J19 An Evaluation of Gray Value Measurements and Hyperspectral Imaging (HSI) as a Method for Differentiating Optical Characteristics of Porous-Tipped Pen Inks

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Learning Overview: After attending this presentation, attendees will have gained knowledge about the capabilities of objective image analysis using gray value measurements and HSI aiming to increase the differentiation between porous-tipped pen ink samples.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by expanding on gray value measurement research and exploring HSI for the applicability of pen ink analysis to increase confidence and transparency in forensic document examinations.

Porous-tipped pens, commonly recognized by their absorbent porous tip composed of compressed felt, fiber, plastic, nylon, or ceramic, are an under-researched area in the field of questioned documents. Most research has been focusing on ballpoint and gel ink pens since these types of pens are often seen in casework. Porous-tipped pens appeared commercially in the 1950s and have since evolved into popular writing instruments for artists, designers, hobbyists, and journalists alike. These pens can be used to create pieces of art, comics, fashion or interior designs, storyboards, and much more. Porous-tipped pens are available in a variety of colors with a range of tip types from ultra-fine points to brush tips to broad chisels. The ink used for porous-tipped pens is fluid, allowing for the potential to blend colors similar to watercolor painting. Forensic Document Examiners (FDEs) frequently utilize filtered light and radiation to reveal differentiating optical features of pen inks in a non-destructive and non-invasive manner. The primary drawback is the inherently subjective nature of solely relying on visual examination of the detected optical characteristics. The blending feature of porous-tipped pens can also lead to difficulties for FDEs due to the change in color as a result of blending ink in artwork. Gray value analysis and HSI are proposed as objective approaches that can help increase transparency and confidence in pen ink discrimination. There is little research regarding the use of these two methods for pen ink analysis; however, HSI has been established as a useful method among art conservationists to analyze artistic manuscripts, drawings, and paintings.

There is a need within the field not only to further investigate newer types of porous-tipped pens and their blending capabilities, but also to continue to develop more efficient methods to analyze ink samples non-destructively and objectively. It is hypothesized that the combination of gray value analysis and HSI will aid in discriminating between porous-tipped ink samples. The goal of this project is to determine the most efficient protocol to objectively characterize and differentiate blended porous-tipped pen inks based on their optical characteristics. A protocol that utilizes the high-resolution imaging system by means of a Video Spectral Comparator (VSC) is being developed consisting of a combination of the most efficient illumination types and filters to maximize the discrimination of porous-tipped marker samples for a given color family. An objective and reliable image analysis approach is established based on gray value measurements and HSI that derives numerical data from images collected with the VSC.

Porous-tipped pens from five different brands were chosen for this project, as well as four different types of paper to determine if the paper medium influences the optical characteristics of the ink samples. Ink stroke samples using six colors from each brand were used to create 120 total samples. Several blended ink samples were also created as unknowns to test the proposed methods. Visual examination was performed to determine if samples could be differentiated based on color alone. All samples were recorded using the VSC under eight filters. Illumination conditions such as Infrared (IR) absorbance, IR luminescence, and Ultraviolet (UV) fluorescence were used to discriminate between ink samples in the same color family. The gray values of samples that underwent IR reflectance and IR luminescence were measured using ImageJ software. All samples were further examined under the HSI feature of the VSC to obtain an image cube, and reflectance visible spectra were collected. It was observed that both gray value analysis and HSI separately increased the number of differentiations compared with visual examination and filtered light examination. This project is a part of a broader study to investigate, develop, and propose potential methods, both traditional and novel, to analyze porous-tipped pens.

Questioned Documents, Ink Analysis, Image Analysis

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