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USE OF THE DIGITAL IMAGES FOR MEASUREMENT OF SMALL PLANAR OBJECTS GEOMETRIC PARAMETERS WITH HIGH PRECISION

Abstract. Web application for measuring of the sizes and the area of small planar objects use the scan data of digital images has been created. The application has a means of programmatically change the sizes of image. The influence of the digital image sizes on the measurement accuracy was investigated. It is shown that with an increase in size by a factor of 6 7, the relative error at measuring of the length is no more than 0.25%, and at the measurement of of the area is no more than 1%.
Keywords: digital image, determination of parameters by scan data, measurement of area and length.

Statement of the problem and purpose of research. In science and technology, it is often necessary to measure the sizes and area of small surface objects of materials and industrial products. The dimensions of such objects are usually a few millimeters or less. Such objects, in particular, include small electrodes used in the study of varistor materials at high electric currents [1].

It is impossible to measure the dimensions of planar objects with conventional measuring instruments, such as micrometers, since they are inseparable from the surface and have a flat shape. As shown in [2], the measurements can be performed if the surface with such objects is photographed by a digital camera and the appropriate processing of the digital image is performed. Processing consists in scanning the coordinates of object. With a known image scale, based on the scan data, the dimensions and area of a planar object can be calculated. Since the absolute error in scanning digital images is ±1 pixel, this makes it possible to ensure high measurement accuracy at a high resolution of digital photocamera.

The purpose of this work is to create a program for measuring, based on scan data, the sizes and areas of small planar objects and to study the possibility of increasing the accuracy of measurements at increasing the dimensions of the digital image by programmatically way.

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Major part. Measurement of the geometric parameters of a digital image object is performed by scanning coordinates. To convert the scan data into parameter it is necessary to define the scale of image. For this purpose use the scale segment of digital image with a known length L_C. If coordinates in pixels for the ends of such segment have the values ($x1_C$, $y1_C$) i ($x2_C$, $y2_C$), then the scale M_C is determined as

$$M_L = \frac{L_C}{\sqrt{(x_{1C} - x_{2C})^2 + (y_{1C} - y_{2C})^2}} \,. \tag{1}$$

When measuring the size L of a digital image object, coordinates are scanned at two points on its boundaries. If the values of coordinates are (x1, y1) i (x2, y2), then the length of object is calculated by the formula:

$$L = M_L \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \,. \tag{2}$$

Taking into account the scanning error ±1 pixel, the relative measurement error δ_L, is determined in this case as

$$\delta_L = \pm \frac{2}{\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}} \cdot 100\% \tag{3}$$

When measuring the area S of object, the coordinates are scanned along the contour enclosing the object. The Gauss formula [3] use for S calculation:

$$S = \frac{M_L^2}{2} \left| x_N y_1 - x_1 y_N + \sum_{i=1}^{N-1} \left(x_i y_{i+1} - x_{i+1} y_i \right) \right| . \tag{4}$$

Taking into account the error of scanning ±1 pixel, it can be shown that the relative error at measurement of area δ_S is determined as

$$\delta_S = \pm \frac{4 \sum_{i=1}^{N-1} \sqrt{(x_i - x_{i+1})^2 + (y_i - y_{i+1})^2}}{\left| x_N y_1 - x_1 y_N + \sum_{i=1}^{N-1} \left(x_i y_{i+1} - x_{i+1} y_i \right) \right|} \cdot 100\% \tag{5}$$

A program for measuring the size and the area of small planar objects must realizes the algorithm of image processing, which consists of the following stages: 1). Loading the image to a screen of computer; 2). Scaling of the image; 3). Scanning the coordinates of object; 4). Calculation the value of geometric parameter and the error of its measurement based on the scan data.

To implement the described algorithm, a web application was created using the languages HTML5, CSS3, JavaScript and the Canvas technology. We used the Canvas technology to visualize the scan points on a digital image using vector graphics. Any Internet browser can be used as a software environment for a web application.

