

It is the pixel gray levels in the image at a distance α in the direction α,
N - number of gray levels,
I (x, y) - pixel color value with coordinates (x, y) in the image,

$$(t,v) = (r + l\cos\alpha, s + l\sin[\alpha)]$$

$$(t,v) = (r + l\cos\alpha, s + l\sin[\alpha)]$$ [2, 5, 9, 11].

2. Material and research methods

The research material in the form of rape leaves was collected from the village of Winna Góra from the Experimental Station of the Institute for Plant Protection in Poznań, State Research Institute. The research material was acquired at the turn of May and June. The rape leaf material was scanned at the Institute of Biosystems Engineering using the laboratory equipment of the Epson Perfection V 750 Pro. The scanner has been set to the default parameters (Fig. 2).

Based on the calculated GLCM matrix and the given normalization process, we can approach the problem of determining the individual properties. Matlab software was used to select appropriate matrix properties. The graphical results of each feature were used to interpret the best results describing the problem. Out of the generated properties, the best results were obtained for the properties: Contrast, Correlation, Entropy, ASM (Angular Second Moment), Inverse Different Moment (Fig. 3).

Source: own work / Źródło: opracowanie własne

Fig. 2. The test apparatus and the result after the scan
Rys. 2. Aparatura badawcza oraz wynik po wykonaniu skanu

Visual Studio 2015 environment was used to create applications for generating learning sets. Two libraries were used for the purpose of the problem: the first library one - Aforge NET- for working with image segmentation, the second - the Accord Net - to generate a GLCM matrix (Table). The matrix enumeration process has been implemented in the code using the available functions. No library available for the purpose of enumerating the properties because they do not have the appropriate functions. The following formulas were used to calculate properties:

Table. Table of GLCM matrix properties with patterns
Tabela. Tabela właściwości macierzy GLCM z wzorami

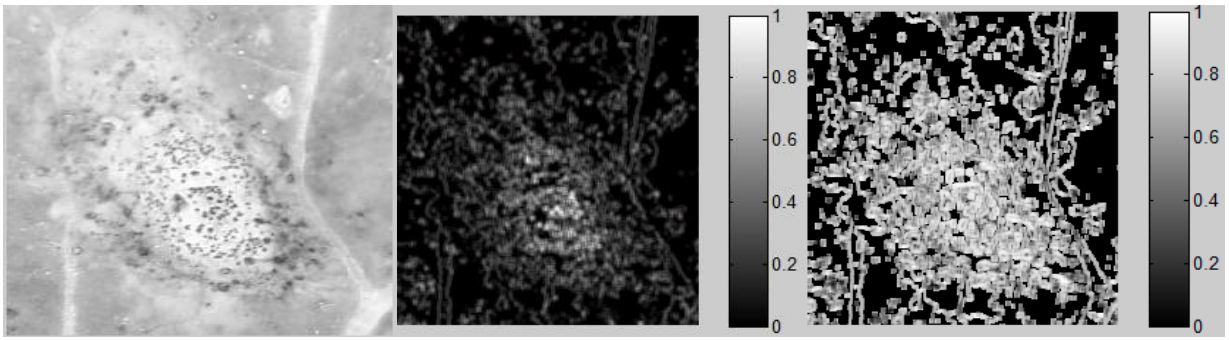
Contrast	$\sum_{i,j=0}^{N-1} P_{i,j}(i-j)^2$
Correlation	$\frac{\sum_{i,j=0}(i,j)P_{i,j} - \mu^2}{\sigma^2}$
Entropy	$\sum_{i,j=0}^{N-1} P_{i,j}(-\ln[\![P_{i,j}]\!])$
ASM	$\sum_{i,j=0}^{N-1} P_{i,j}^2$
Inverse Different Moment	$\sum_{i,j=0}^{N-1} \frac{P_{i,j}}{1+(i-j)^2}$

Source: own work / Źródło: opracowanie własne

Where:
I, j = 0, ..., (N-1) are the gray levels of pixels in the image at a distance α in the direction α,
$P_{i,j}$ $P_{i,j}$ is the GLCM matrix,
μ and σ are the mean deviations and standard deviations of the GLCM matrix. [6, 14].

