Forensics Opening Workshop
August 31 – September 4, 2015

SPEAKER TITLES/ABSTRACTS

Colin Aitken
University of Edinburgh

"Evaluation and Interpretation of Evidence: What Can Be Done, What Is Done, What Should Be Done"

The goal of this research program is to strengthen the statistical and applied mathematical bases of forensic science. This talk will concentrate on the statistical basis and mainly on the evaluation and interpretation of evidence. There will be a review of recent statistical developments to show some areas in which statistical analysis has helped and what can be done currently in assisting, first, the forensic scientists evaluate and interpret their evidence and, second, the courts in understanding that evidence. Illustrations of what is being done will be given with reference to two recent court cases in England, and some publications and activities. The presentation will conclude with proposals for research and education in the context of the legal framework within which forensic scientists work.

John Black
Black & White Forensics, LLC

"Fundamental Tenets of Latent Fingerprint Examination"

This lecture will address some of the fundamental principles of latent fingerprint examination, beginning with uniqueness and persistence. We will then closely examine the current framework for decision-making and how the concept of 'sufficiency' plays a major role in these decisions. A discussion regarding the accuracy of latent print examiners' conclusions will complete the presentation.

Eugene Fiorini
Muhlenberg College

"Education: Connecting Forensics and Mathematical Sciences"

The issues facing the forensic science community call for a new type of workforce, trained in the mathematical sciences through multidisciplinary and multi-national communication and collaboration. To function in this rapidly developing forensic world, students in mathematical sciences classes will need to appreciate the most important concepts at the interface between their discipline and others. They will need to develop an increasingly sophisticated understanding of the ways that disciplines interact, the new knowledge that is created through this interaction, and the new educational and career opportunities in an inherently multidisciplinary field. Students from non-mathematical disciplines will benefit from observing the importance of mathematical sciences tools for their discipline.

This session will begin the discussion on what materials exist and which materials could be developed for undergraduate and graduate students interested in a forensics career. How do we connect mathematical sciences with other forensic disciplines? Do we develop multidisciplinary courses that relate to forensics? Do we inject multidisciplinary forensic topics into existing curricula? Are case study courses a good medium? Do we put more emphasis on multidisciplinary forensic projects as part of existing courses? Does it matter what the "other" discipline is, or is some multidisciplinary experience sufficient? How do we prepare mathematical sciences students to work in forensic disciplines that they might not encounter until later in their careers? What is the role of team experiences? Could increasing emphasis on forensic topics early in undergraduate education improve retention of STEM majors? Do forensic topics provide opportunities for involvement of undergraduates in research, e.g. because of the availability of forensic data sets? How do we prepare faculty for multidisciplinary education in forensic topics?

The session will begin with a brief introduction of the current status of materials, then proceed with a breakout session discussing possible options, and return to share those ideas with the group.

Stephan Huckemann
University at Gottingen

“Challenges in Image Analysis of Fingerprints”

Fingerprint analysis usually comprises the following five tasks: 1) image segmentation, 2) orientation field estimation, 3) image enhancement, 4) feature extraction and 5) feature matching. This talk focusses on the first three tasks and concludes with challenges towards latent fingerprint analysis.

Anil K. Jain
Michigan State University

“Forensic Pattern Recognition”

Pattern recognition techniques are used to learn to automatically recognize physical objects (e.g., alphanumeric characters) or abstract multidimensional patterns (e.g., *n* points in a *d*-dimensional space). The recognition could involve (i) classification into one of pre-specified categories (supervised learning), (ii) grouping or clustering (unsupervised learning), or (iii) learning the similarity between two patterns, say face images. Pattern recognition systems are routinely used for license plate recognition, document classification, speech and speaker recognition, blood cell (leukocyte) classification, military target recognition, industrial inspection, etc. The design of a pattern recognition system requires the following modules: (i) sensing, (ii) feature extraction, (iii) learning decision rules, and (iv) performance evaluation. In this talk I will introduce the topic of forensic pattern recognition and provide examples of systems for fingerprint matching, face recognition and ballistic image matching based on breech face impression.

