D32 Using Finite Element Modeling to Extend Non-Contact Age Estimation of Blood Stains to Complex Blood Stain Morphologies

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After attending this presentation, attendees will gain insight regarding the possible use of finite element modeling to enhance spectroscopic methods for non-contact age estimation of blood stains.

This presentation will impact the forensic science community by providing an improved non-contact method for the age estimation of blood stains.

Many crimes involve the transfer of biological materials, including hair, tissue, and bodily fluids such as blood. Knowledge of the age of such biological traces is of great importance; a temporal relation of a biological trace to the pertinent crime may render the sample as "activity level" evidence. As a result, there is a clear need for age estimation methods for biological traces.

An innovative non-contact method for estimating the age of blood stains was recently developed. To this end, Visible Near Infrared (VIS-NIR) spectroscopy reflection measurements were used in conjunction with a physical one-dimensional light transport model describing the wavelength-dependent reflection profile of a blood stain. In this model, blood stains were represented as a two-layered system: a top layer of blood deposited on a substrate, with layer-dependent optical properties. In addition, the chemical reaction governing the aging of blood stains was assumed to consist of three phases: full oxygenation of the hemoglobin to oxyhemoglobin; subsequent auto-oxidation to methemoglobin; and a further denaturation to hemichrome. The stoichiometry of these three phases was assumed to vary with time, corresponding to the chromatic changes observed in aging blood stains. By probing the relative quantities of these chromophores using reflectance spectroscopy, the present approach provided an estimate of blood stain age. This was achieved by means of a least-squares fit of the light-transport model to the measured reflection spectrum of a blood stain.

Despite the excellent predictive capabilities of this approach for special cases of blood stain morphologies, namely complete layer separation and no layer separation, more complex morphologies remain challenging. The diversity of blood stain morphologies is a direct consequence of the continuum of possible porosities, rheologies, and geometries of various blood stain substrates. This multitude of blood stain morphologies corresponds to different regimes of light propagation, which in turn represents the limits of validity of the currently employed light-transport model. This has implications for the applicability of this approach in forensic practice as the number of conceivable morphologies of blood stains exceeds the two mentioned special cases.

This presentation explores how the theory of light-transport can be further developed to probe complex blood stain morphologies, thus enhancing the versatility of the approach. To this end, finite element modeling is used in conjunction with phantom measurements to simulate and investigate the effects of blood stain morphology on light propagation. The findings of this study form the basis of an extended light-transport model for improved applicability and dating accuracy of the developed non-contact approach.

Blood Stains, Age Estimation, Non-Contact

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