To control the processing of raster images, the web application interface has a toolbox containing visible and hidden blocks with the necessary fields of form and the buttons. The program opens hidden blocks at processing stages when these blocks are needed. For working with the large images web page of application has a canvas of 10000×7000 pixels. The top-left corner of canvas is positioned at the top-left corner of browser window with the coordinates (0, 0). The same coordinates of the upper left corner for images embedded in canvas the program ensures at the first stage of processing algorithm.

Scanning is carried out by clicking the left mouse key in the selected point of digital image. The coordinates are read at event "mouseup". This event launches a script that puts the scanned data in arrays of program and draws a white circle in the scan point of digital image. Script connects neighboring scanning points by the straight lines of white color. The program allows user to correct the scan results. Correction is performed by removing the coordinates of the last scanned point from the arrays and clears the visual display of this point in canvas. Correction allows the user to carry out repeated scanning more correctly.

The scripts serving various stages of the processing algorithm have the means for checking the filling of form fields and performing scanning. They form the messages to user when form fields are not filled, filled incorrectly, or when scanning has not been completed.

After completing the coordinates scanning for measured object, the program calculates geometric parameter and relative error of its measurement using the formulas (2) - (5). The results of calculation are displayed in the hidden form fields of toolbox. In fig. 1 is shown the view of program web page at the final stage of processing at measuring the area of small electrode on the surface of varistor disk. For determine the scale of image M_L, segment of the rule 20 mm long was used. The value of scale was 36 μm/pixel.

The digital image presented in fig. 1 has the dimensions determined in the graphic file. Therefore, the relative error in measuring of the area for electrode with diameter of 3 mm is quite large ~ 6%. According to equation (3), the relative error in measuring the length decreases with increasing of the object sizes. Therefore, when the resolution of monitor screen is constant, one should expect a decrease in the measurement error with an increase in the size of testing digital image.

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Figure 1 - Web page of the application on final processing stage, when measure the area of planar object. The digital image has its original dimensions presented in graphic file

It is possible to control the size of image by programmatically means if to use the "width" property of the Image object of language JavaScript. For this purpose, the program was supplemented with two scripts that are executed when the buttons "Increase of sizes" and "Decrease of sizes" (Fig. 1). The script executed when the "Increase of sizes" button is pressed increases the current width of the image by multiplying on 1.05 the value of program variable w, which stores the image width. The script executed when “Decrease of sizes” button is pressed decreases the width of the image by multiplying on 0.95 the value of w. This allows the user to resize the digital image.

Fig. 2 shows results of measuring the planar object area when the image is enlarged of 7 times. In this case the scale of digital image is 5.1 μm/pixel. As it can be seen at the increasing of image size takes place the significantly increasing in measuring accuracy. The value of relative error at measuring of electrode area is less than 1%.

The scale of the digital image M_L, defined in μm/pixel, practically is the division value for measuring device and determines the absolute error at the length measurement. Since the value of scale M_L = 5.1 μm/pixel when the size of digital image is increased by 7 times then the accuracy of length measure exceeds the accuracy of standard micrometers with a division value of 10 μm.