Karen Kafadar
Univerity of Virginia

"The Role of Statistics in Forensic Science"

The use of statistics and probability in assessing DNA evidence is well known. The incorporation of statistical design, methodology, and uncertainty in other forms of forensic evidence is much less frequent, especially pattern evidence (fingerprints, ballistics matching, hair comparisons) which often arises in forensic evidence (and will be covered in depth by later speakers). In this talk, I will discuss the role of statistics in (a) developing quantitative procedures for pattern evidence based on science from other disciplines (e.g., imaging); (b) approaches to identifying sources of variability in such procedures; (c) experimental designs for comparing accuracy rates from "previous" versus "proposed" procedures; and (d) the role of traditional concepts from statistical process control in laboratory procedures.

Peter Neufeld
Innocence Project

"Upstream Remedies to Prevent Wrongful Convictions: The Statistical Significance of Research"

The National Academy of Sciences' 2009 report, *Strengthening Forensic Science in the United States: A Path Forward*, noted the paucity of research in forensic science. Most research that had been done in non-DNA forensic disciplines did not include the assistance of statisticians or included problematic statistics promulgated by non-statisticians. The statistical community has taken on the enormous challenge of moving an entire practice to quantify uncertainty and properly express the limits of the testing data. Had statisticians been engaged earlier in the history of forensic science, wrongful convictions in which the misapplication of forensic science was a contributing factor may have been avoided. This talk presentation will describe the methods of the microscopic hair comparison review jointly undertaken by the FBI, Innocence Project, and the National Association of Criminal Defense Lawyers, describe the statistical problems exhibited by FBI agent testimony, and describe the scientifically invalid testimony that could have been avoided had statisticians been engaged in the first place.

Jacqueline Speir

"Preliminary Efforts to Quantify the Chance Similarity in Shape and Position of Randomly Acquired Characteristics in Footwear"

The objective for this research is to evaluate the chance coincidental association of randomly acquired characteristics (RACs) on the outsoles of a variety of footwear makes and models. To accomplish this goal, we have developed feature vectors to describe the shape and positional information associated with detected RACs. Once characterized, the features can be mathematical compared to determine similarities in type and position, thereby contributing to the literature on the discrimination potential of footwear evidence.

William Thompson
University of California, Irvine

"Managing Contextual Bias in Forensic Science"

Contextual bias is said to occur in forensic science when examiners are influenced by task-irrelevant information--i.e., information that is irrelevant to the analytic tasks examiners are asked to perform. A first step in addressing contextual bias is deciding what facts are task-relevant and task-irrelevant for common forensic tasks. For example, should a latent print examiner's conclusions on the source of a print be influenced by information about a suspect's criminal history? The suspect's alibi? Whether other evidence incriminates the suspect? A formal standard for task-relevance, which provides clear answers to these questions, will be proposed. The next step in addressing contextual bias is the development of context management procedures that allow analysts to have access to information that is task-relevant while shielding them from exposure to information that is task-irrelevant and potentially biasing. Various possible context management procedures will be discussed. Along the way the talk will address the underlying psychological mechanisms that create the potential for contextual bias and make the problem difficult to manage.

Bill Tobin
Forensic Engineering International

"What is 'Forensic Science'? A USMC Methodology for Amplification"

Decades of Hollywood "CSI" portrayals and flawed or nonexistent designs of experiments have imbued erroneous perceptions of forensic practices in the minds of jurists, advocates, jurors, and forensic practitioners. This session will provide an overview of pragmatic insight from a mainstream scientist who became an FBI Agent investigating criminal activities in Chicago and Detroit, and who was subsequently assigned to the FBI Laboratory "in the forensic trenches" as a forensic metallurgist, eventually testifying as an expert on similar issues before the U.S. Senate Subcommittee on the Judiciary. The presentation will use U.S. Marine Corps drill instructor methodology to impart understanding of the realities of forensic practices, how they were developed, inferential logic processes, fallacies of induction, potential biases, rates of error, and scientifically defensible inferences.

