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A user-friendly technical set-up for infrared photography of forensic findings

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ABSTRACT

Infrared photography is interesting for a use in forensic science and forensic medicine since it reveals findings that normally are almost invisible to the human eye. Originally, infrared photography has been made possible by the placement of an infrared light transmission filter screwed in front of the camera objective lens. However, this set-up is associated with many drawbacks such as the loss of the autofocus function, the need of an external infrared source, and long exposure times which make the use of a tripod necessary. These limitations prevented up to now the routine application of infrared photography in forensics.

In this study the use of a professional modification inside the digital camera body was evaluated regarding camera handling and image quality. This permanent modification consisted of the replacement of the in-built infrared blocking filter by an infrared transmission filter of 700 nm and 830 nm, respectively. The application of this camera set-up for the photo-documentation of forensically relevant post-mortem findings was investigated in examples of trace evidence such as gunshot residues on the skin, in external findings, e.g. hematomas, as well as in an exemplary internal finding, i.e., Wischnewski spots in a putrefied stomach.

The application of scattered light created by indirect flashlight yielded a more uniform illumination of the object, and the use of the 700 nm filter resulted in better pictures than the 830 nm filter. Compared to pictures taken under visible light, infrared photographs generally yielded better contrast. This allowed for discerning more details and revealed findings which were not visible otherwise, such as imprints on a fabric and tattoos in mummified skin.

The permanent modification of a digital camera by building in a 700 nm infrared transmission filter resulted in a user-friendly and efficient set-up which qualified for the use in daily forensic routine. Main advantages were a clear picture in the viewfinder, an auto-focus usable over the whole range of infrared light, and the possibility of using short shutter speeds which allows taking infrared pictures free-hand. The proposed set-up with a modification of the camera allows a user-friendly application of infrared photography in post-mortem settings.

1. Introduction

Photographic documentation is an important means of collecting and preserving physical evidence and is crucial in legal processes [1]. Especially concerning the documentation of injuries of the skin, photography is often the only means of preserving the evidentiary value of the injury. Since the unaided human eye is incapable of seeing outside the visible light spectrum (ca. 380–780 nm), special photographic techniques are utilized to create images in the non-visible zones of electromagnetic radiation. Reflected infrared (IR) photography captures IR light in the near IR range (ca. 700–1100 nm) which is reflected by objects in substantial amounts. Thus, specific absorption and reflexion properties of these objects can be detected that otherwise, using conventional visible light photography, would be invisible.

The use of IR light has a long tradition in forensic sciences. As early as in 1970 IR light has been used to examine documents for alterations. Additions made to the document may be detected by a

Abbreviations: F, focal length; HDR, high dynamic range; IR, infrared; ISO, sensitivity of sensor according to ISO 5800; SLR, single-lens reflex camera; TTL, through the lens; UV, ultraviolet light.

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difference in IR luminescence between the original text and the additions, and entries that have been chemically erased can be visualized because the pigments remain on the surface of the uppermost fibres of the paper [2]. IR light is also suitable for visualizing blood and has the advantage over chemical methods that it does not physically interact with the blood [3]. Blood appears dark in an IR image since near infrared light is strongly absorbed by blood whereas many backgrounds reflect it [4]. Thus, IR photography can be used for the detection of blood stains, even on coloured backgrounds, after a long time span, or when diluted or covered with several layers of paint [5–8]. In general, the detection of blood with IR photography works well when blood has been absorbed into a porous surface, whereas blood on a non-porous item like a vinyl surface becomes invisible under IR light [3]. In IR pictures skin appears light, milky, and homogenous even if pigmented [9]. Thus, IR photographs can show where bleeding has occurred, even below the surface of the skin, at the deeper levels of the dermis and below [1]. IR photography is suitable to show tattoo ink located between the epidermis and the dermis [10]. At crime scenes IR photography can be used to non-destructively examine gunshot residues, that exit the muzzle's bore when a weapon is fired, by revealing a visible powder pattern even on dark or multi-coloured fabrics [11]. Trace impression evidence such as tire prints on a dark background may be invisible to the naked eye, but may become visible using IR light [7].

