A198 A 3D Imaging Device for Tire and Footwear Impressions

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After attending this presentation, attendees will see a description of a new prototype device to capture three-dimensional (3D) height images as well as two-dimensional (2D) color images of tire and footwear impressions.

This presentation will impact the forensic science community by introducing a new device and a new method for non-destructively capturing the details of impression evidence by producing high-resolution 3D depth images with metric measurements co-registered with high-resolution color images.

The anticipated manner of using this device will be to take the device to the field and scan impression evidence. The result of this is an HD video on an SD card that is then processed in the crime lab in order to generate the 3D impression image and the 2D color image of the evidence. The resulting 3D impression evidence can be used to match suspect footwear or tires. Through the use of automated matching algorithms that utilize the 3D impression image, a goodness-of-fit measure can also be calculated.

The design of the device is based on a class of methods known as “shape from structured light.” It uses a camera/line laser assembly that can estimate the surface depth values along a single laser line in the image based on the deformations of the laser line caused by the surface shape. This results in a one-dimensional (1D) depth image in one frame of the video along the laser line. The depth image of the entire impression is generated by moving this camera/line laser assembly along a motorized rail at a precisely controlled and constant speed and estimating the depth values along successive laser lines. The desired 3D image of the impression is obtained by stacking these one-dimensional depth values along the axis aligned with the rail movement direction.

The camera used in the camera/laser assembly is a high definition (HD) video camera. Scanning of the surface consists of recording the video at 30 frames per second (fps) as the camera/laser assembly moves along the rail. This video is later processed in the crime lab to compute the impression depth image. The HD video camera is oriented such that the highest resolution of the camera image is perpendicular to the rail motion, thus increasing the resolution in this perpendicular direction. The image formation model along this direction is perspective projection. The resolution of the image along the rail motion depends on the speed with which the camera assembly is moved—the slower the motion, the higher the resolution of the depth image in this direction. Moreover, the image formation model in the direction of the rail movement is orthographic projection. This allows long span impression evidence such as tire track impressions to be scanned in a single attempt without the need to consider camera models and the necessity to stitch together multiple 2D images.

In order to obtain the proper metric scale of the impression evidence, a calibration object is placed next to the impression and this object is scanned as part of the data. This eliminates the need for pre-calibration of the system. Instead, the calibration object in the captured video and the object’s true dimensions are used in order to compute the impression surface shape with true scale information.

The resulting device is portable, easy to use, is non-destructive of the evidence, saves time at crime scenes compared to current methods, and provides metric information about the surface shape. The device is designed to be able to digitize long tire track impressions (up to 1.75m) in a single scan without the need to capture multiple images and stitch them together. The 3D images produced by the device can have a resolution in depth of 1mm to 0.5mm, capturing fine details. The image resolution along the rail motion can be as little as 0.0438mm. The image resolution perpendicular to the rail motion at a distance of 500mm is about 0.2369mm. The basics of the design, how the device works, and some impression digitization results using it will be presented.

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Impression Evidence, 3D Image, Depth Image

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