Sarena Wiesner

"Characterizing Shoeprints - from Class Characteristics to Accidental Marks"

In this presentation we introduce SESA (Statistical Evaluating of Shoeprint Accidentals) software, based on more than 12,000 accidentals in shoesoles. It is able to calculate the statistical probability that a specific accidental will appear on another sole. Every accidental characteristic will not repeat itself exactly, , but another accidental might be similar enough to confuse the expert. The software is capable of calculating the overall chance for any combination of accidentals. This methodology can be applied to many other forensic fields.
*This research project was sponsored by the NIJ, task no. 3211

Evaluation of accidental characteristics in shoeprints, leading to the level of confidence derived during the comparison process, is performed today in a qualitative assessment, without any statistical aid (in the "conclusion scale" method, not in the Likelihood ratio method used by the Bayesian approach)

In this presentation, we will show the results of an extensive research project conducted to develop a computer algorithm that will enable the shoeprint expert to estimate the evidential value of shoeprint defects in a quantitative way. Hundreds of shoe-sole impressions with a total of thousands of defects on them were collected. As a side product of the research, a program for computerized detecting the borders of defect contours was developed. The location, orientation and the contour of each defect were determined for all the defects on each impression. The evidential value of the defects found on a certain shoeprint is estimated based on multiplying the statistical calculations for the shape, location and orientation of each defect, as the defect appears on the test impression. This research required decision making at various stages of development. These junctions had a vast effect on the statistical outcomes of the program. These dilemmas and their resolutions will be presented as well. This research deals only with individual characteristics as they appear on the test impression. Real shoeprints and calculations for the design, size the degree of the shoe-wear are not part of this research. The numerical results of the software can be used by all methods of evaluating shoeprints- Bayesian and conclusion scale practitioners.

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Yoram Yekutieli
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“Challenges in Image Analysis of Shoeprints”

Image analysis and image processing of shoeprints are essential ingredients of numerous tasks mostly related to recognition and identification, but also to image enhancement, data visualization and other objectives. A brief overview of these tasks with some examples will be given.

The major part of the talk will focus on challenges in image analysis of shoeprints, we faced in developing the SESA (Statistical Evaluating of Shoeprints Accidentals) system. The lessons we learned will be presented as well as our understanding of the challenges ahead.

Our main objective in the SESA project was to describe the probability of occurrence of accidental characteristics in shoe prints. Accidentals are (usually) small defects such as tears, cuts and nicks, caused to the shoe sole during the usage of the shoe. Accidentals present on the suspect’s shoe as they appear on the test impression and identified on crime scene prints as well, may provide enough information to establish identification of the shoe.

In developing the system we faced both theoretical and practical challenges. For example, we had to decide how to define accidentals and how to mark them digitally. The challenges here include issues of segmentation, shape description and analysis, and texture modeling.

In order to estimate the probability of occurrence of accidentals we marked numerous accidentals on multiple shoeprints, and measure three features of each accidental: its *location*, *orientation* and *shape*. This raised further questions of defining and measuring each feature: what is *location* of a characteristic and with respect to what should it be measured, how *orientation* should be defined and measured, and what is *shape* and how to measure it. Each question lead to more open tracks, as will be described.

Combining the information from many shoes of various patterns raised the problems of alignment and normalization. Challenges here are defining and constructing a universal shoe aligned coordinate systems, and dealing with partial shoeprints.

Noise is a major issue when building pattern recognition systems. The challenges here are measuring the noise of the different components of the system, including those that involved human operators. Issues of human-machine interaction and user interfaces that are tightly related to the image analysis system add complexity.

In developing SESA we dealt mainly with controlled test impressions, but we gained insights on the broader problem, and that assisted in identifying the major challenges ahead:

Dealing with variable inputs. The inputs to analysis systems may vary considerably, depending on the retrieval and acquisition methods, and whether the shoeprints are crime scene prints or lab impressions.

Treating noise. Related to the large variations in inputs are the numerous sources of noise in shoeprints.

Lack of information. In practice, shoeprints may lack information needed by the expert examiner to identify details without the shoe itself or at least images of the shoe sole. Can automated systems be developed to use only shoeprints? How should shoeprints and shoe sole images be used together?

Scalability of recognition systems and databases of shoeprint accidentals. There are a lot of challenges in managing large systems that are supposed to be used by a community of researchers and practitioners. Some are related to image analysis, e.g. establishing standard tools of marking and analysis, and developing fast and accurate retrieval systems.

Sandy Zabell
Northwestern University

"Detecting Bias: Examples and Approaches"

In this talk I discuss a number of examples of how bias can arise in scientific studies, emphasizing the importance of the role of blindness in evaluation as a key antidote to this basic problem. The double-blind, randomized controlled trial, in particular, has become the gold standard for scientific studies in clinical medicine; the reasons for the importance of each of the three elements in this approach will be laid out via a series of sobering and cautionary tales.