



# Hardware-software complex for compiling the gunshot damage passport

I.G. Palchikova<sup>1</sup>, E.S. Smirnov<sup>1</sup>, I.A. Budaeva<sup>1</sup>, I.V. Latyshov<sup>2</sup>, V.A. Vasiliev<sup>3</sup>, A.V. Kondakov<sup>4</sup>

1.TDI SIE, SB RAS, Novosibirsk; 2. St. Petersburg Univ. of the MIA, 3. Volgograd Acad.of the MIA, 4. St. Petersburg Acad. of the IC

E-mail: evgenii.s.smirnov@yandex.ru

## Abstract

To automate the tasks of forming a gunshot damage passport, a hardware-software complex was developed. Complex consists of a digital image acquisition device with the spectrozonal and multispectral illuminator, the specialized software and algorithms for processing the digital images of gunshot residues. The forensically significant characteristics of the object of study and the gunshot residues are analyzed and quantitative determined.

## Introduction

Research work on the collection and systematisation of information on firearms [1, 2] has led to the identification of strictly defined forensically relevant characteristics of gunshot residues [3, 4]. Generally, generalized evaluation approaches are used in forensic ballistics [5]. Visual assessment of trace characteristics on a target depends on the abilities and functions of the examiner, and at the same time it establishes reference points for comparison with instrumental measurement. Visual assessment is not easy to perform, much less to reproduce (repeat), even with trained experts, because organoleptic criteria are influenced by personal preferences, lighting, visual deficiencies and other factors. In addition, different expert communities apply different scales to describe and evaluate certain characteristics, e.g. colour. At the same time, an instrumental method based on mathematical processing of a colour digital image enables [6, 7] to objectively perform measurements of forensically relevant characteristics on a digital image of a target and to express the results in a quantitative form. Significant characteristics are defined and described in detail in [7, 8].

Now we present our results of the development of a hardware and software complex consisting of a mobile recording device, specialized software and algorithms for processing digital images of targets for quantitative determination and analysis of forensically significant characteristics of the object of investigation, as well as traces of gunshot detected on it.

## The Purpose of the Device and its Components

The structure of the hardware-software complex, which uses computer vision approaches and the principles of digital image acquisition and processing to identify, calculate and systematise forensically relevant characteristics of a target, is presented in Fig. 1.

To illuminate the target under study, any of the seven illuminators built into the stand-alone spectro-zonal and multispectral white light with high colour rendering index "PhotoBox 3138" are to be used. [9]. Illumination and conditions of observation are chosen according to GOST R 52489-2005 taking into account properties of the test item and information that should be obtained during the measurement.

The optical system of the lens (Fig. 1) carries out the transfer of the image of the target to the plane of the photosensitive matrix of the recorder. A digital colour camera Canon EOS 500D (Canon Inc., Japan) is used as the recorder and the main element of the measuring unit, the characteristics of the camera and the required photo shooting parameters are given in [6]. The data logger operation is provided with the computer control.

