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Short communication

A comparative analysis of vine leaves area measurement algorithms

Krasimira Georgieva, Nely Georgieva, Zlatin Zlatev*, Georgi Georgiev
Trakia University, Faculty of Technics and Technologies, 38 Graf Ignatiev, Str., 8602 Yambol, Bulgaria
*e-mail: *zlatin.zlatev@trakia-uni.bg*

Abstract

More and more frequently in contemporary scientific literature information can be found on the use of mobile devices such as video cameras and smartphones by which an area of different objects, for example – vine leaves, can be measured. Software, methods and algorithms for measuring area of leaves are described in general without methodological details. The necessary accuracy of the measurement is not commented too. In this paper a comparative analysis is made for four algorithms which are intended for measuring area of vine leaves in terms of measurement accuracy and performance of the computer system. In this study it is found that in the algorithm with nested loops the number of operations is increased but this is not influence on the precision of the measurement but the threshold level of binarization is affected on the precision of the measurement. This is proven by analyzing the execution time and operations number of various algorithms.

Keywords: leaf area; measurement algorithm; measurement error

INTRODUCTION

Methods for measuring the area of the vine leaves can be grouped into the following categories: A classic method using a millimeter paper or planimeter; Measurement by model describing the relationship between the short and long axis of the leaf and its area; Specialized scan type devices for measuring leaf area; Use of personal computers and mobile devices with video camera and software to measure leaf area.

On the contemporary state of science and technology increasingly more mobile devices and personal computers with video camera and software are used for express and accessible measuring of area of vine leaves. These devices use software algorithms to identify and measure the area of vine leaves, and to determine the degree of infection of plants. The review of available literary sources (Sannakki et al., 2013; Orlando et al., 2016) shows that the software, methods and algorithms for measuring area of leaves are described in general without methodological details. Also the necessary accuracy of the measurements is not commented.

The aim of the article is to make a comparative analysis of four algorithms for measuring area of vine leaves in terms of measurement accuracy and performance of the computer system.