While there are undoubtedly many important applications and opportunities of IR photography in forensic science, the handling of IR photography has many limitations which to date prevent the routine use of this technique. To produce an IR photograph all visible light must be filtered out which is traditionally performed by placing an IR light transmission screw filter over the lens [12]. The problem thereby is that these filters are visually opaque and block the photographer's view of the subject through the camera's viewfinder. Thus, before placing the screw filter in front of the lens the focus has to be chosen, and exposure time and aperture have to be estimated as the opaque filter is associated with the loss of the autofocus function. A further disadvantage is the mandatory use of a tripod due to the long exposure times which are needed as only a very small amount of light (i.e. IR light) is transmitted to the image sensor [13]. For all these reasons, Albanese and Montes [14] concluded that the complex set-up makes IR photography too cumbersome for the practical use in most forensic situations.

However, with a specific and permanent camera modification a user- friendly and efficient application of IR photography became possible. The objective of this study was to describe the technical setting of the methodology using a specific camera modification, and to present results of various applications of this IR photography set-up in a forensic context showing examples of trace evidence, and external as well as internal findings.

2. Material and methods

2.1. Camera modification

Objects reflect, transmit, scatter, and absorb light. The visible portion of light has wavelengths extending from about 380 to 780 nm. Thus, the reflection of light with wavelengths of more than 780 nm, defined as IR light, is invisible to the human eye. The limit is not sharp since the sensitivity of the human eye decreases gradually and not abruptly at the borders of the visible light range. IR light used for reflected IR photography ranges from about 700 to 1100 nm. Digital SLR cameras are inherently sensitive to light with wavelengths in this range. Usually in off-the-shelf cameras, IR light is blocked from reaching the image sensor of the camera by IR absorbing filters installed in front of the sensor in order to allowing only visible light to pass. These IR blocking filters improve optical performance, assist with chromatic aberration correction, and guarantee that resulting images look identical to what is seen by

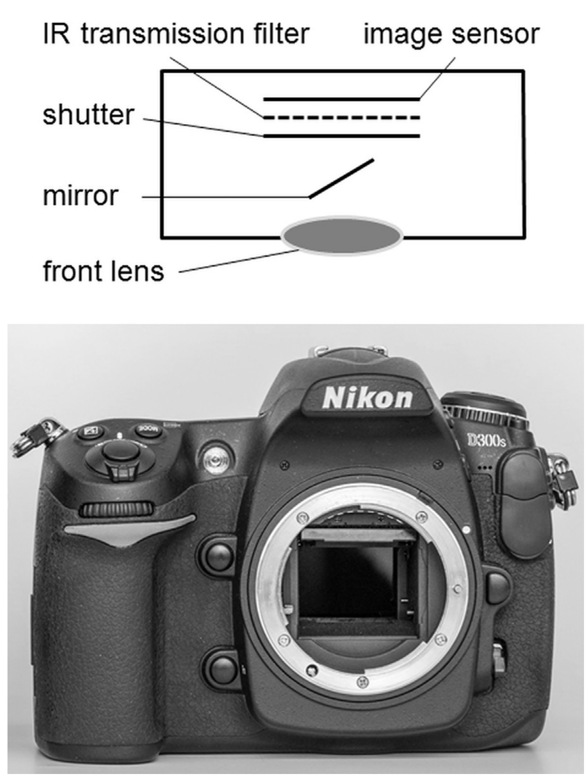

Fig. 1. Nikon D300s with the IR blocking filter removed and a schematic drawing of the defined modification of the camera. For using the camera in the IR range the inbuilt IR blocking filter system between the shutter and the image sensor was replaced by an IR transmission filter which blocks UV and visible light from reaching the sensor.