PROCEEDINGS

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Volume 12, 2015

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PROCEEDINGS
of the Union of Scientists – Ruse

ISSN 1314-3077

ISSN 1314-3077

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SOFTWARE SYSTEM FOR DIGITAL ANALYSIS OF FINGERNAIL IMPRINTS IN FORENSIC MEDICINE

Rumen Rusev

Angel Kanchev University of Ruse

Abstract: *This paper describes the design and implementation of a software product for digital image analysis of nails imprints on human skin. Its purpose is to create a set of objective criteria for a complete match or similarity between the nail imprints on human victims of a crime with the fingernails of the possible suspect. The software product was created mainly for the needs of the forensic medicine.*

Keywords: *Software system, digital analysis, image processing, forensic medicine, fingernail imprints.*

INTRODUCTION

In the field of the forensic science more and more often methods are used for matching marks on human skins and the possible objects that caused them [5]. Such marks are traces of bites, blunt object hits, fingernails imprint and others. In the contemporary forensic science such finds are documented with digital photos and further analysis often comes down to the visual comparison of the found mark with the possible causer. There are a number of methodologies [2, 5] which allow, based on a number of numerical distance measurements in a nail imprint, to find its most probable match. In order to avoid the subjective distortion, the errors caused by geometrical deformations and the perspective deformations during the process of getting the image a software product is offered that allows an accurate size measurement of the marks on the digital image with error compensation.

PROBLEM DEFINITION

During the process of collecting evidence in the forensic medicine very often are present fingernail imprints on the human skin. For the further analysis are created digital images of the relevant sections. In order to be able to measure the size and the distances in the image is included a measurement line so that it is possible to match a part of the imprint with a part of the measurement line. This is done in order to be able to achieve relatively accurate measures. Normally the object and the measurement line are not parallel to the sensor of the digital camera which causes perspective distortion of the size. The main purpose of the software product described in this paper is to develop an approach which after calibrating the software with a measurement line to allow getting accurate sizes in millimetres with the option for possible perspective deformation. Such digital data from a couple of nail imprints would allow accurately measure how close the two imprints match.

CHOICE OF GEOMETRICAL CHARACTERISTICS FOR COMPARISON

On Fig. 1 images are shown of a nail imprint on a human face of a deceased person. Apart of the examined mark is also showed the measurement line according to which can be determined the actual sizes of the imprint.

Fig.1. Image of fingernail imprints on a human face

In order to look for the person who left this mark is necessary to obtain the nail imprints on an imitation of human skin which is used in the forensic medicine. – EC1 Petrolatum [1, 5]. This is done when applying perpendicular pressure on the surface as shown on Fig. 2 a) which produces the imprints shown on Fig. 2 b).

a. way of obtaining *b. result*

Fig.2. Nail imprints on an imitation of human skin

The next important step is to determine the parameters that characterize the fingernail imprint. After discussions with forensic science experts and the conduction of multiple experiments and data analysis were chosen the parameters, shown on Fig. 3 – the values x_1, x_2, a, b, c_1 and c_2. The distance between the ends of the nail imprint is denoted with x. The distance b is the maximum between the line x and the furthest point from the mark. This perpendicular splits x into two segments, denoted on the figure 3 with x_1 and x_2. The perpendicular distances from the middle points of x_1 and x_2 to the impact contour are marked as c_1 and c_2. The a value is calculated analogically to c_1 and c_2 with respect to the line x.

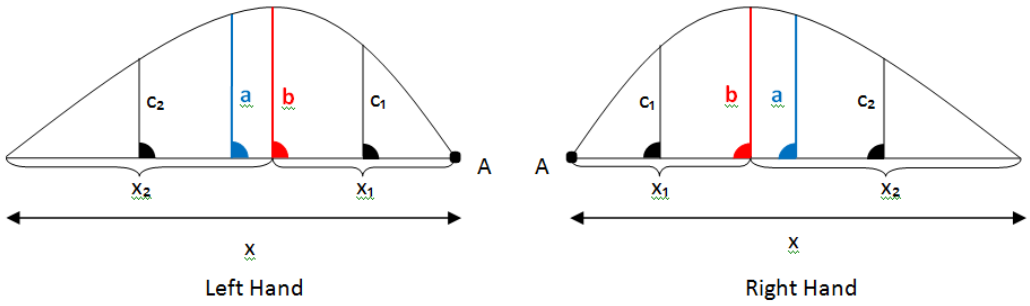

Fig.3. Parameters that characterize the fingernail imprint

This methodology allows obtaining of 6 independent parameters which could be used for statistical analysis that'll allow calculating the degree of similarity of two different fingernail imprints.

