Likelihood Ratios of Hair Using RGB Color Values and Diameter

Victoria Echternach, Casey Rech, Emma Redman, Isabel Sandone and Lawrence Quarino, Ph.D., ABC-GKE

-GKA

Cedar Crest College, Allentown, PA 18104

Introduction

Microscopic hair comparison has been under attack for many years by scientists, lawyers, and legal scholars and has caused many forensic laboratories and laboratory systems to discard it. One of the major criticisms is the subjective nature of hair comparison and a lack of statistical evaluation. The presented study hopes to establish a model whereby a likelihood ratio could be calculated to assess the probability of encountering a random hair using two objective measurable variables, diameter and color.

Materials and Methods

- Human hairs were collected from vacuum sweepings from common places (e.g. lecture halls) at Cedar Crest College using a trace evidence vacuum (**Figure 1**).
- Two hundred and fifty hairs were mounted in DPX mounting media (n_D-1.521).
- Photographs were taken of each hair under 200x using an Olympus BX53 polarized light microscope (**Figure 2**) set up for Kohler Illumination under standardized lighting conditions. Photographic parameters included correction for white balance and an ISO of 200. Measurements were taken of the captured image.
- Using a measurement tool in the CellSens software, diameters of each hair were taken in 3 locations along the hair shaft toward the middle of the hair. Similarly, 5 RGB values were taken at different points in the cortex approximately 3 µm from the edge of the hair (**Figure 3**).
- Mean and standard deviation of each parameter was taken of each hair.
- The mean standard deviation of each color and diameter of all hairs was used to construct a floating bin database (**Figure 4**).
- Hairs taken from 4 of the authors were examined and compared to the database.
- A random match probability for each hair was determined using the product of the frequency of a matching color or diameter with hairs in the database.
- A 95% upper bound confidence interval was determined from each random match probability using $p+1.96[p(1-p)/N\}^{1/2}$. The reciprocal of this value was used to determine a likelihood ratio.

Figure 1 – Trace Evidence Vacuum

Figure 2 – Olympus BX53 Polarized Light Microscope

Results and Discussion

- Mean frequencies of diameter for the 4 test hairs ranged from 0.100 - 0.188.
- Mean frequencies for red, green, and blue for the 4 test hairs ranged from 0.152-.232, 0.132-.308, and 0.112-0.352 respectively.
- Random match probabilities ranged from 10^{-3} to 10^{-4}. All upper bond confidence intervals were in the 10^{-3} range.
- Likelihood ratios of 336 (blonde hair), 216 (dark dirty blonde brown hair), 164 (red hair), and 106 (light brown hair) were determined.

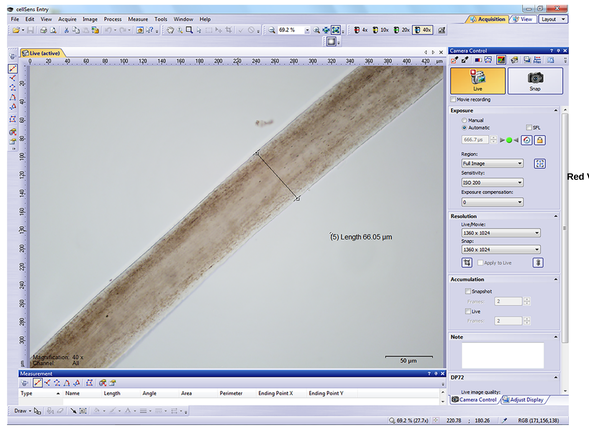

Figure 3 – Image Capture Using CellSens Software

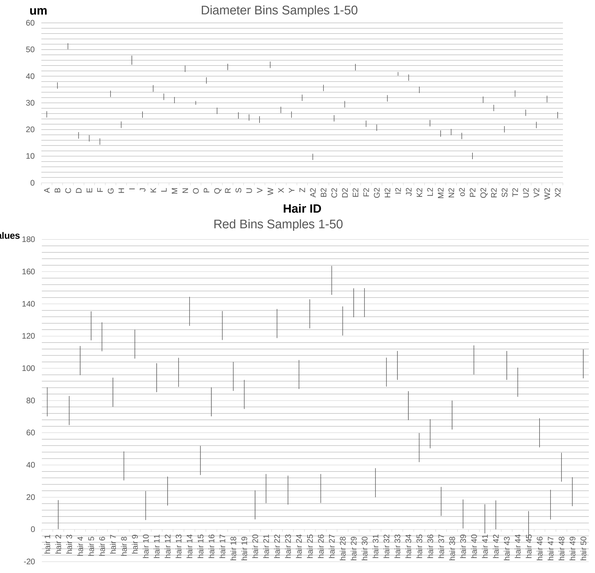

Figure 4 – Schematic of Floating Bin Construction for Diameter (top) and Color (red shown)

Discussion

- The use of color and diameter in this study for hair discrimination is in agreement with previously published work using multivariate statistical analysis (1).
- Statistical probabilities in this study were much lower than previous studies which also included subjective determination of hair characteristics (2-3).
- The use of subjective use of hair characteristics may vary from examiner to examiner whereas objective measurements such as color will not.
- Given that there are over 180 million RGB combinations, the likelihood ratio for any one hair regardless of color is likely to have the same order of magnitude.

References

1. Mills M, et al. J Microscopy, Vol 270, 2014.
2. Gaudette BD, Keeping ES. J Forensic Science, Vol 19, 1974.
3. Wickenheiser RA, Hepworth DG. Journal of Forensic Science, Vol 35, 1990.