MATERIAL AND METHODS

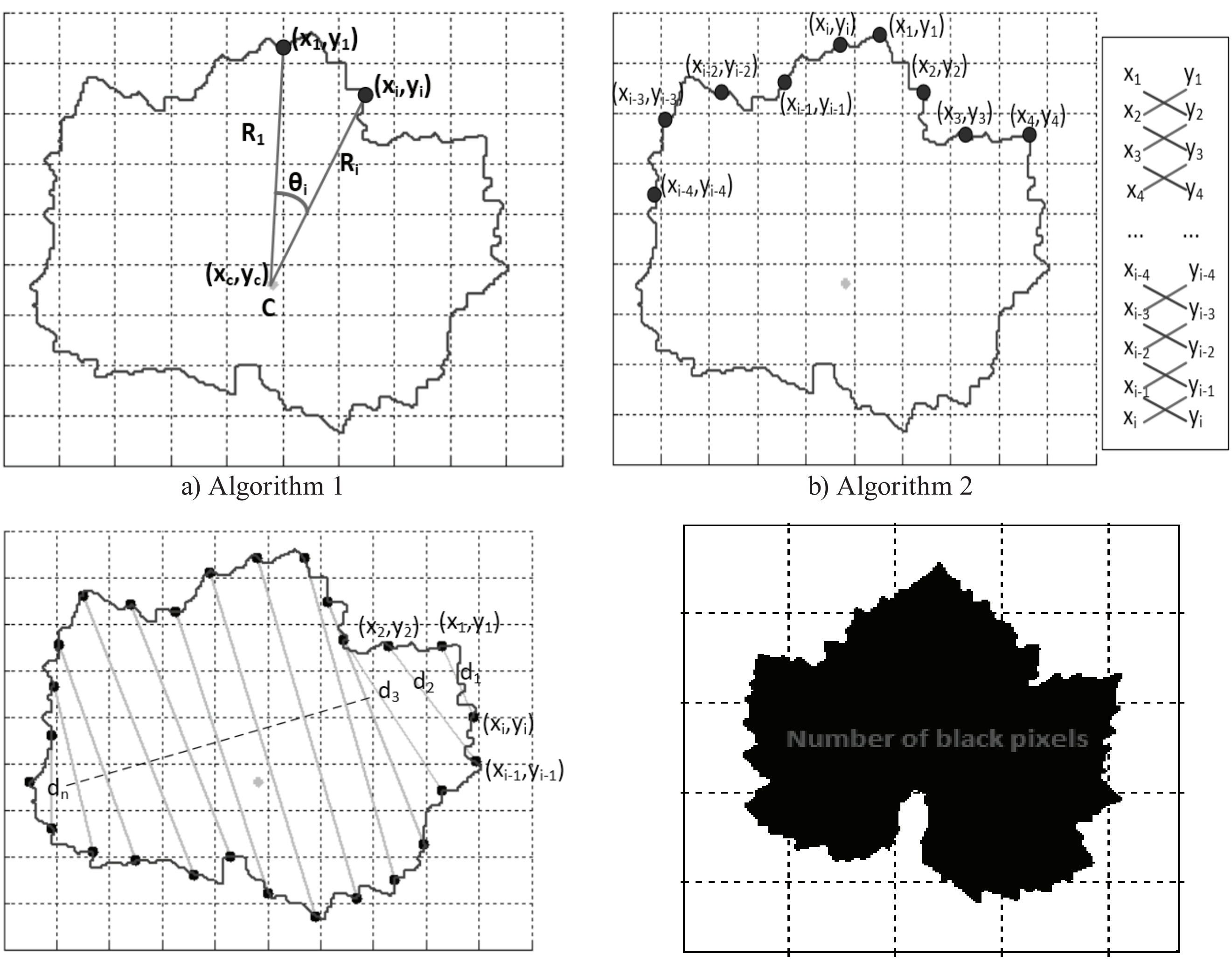
The experimental material used in the study is 200 vine leaves harvested from vineyards in the village of Boyanovo, Yambol, Bulgaria. The leaves are selected randomly without regard to the place of plantation and they are from the one of the same sort of grape plants. Selected leaves are without external signs of disease.

The reference method of measurement is the measurement by a planimeter.

The colour digital images of the vine leaves are obtained with industrial video camera DFK41AU02 with resolution of 1280 x 960 pixels. The adjustment of video camera is made by a gauge block 10 of the Mitutoyo firm, metal, grade K and central deviation 0.02 μm.

The selected algorithms for determining the size of an object in an image are available on the Internet and use basic functions for recognition (Finley, 2006; Mladenov et al., 2011; Chaudhary et al., 2012; Zlatev et al., 2014). Algorithms are used in their original form without modification. The operation principle of the algorithms being studied is presented in Figure 1.

Algorithm 1 detect the center of mass C of the contour of the leaf. The contour is a shape with an irregular oval form, its radiuses are of different length. Determine first radius contour that represents the distance from x_l to x_c. Then, at a certain angle θ_i, all other radiuses are determined – the distances from y_i to y_c. The number of pixels in the leaf area is defined as the sum of all radiuses of contour R_i measured at θ_i angle. Algorithm 2 works regardless of whether the contour coordinates are clockwise or counter-clockwise. The coordinates of the contour points are multiplied sequentially. Algorithm 3 works whether the contour coordinates are either clockwise or counter-clockwise. It determines the sum of the distances d_n between two opposite points of the contour. Algorithm 4 create binary black and white image, all black pixels are counted by two nested loops to determine the number of black pixels lying in the contour of the leaf.



a) Algorithm 1 b) Algorithm 2

c) Algorithm 3 d) Algorithm 4

Figure 1. Operation principle of algorithm for measurement of vine leaves area

A coefficient of determination of R^2 is used for determination of the relationship between the area of the leaves measured by a planimeter and that determined by the algorithm. Used criteria for evaluating the errors of measurement are a sum of squares of errors and root mean square error. A level of significance P-level ≤0.05 between the measured areas by the reference method and algorithm was adopted. The time to work on algorithms is measured and the number of iterations in the algorithms has been determined.