SYSTEM IMPLEMENTATION AND RESULTS

The designed and developed for the needs of the forensic science software has the following functionalities:

- visualisation of a digital image;
- pre-processing for image enhancement [3,4];
- calibrating after interactive specifying two points from the image for which the actual world distance is known;
- manual selection of the two ends of the examined fingernail imprint segment;
- manual selection of the highest point of the fingerprint curve;
- automatic calculation of the distance *b* (see Fig. 3);
- automatic construction of the perpendicular lines that determine c_1 and c_2 and manual selection of the intersection points with the contour;
- automatic calculation of the distances c_1 and c_2;

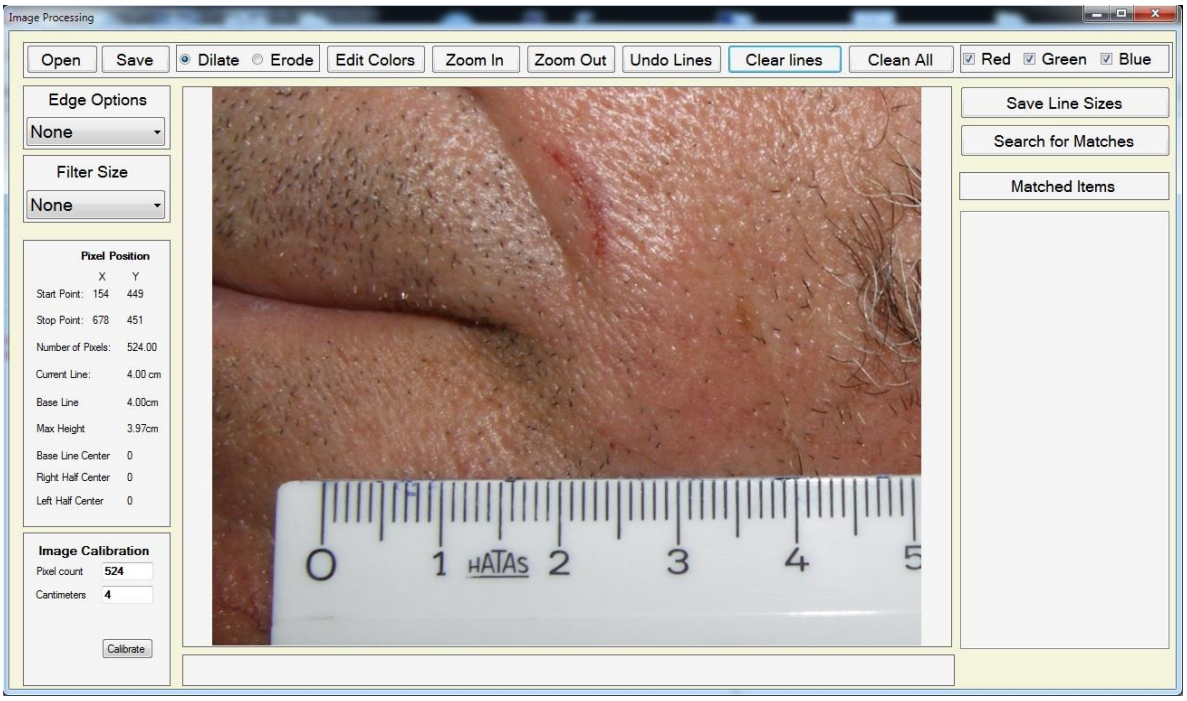

Fig.4. User interface and calibration of the system

On Fig. 4 is shown the user software interface and the process of system's calibration based on known world distance from the image.