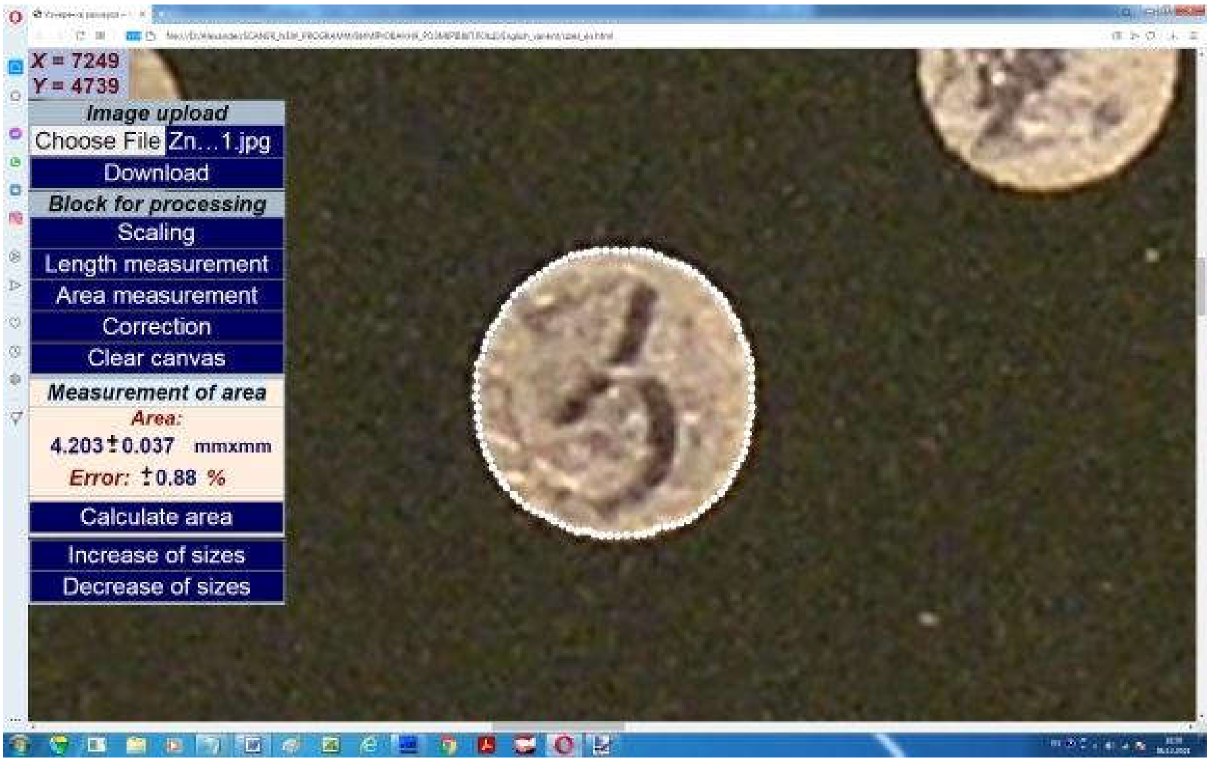

Figure 2 - The web page of application after measuring the planar object area when the image is enlarged of 7 times

The program was used to study the dependence of absolute error at the length measuring and the relative errors at measuring of the size and area of planar objects from the magnification of digital image. The value of magnification was calculated as the product of 1.05×1.05×1.05× ... with the number of multipliers equal to the number of the "Increase size" button pressing. The measurements were made for different magnifications by means of the program described above. The results are shown in fig. 3.

As can be seen, the absolute and relative errors at the measurement of geometric parameters decrease with increasing of digital image sizes. This gives a possible, by means of increasing the image size by a factor of 6 - 7, to obtain a relative error in measuring the length of planar objects less than 0.25% and a relative error in measuring the area less than 1%.

