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Original Research Paper

# Automatic estimation of a scale resolution in forensic images

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ABSTRACT

This paper proposes a new method for an automatic detection of a resolution of a scale or a ruler with graduation marks in the shoeprint images. The method creates a vector of the correlations estimated from the co-occurrence matrices for every row in a shoeprint image. The scale resolution is estimated from maxima in Fourier spectrum of the correlations' vectors. The proposed method is evaluated on over 500 images taken at crime scenes and in a forensics laboratory. The experimental results indicate the possibility of applying the proposed method to automatically estimate the scale resolution in forensic images. The automatic detection of a scale resolution could be used to automatically rescale a forensic image before the printing this image in "one-to-one" scale. Furthermore, the proposed method could be used to automatically rescale images to an equal scale thus allowing to compare the images digitally.
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## 1. Introduction

At crime scenes footwear impressions or shoeprints are often found that later may be used as evidence in a crime investigation [1]. Several methods exist that concerns preservation of shoeprints for further use in crime scene investigations and in court. Photographies can directly be taken of a shoeprints at a crime scene [2] and in cases where footwear impressions are left in the snow or in the soil they may be casted [3].

In other cases an impression may be lifted using a so-called electrostatic lifting device [4]. Basically, in electrostatic lifting; a plastic film is placed over a footwear impression and subsequently the plastic film is electrically charged causing the film to adhere dust particles of the footwear impression.

A digital image of a shoeprint may be produced based on a shoeprint cast or a lifted shoeprint. The digital image of a shoeprint from a crime scene may be compared with the shoeprint images from other crime scenes and/or from a database with known shoeprints samples.

A photography at the crime scene can be subdivided into general crime scene photography and examination quality photography [1]. The examination quality photography should preserve the details of the impression evidence with greatest accuracy. To ensure the recording of the evidence with the maximum amount of detail specific protocols and recommendations have been established.

For example the Scientific Working Group on Shoe Print and Tire Tread Evidence (SWGTREAD) has published 15 guidelines regarding the evidence collection, examination, qualifications and training for a forensic footwear examiner [5]. The guidelines prescribe the procedures to be used, the requirement to the equipment to be employed such as cameras, tripods, lighting, scales and other factors. For instance, a finely divided rigid scale should be placed level and parallel to the impression and film plane [2].

To provide information on the absolute size of a shoeprint in an image of it; a rigid scale should be included with the shoeprint when the photography of the shoeprint is taken [6,2]. An example of a forensic photography of a shoeprint with a scale included is shown in Fig. 1. To document the absolute size of objects at a crime scene; different types of rulers or scales can be used and in Fig. 2 examples of scales that may be used in forensic photographing are shown.

However the examination quality photography might not be possible under certain circumstances. For example the imprints left in the snow can begin to deteriorate before a properly equipped and trained crime scene photographer arrives on the scene. Hence a first crime scene responder might use the available means to preserve the details of the scene and of the evidence.

Therefore the forensic photographies may contain an image of a scale with unknown units, a transparent scale with a background visible through the scale or a bent scale, as illustrated by Figs. 3(a)–(c), respectively. Furthermore, several factors can reduce

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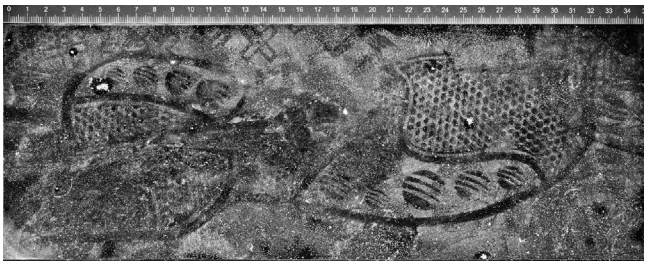

**Fig. 1.** Photograph of a shoeprint including a ruler, taken at a crime scene.

the quality of shoeprint images acquired at crime scenes. Examples of such factors are; poor contrast, see Fig. 4(a), uneven flood lamp or camera flash illumination, see Fig. 4(b), blurred millimeter marks, see Fig. 4(c) and noise in scale images, see Fig. 4(d).

An image of a ruler or scale of sufficient quality in forensic photographies of shoeprints enables investigators to reproduce shoeprint images in the same scale for further analysis [7]. For instance if the method, known as superimposition [1] is used for further analysis; one shoeprint image is printed on a transparent medium and subsequently compared with other shoeprint images by placing the transparent shoeprint image on the top of each of the other shoeprint images it is of interest to compare with.