RESULTS AND DISCUSSION

The results from a comparative analysis of the four basic algorithms for measurement of vine leaves area are presented in Table 1. The P-level of significance analysis shows that the investigated algorithms are similar in results to the data on the area of the vine leaves obtained by the reference method. The impact on performance of the algorithms gives the number of calls to one operation.

This number is the higher in Algorithms 1, 2 and 4, which are also as stated using loops of the type For-End and nested ones. The work of Algorithm 3 is affected by the shape of leaf. There can be receiving the results with errors because some of the distances between points of the contour can be measured outside of the leaf. Algorithm 4 is affected by the threshold level of binarization of the image which change in interval [0,1]. This level is set manually for the measurements in the study. Its changes ±7% from the appropriate value decreases the coefficient of determination under 0.7. The same results were obtained in determination the correlation between the execution time of the algorithms and the number of operations. In the above initial conditions and set criteria a correlation 0.98 was established between processing time and the number calls to a single operation.

CONCLUSION

Various methods for measuring area of objects are offered in the study literature. In the compare with the reviewed Algorithm 4, better metrics show the algorithms using the center of gravity of the object and radius, as well as those that enumerate the pixels of the object in the image. A drawback of these algorithms is the use of nested loops, which increases the number of operations performed and the measurement time. In this study it is found that in the algorithm with nested loops the number of operations is increased but this is not influence on the precision of the measurement but the threshold level of binarization is affected on the precision of the measurement. This is proven by analyzing the execution time of various algorithms. From the study it is found that in addition to the elements of the algorithms on their operation affects the threshold level of binarization.

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Table 1. A comparative analysis of algorithms for measurement of vine leaves area

	Algorithm 1	Algorithm 2	Algorithm 3	Algorithm 4
[a]R^2 of [b]A_A and [c]A_L	0.75	0.81	0.79	0.82
[d]SSE	$2.14.10^{-8}$	$1.17.10^{-8}$	$1.79.10^{-8}$	$1.57.10^{-8}$
[e]RMSE	0.27	0.24	0.22	0.23
[f]P-level	0.041	0.002	0.003	0.001
[g]T_p, s	3.68	4.59	3.46	3.61
[h]N_i	58	78	46	53

[a]Coefficient of determination; [b]Area of leaf measured by algorithm; [c]Area of leaf measured by planimeter; [d]Sum of squired errors; [e]Root mean squired error; [f]Level of significance; [g]Processing time of the algorithm in seconds; [h]Number of iterations (calls to one operation)

REFERENCES

Chaudhary, P., Godara, S., Cheeran, A. N., & Chaudhari, A. K. (2012). Fast and accurate method for leaf area measurement. *International Journal of Computer Applications*, *49*(9), 22-25.

Finley, D. (2006). Area of a polygon. Available at: http://www.mathopenref.com [Accessed 12 December 2016]

Mladenov, M. I., Penchev, S. M., Dejanov, M. P., & Mustafa, M. S. (2011). Quality assessment of corn grain sample using color image analysis. *Sensing and Instrumentation for Food Quality and Safety*, *5*(3-4), 111-127.

Orlando, F., Movedi, E., Coduto, D., Parisi, S., Brancadoro, L., Pagani, V., Guarneri, T. & Confalonieri, R. (2016). Estimating Leaf Area Index (LAI) in Vineyards Using the PocketLAI Smart-App. *Sensors*, *16*(12), 2004.

Sannakki, S., Rajpurohit, V., Nargund, V. & Kulkarni, P. (2013). Diagnosis and classification of grape leaf diseases using neural networks. In: *Proceedings of 4th International Conference on Computing, Communications and Networking Technologies*, July 4-6, 2013, Tiruchengode, India (pp. 1-5). IEEE.

Zlatev, Z., Ribarski, S. & Mladenov, M. (2014). Automatic measurement of Loin eye area with computer vision system. *Agricultural Science and Technology*, 6 (2), 224-227.