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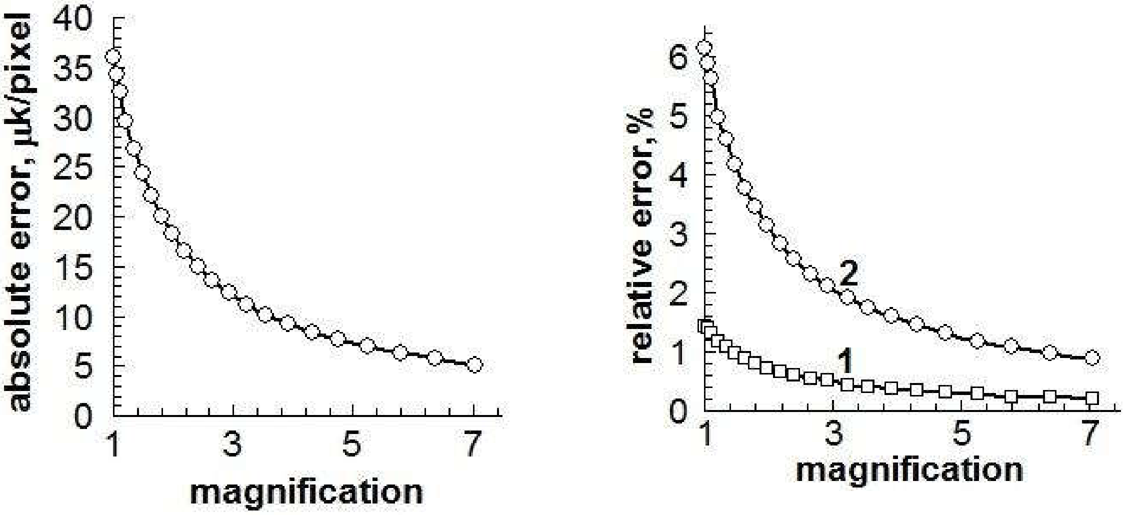

a b

Figure 3 - Dependence of the absolute error at the length measuring (a) and the dependences of relative error for measuring the length (1) and area (2) (b) from the magnification of digital image sizes

Conclusions. By means of the languages HTML, CSS, JavaScript and Canvas technology web application for measuring the dimensions and area of planar objects of digital images by scan data has been created. The application has a means for programmatically resizing the image. It is shown that when to increase the size of image by a factor of 6-7, the relative error at measuring of the length is no more 0.25% and at measuring the area is no more 1%.

REFERENCES

1. Ivon A.I. High-current measurement of the grain resistivity in zinc oxide varistor ceramics / A.I. Ivon, R.I.Lavrov, A.B. Glot // Ceramics International.– 2013. – V.39.– p. 6441 – 6447.

2. Ivon A.I., Ivon Y.A., Lavrov R.I. Application of bitmaps for increasing data processing accuracy in physical experiment / System technologies. 2014, issue 1 (90), p. 10 – 17.

3. Gauss's Area Calculation Formula. Website URL: https://www.thecivilengineer.org/education/calculation-examples/item/1319-calculation-example-three-point-resection.

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Використання цифрових зображень для вимірювання геометричних параметрів малих планарних об'єктів з високою точністю

Досліджено можливості використання растрових (цифрових) зображень для вимірювання з високою точністю розмірив і площі малих планарних об'єктів. Виміряти геометричні параметри таких об'єктів звичайними інструментами, наприклад, мікрометрами неможливо, оскільки вони невіддільні від поверхні і мають плоску форму. Цифрові зображення, отримані за допомогою цифрової фотокамери дають можливість виконати вимірювання програмним шляхом, виконавши сканування координат об'єктів. Оскільки похибка сканування не перевищує ±1 піксель можна забезпечити високу точність вимірювання.

Метою роботи є створення засобами подання інформації в мережі Інтернет прикладного web додатку (програми) для вимірювання розмірів і площі планарних об'єктів і дослідження можливості підвищення точності вимірювань за рахунок збільшення розмірів цифрового зображення програмним шляхом.

Програма реалізує алгоритм обробки цифрових зображень, який складається з завантаження зображення, масштабування, сканування координат об'єкту і розрахунку на підставі даних сканування геометричного параметру, що вимірюється. Для розрахунку площі планарних об'єктів використана формула Гауса.

Програма має засоби для зміни розмірів цифрового зображення програмним шляхом. Досліджено вплив розмірів зображення на точність вимірів. Показано, що при збільшенні розмірів в 6–7 разів відносна похибка вимірювання довжини складає не більше ±0,25 %, вимірювання площі не більше ±1%. Це обумовлено зменшенням абсолютної похибки вимірювання довжини при збільшенні розмірів цифрового зображення, оскільки похибка його сканування ±1 піксель остається незмінною.

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