## B23 Quantifying Measurement Variation and Evidential Value When Performing Body Height Estimations in Digital Images

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After attending this presentation, attendees will understand principles of how to cope with measurement errors when performing body height measurements in images and how to quantify eventual evidential value.

In forensic practice, height estimations on perpetrators visible in video footage from surveillance cameras are regularly requested. The approach to this at the Netherlands Forensic Institute is the following: the crime scene is visited with a number of test persons. A Closed Circuit Television (CCTV) or camera image is selected in which the perpetrator is standing more or less in upright position. The test persons are positioned at the same location and in front of the same camera as the perpetrator on the original footage in as much as possible the same pose. This procedure is called a reconstruction and yields validation readings that allow to correct interpretation of height estimates of the perpetrator.

On the basis of 2-D photographs and fixed location points, a 3-D model of the scene of the crime is created. Using common points of the 3-D model and the camera view on the questioned image, the location and orientation of the camera is determined, and the 3-D model is projected such that it has the same perspective as the camera images. Next, investigators perform height measurements on the test persons and the perpetrator by placing cylinders over the bodies in the 3-D model, from feet to head. The height of the cylinders approximates the actual height of the test persons and perpetrator, reduced by the loss in height by the pose of the perpetrator. Variation between actual and measured heights of the test persons and the perpetrator is introduced by factors like creation of the 3-D model, finding of camera orientation and focal length, presence of lens distortion, pose of the perpetrator in the chosen image, presence and height of head- and footwear, interpretation of head and feet in the images by investigators. This variation may be decomposed into a systematic and a random part. By measuring reference objects in the image, like measuring sticks, an estimate of the systematic error by variation in the modeling of the crime scene can be made. Systematic error by varying height loss because of pose cannot be estimated directly. In practice (casework), systematic errors amount to several centimeters and vary from case to case. Since variation introduced by head- and footwear cannot be removed without extra knowledge, height measurements are usually of the test persons and the perpetrator including head and footwear.

The goal is to answer the following two questions:

1. On the basis of the measurements, how can probability statements be given (confidence intervals) on the actual height of the perpetrator?
2. In case there is a suspect: what is the evidential value, in terms of a Likelihood Ratio, of eventual resemblance of suspect's and perpetrator's height?

These questions have not received much attention in the literature, which has focused more on technical methods than validation. Using normal approximations and the observed variation on test persons, a method is described for obtaining confidence intervals for the height, including head- and footwear, of the perpetrator. Since the number of test persons is usually limited, the result is in terms of the Student-t distribution. In addition, an expression is obtained for the Likelihood Ratio, measuring the strength of evidence of resemblance of the actual height of a suspect and the measured height of the perpetrator. This depends both on the rarity of the estimated perpetrator's height and on its closeness to the suspect's height. The analysis of validation measurements described in the current paper does not depend on the method used and holds up as well if measurements are made on the basis of projective geometry (vanishing points).

**Evidential Value, Body Height Estimation, Confidence intervals**

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