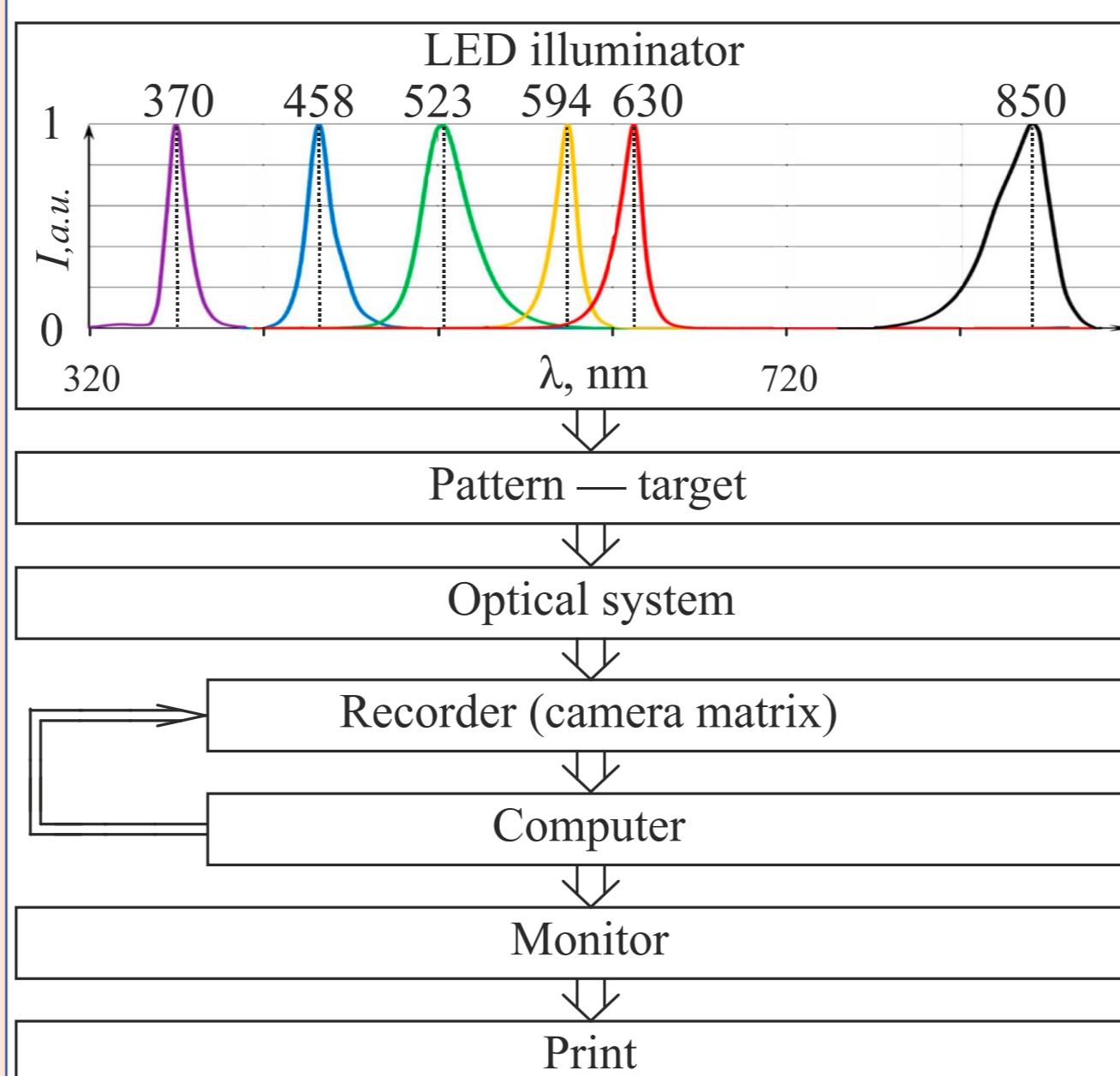


Fig. 1. The structure of the hardware-software complex.

## Acquisition and Processing of the Digital Image

The characterization process involves preparing a target, taking and recording its image with a digital camera, which is then sent to a computer, where the specially designed ImgOpinion desktop application processes it and presents the results on a monitor or as a file suitable for use with databases.

Digital images are recorded in the camera's customised 14-bit RAW format and converted into an adaptable 16-bit TIFF format, which does not limit the number of brightness gradations contained in the 14-bit image. In our experience, in addition to the TIFF format, PNG and DICOM formats are also suitable for 16-bit digital images. These formats do not introduce additional distortion to the original image.

The specialized ImgOpinion software performs optical-structural analysis of digital images, image segmentation, calculation of quantitative characteristics for detected areas on gunshot traces, estimates the amount of gunshot soot [7] and its distribution on the target surface. ImgOpinion is intended for use in expert laboratories. The application is written in the Java programming language and runs on the Linux and Windows families of systems, the system requirements of the application are the same as [10]. The ImgOpinion program window in the "automatic search for areas on gunshot traces" mode is shown in Fig. 2, where the menu bars and window switches are located on the left side of the figure, and the window for the processed image, where the outlines of deposition zones defined by the Otsu segmentation algorithm [7], are displayed on the right.

The ImgOpinion application generates a damage passport [8], which is an information resource containing information about the type of the incoming object with gunshot residue, its