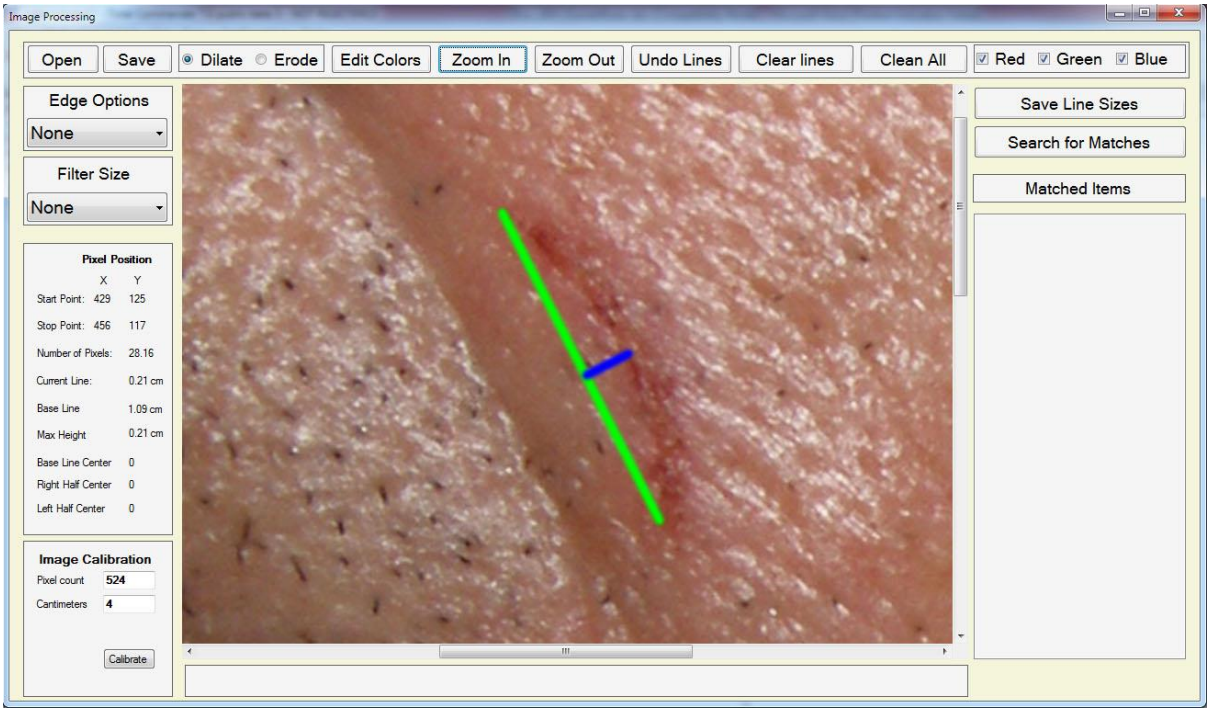

Fig.5. Process of measuring

On Fig. 5 is shown the measuring process of the values of *x* and *b*. To achieve the best precision the image is zoomed in.

After the completion of all the activities are obtained the values of all 6 parameters. They can be saved in a file for further analysis and comparisons with other fingernail imprints.

CONCLUSION

As a result of the described project was developed a software product. It can be used for the automation of the forensic scientists' work in the fingernail imprints analysis and comparison. The use of the software decreases the measure errors and can compensate for the perspective distortions in the images taken by digital cameras. The same approach could be used in any cases where is needed measurement of distances in digital images. The software system can be further developed through including functionality for an automated comparison of marks against another fingernail imprint or searching in a database with a certain degree of match.

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СОФТУЕРНА СИСТЕМА ЗА ЦИФРОВ АНАЛИЗ НА ОТПЕЧАТЪЦИ ОТ НОКТИ ЗА НУЖДИТЕ НА СЪДЕБНАТА МЕДИЦИНА

Румен Русев

Русенски университет "Ангел Кънчев"

***Резюме**: Тази статия описва проектирането и реализацията на програмен продукт за цифров анализ на изображения от отпечатъци на нокти върху човешка кожа. Целта е чрез него да се получат обективни критерии за съвпадението или сходството отпечатъци от нокти върху хора, жертви на престъпление с тези на заподозрени за извършването му лица за нуждите на съдебната медицина.*

***Ключови думи:** софтуерна система, цифров анализ, обработка на изображения, съдебна медицина, отпечатъци от нокти.*

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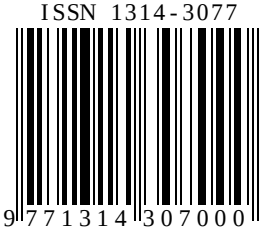
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