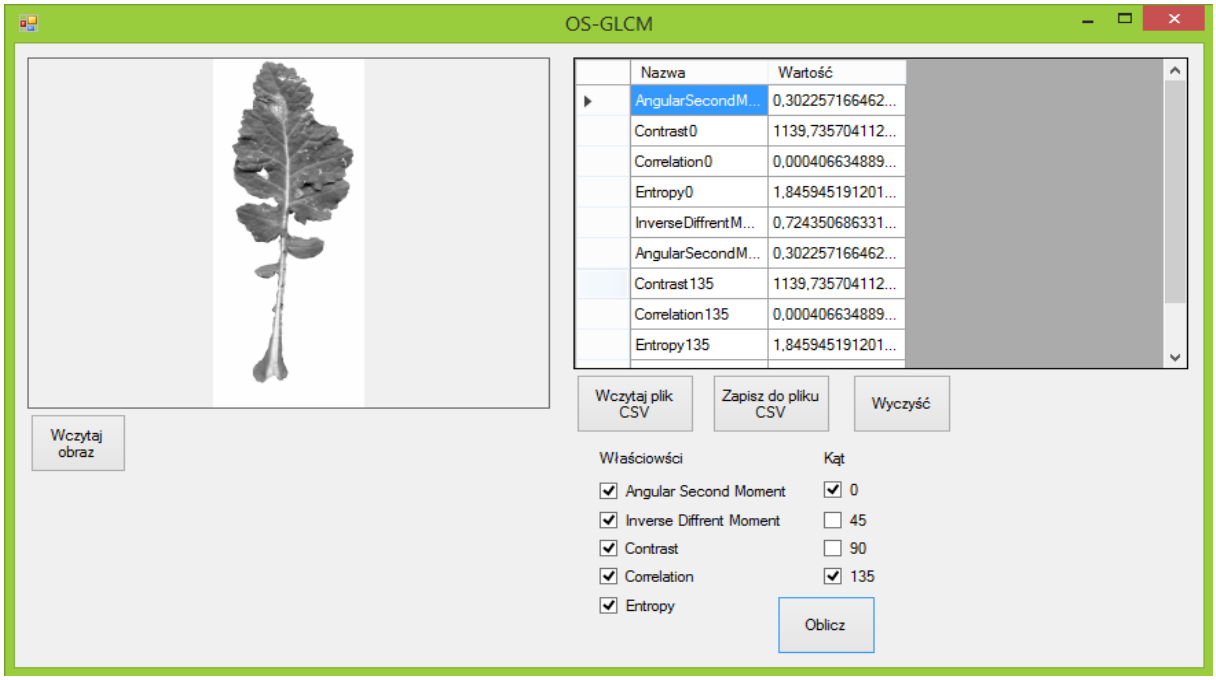
3. Results and conclusions

Based on the above methodology program for calculating the GLCM matrix and their properties was generated. The main purpose of writing this application was to create a free tool to generate learning sets automatically. The learning set that is generated can be used to produce an artificial neural network corresponding to the problem of the interpretation of disease phenomena on the leaf of the rape. The application primarily enables the generation of a GLCM matrix, and calculates interesting features at a given angle from the image loaded into the application.



Source: own work / Źródło: opracowanie własne

Fig. 3. Transformed images in the Matlab environment, left: original gray scale image, after contrast properties, and correlation properties
Rys. 3. Obrazy po transformacji w środowisku Matlab, od lewej: obraz oryginalny w skali szarości, po wyznaczeniu właściwości kontrastu, oraz właściwości korelacji



Source: own work / Źródło: opracowanie własne

Fig. 4. Main view of the program
Rys. 4. Widok główny programu

The application allows you to enumerate multiple properties at different angles simultaneously, without having to repeat the calculation procedure for given values. The image before the matrix calculation process is converted to a gray scale image, which is the procedure required before calculating the matrix. The user-side GLCM property calculation process consists of loading the image into the application and selecting the GLCM angles and features of interest. The automation of the designed application is based on the first stage of the application of the GLCM matrix at the given angle for this purpose, using the available Accord .net library and its matrix calculation functions. The input is a gray scale image and the angle at which the function calculates an interesting matrix. The next step in the application includes enumerating properties. Functions used in property calculation are based on arithmetic and programming loops. The end result of the application is to write the generated values to a file with a .CSV extension. The extra functionality that the app has been equipped with consists in appending values to existing files with the .CSV extension. This gives the user some kind of versatility in action because he or she can use other software to calculate other values to generate learning sets and at a later stage append the value calculated in the application in question. When you add a value to an existing file, the user needs to load the file before calculating the property. (Fig 4).

Generated application gives great possibilities in terms of its use in the construction of artificial neural networks corresponding to the given problems [1, 7, 8, 13]. At the later stage of the redevelopment of the application a module using artificial neural networks will be added to identify the morphological phenomena on the rape leaf [12]. The created application is universal in terms of calculating the GLCM matrix value and its properties for each graphical image in the form of a snapshot, allowing for a variety of issues.

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