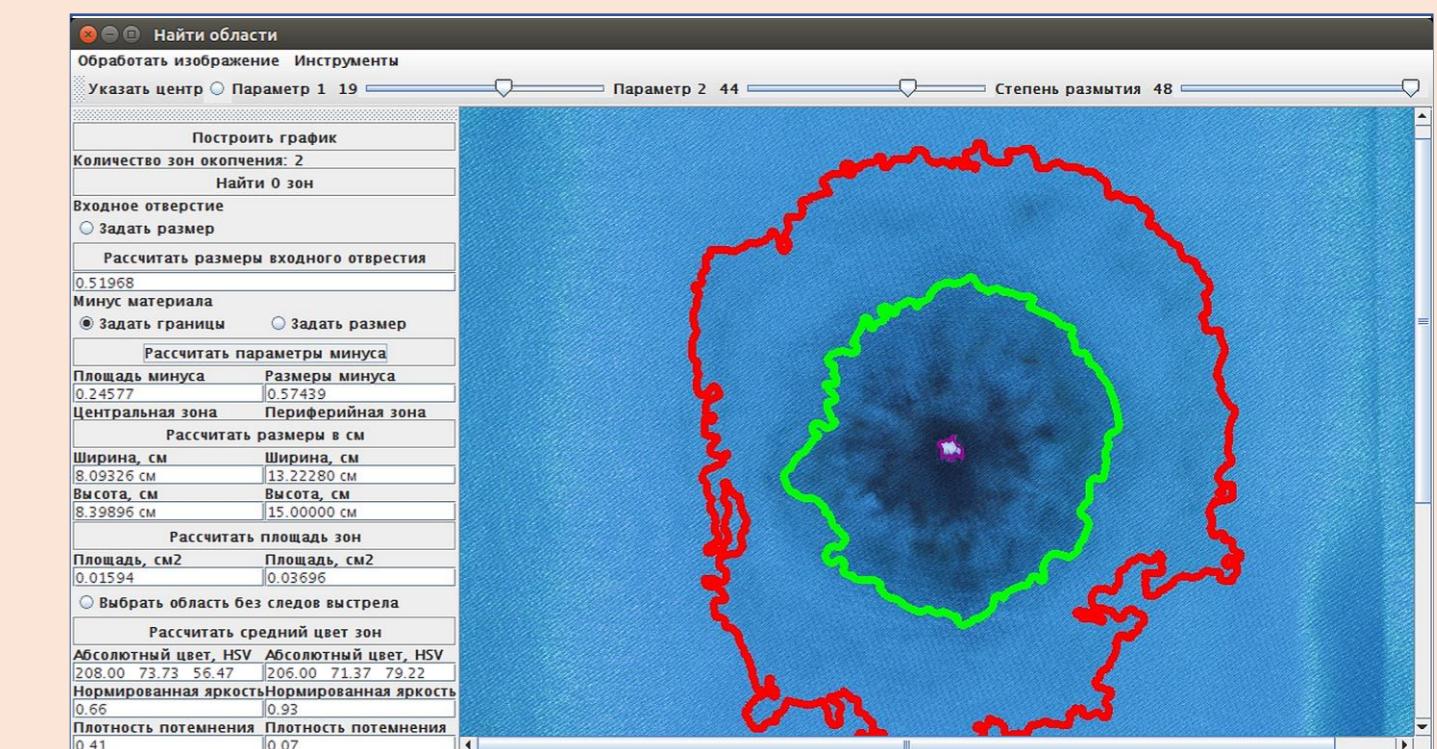


Fig. 2. The main window of the ImgOpinion desktop application.

surface characteristics, gunshot wound morphology and the topography of additional gunshot residue deposits.

## Conclusions

Hardware-software complex has been developed to automate the task of forming a damage passport, which will make it possible to create data systems to speed up the process of accident investigation and establishment of the circumstances of a gunshot.

## References

- 1.Latyshov, I.V.** Firearms and Their Traces on Bullets, Shells and Obstacles. Part 1. 7,62 mm pistol ed. 1933 (TT) (reference manual, in Rus) / I.V. Latyshov, I.I. Nikitin, V.V. Sidorov, I.A. Chulkov. - Volgograd: Peremena, 2001. - 83 p.
- 2.Kardanov, R.R.** The use of modern technologies for systematization of the trace pattern of use of firearms (in Rus) // Criminalistic means and methods in detection and investigation of crimes: materials of VI All-Russian scientific-practical conference on criminalistics and forensic examination with international participation. M., 2014.-216p.
- 3.Belyakov, A.L.** Weapons Science: Part 3. Forensic ballistics. Training manual (in Rus) / A.L. Belyakov, A.N. Matyushenkov, T.V. Popova - Chelyabinsk: Chelyabinsk Law Institute of the Ministry of Internal Affairs of Russia, 2004. - 200 p.
- 4.Smirnov, V.E.** Laws of development of a gas-powder jet at a shot from the small arms (in Rus) // Expert's technique. - Vol.65. - 1987. - p. 34-45.
- 5.Latyshov, I.V.** A firearm and its traces on bullets, cartridge cases and obstacles. Part 28. 5,45 mm AK-105 automatic rifle (Reference book, in Rus) / I.V. Latyshov, I.A. Chulkov, A.S. Kopanev, M.A. Ozdoev. - Volgograd: Volgograd Higher Military Academy of the Ministry of Internal Affairs of Russia, 2017. - 76 p.
- 6.Palchikova, I.G.**, Latyshov, I.V., Kondakov, A.V., Vasiliev, V.A., Smirnov, E.S. Color analysis of digital images during expert investigations of traces of body parts (in Rus) // Reports of the Higher School of the Russian Federation. - № 2 (27). - 2015. - pp. 88-101.
- 7.Palchikova, I.G.** Computer vision in analyzing the propagation of a gas-gunpowder jet / I.G. Palchikova, I.V. Latyshov, E.S. Smirnov, V.A. Vasiliev, A.V. Kondakov, I.A. Budaeva // Sensors - 2022. - Vol. 22(1). - [Electronic resource]. - Access mode: <https://www.mdpi.com/1424-8220/22/1/6> (06.02.2022). DOI: 10.3390/s22010006.
- 8.Latyshov, I.V.**, Palchikova, I.G., Kondakov, A.V., Vasiliev, V.A., Smirnov, E.S. Passport of firearm injuries as an integrative part of innovative hardware and software complexes (in Rus) // Forensic expertise. - 2020. - Vol.2(62). - pp. 58-65. DOI: 10.25724/VAMVD.NMNO.
- 9.Palchikova, I.G.** Autonomous spectrozonal illuminating device with white light function with high colour rendering index (in Rus) / I.G. Palchikova, E.V. Karamshuk, E.S. Smirnov, E.I. Palchikov, M.S. Samoilenco // Instrumentation and Experimental Technique. - 2021. - Vol.3.-P.155-157. DOI: 10.31857/S0032816221030241.
- 10.Photoshop system requirements. [Electronic resource]. - Access mode: <https://helpx.adobe.com/photoshop/system-requirements.html> (15.12.2021).