Another method, referred to as side-by-side examination [1] requires the images of the compared shoeprints to be of the equal size. A shoeprint image used for examination purposes should be in full scale, i.e. in one-to-one scale with the physical evidence [1]. Thus, in a printed version of a shoeprint photo the distance between the center of the millimeter marks of the scale image should be equal to 1 mm. The general manual calibration

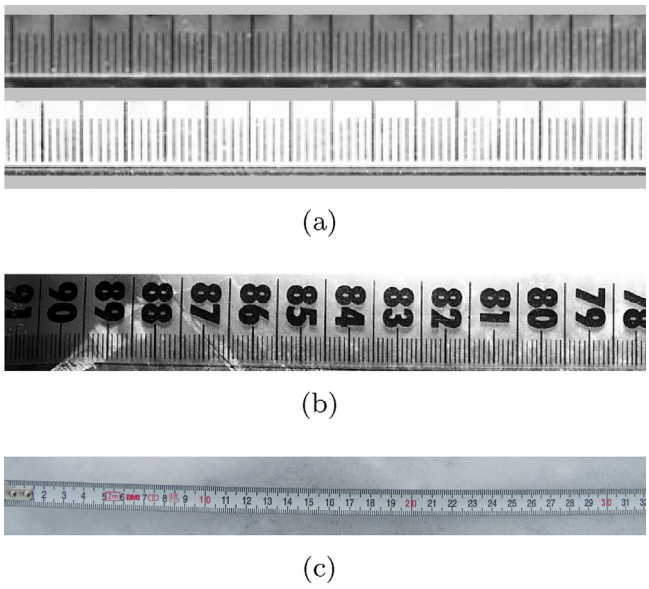


**Fig. 3.** (a) Scales with unknown units, (b) a transparent scale with the background visible through the scale and (c) bent scale.

procedure of a digital image for correctly printed image in full scale using Adobe Photoshop can include 14 steps [8]. This procedure includes a compulsory step of manually indicating the borders of the millimeter marks in digital image's.

A pattern in an image of scale graduations can be considered as a nearly regular texture, where texture describes the spatial variation of pixel intensities in a digital image. Several methods for

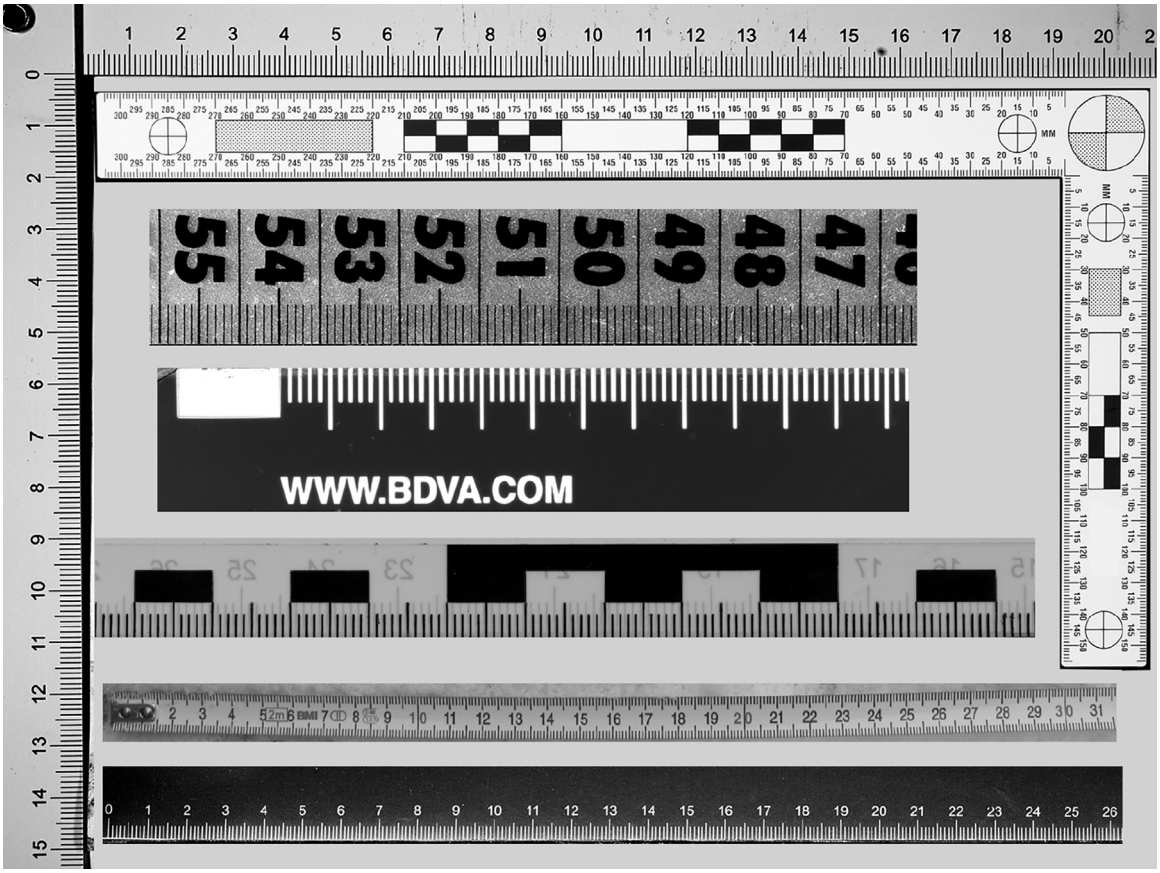


**Fig. 2.** Different types of scales that can be found in the shoeprint images.

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