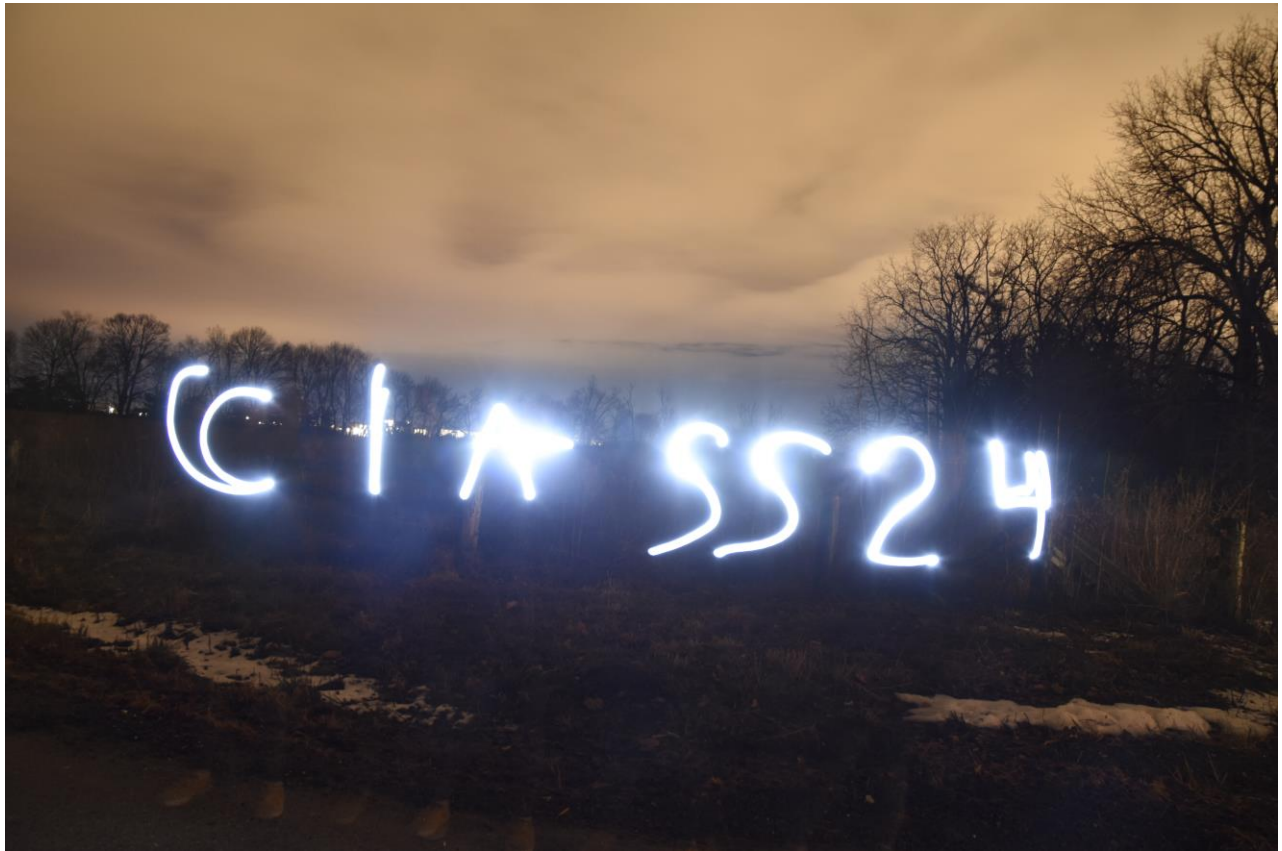


WELCOME TO THE 16th ANNUAL FORENSIC SCIENCE RESEARCH DAY



**Thursday, April 18th, 2024
- Regent Theatre -**



 Photo by: Alexa-Maude Beaudin, Martina Maffei, Liam Murphy Francis Turano (2023)

ONTARIO TECH FORENSIC SCIENCE RESEARCH DAY 2024

Program Schedule

8:30 a.m.	Registration	
8:45 a.m.	Land Acknowledgement & Opening Remarks	Kimberly Nugent, M.Sc. <i>Associate Teaching Professor</i>
8:50 a.m.	Keynote Address	Renata Dziak, M.Sc. <i>Forensic Biologist, Centre of Forensic Sciences</i>
9:10 a.m.	Session I	Chair: Jeff Ward, BFI <i>Adjunct Professor</i>
10:00 a.m.	Session II	Chair: Theresa Stotesbury, PhD <i>Assistant Professor</i>
1:03 p.m.	Closing Remarks	Dr. H������������, PhD <i>Associate Professor</i>
1:05 p.m.	Group Photo & Congrats!	

The research conducted by our fourth-year students would not have been possible without the support and mentorship of our supervisors and mentors!

THANK YOU!

Mission Statement

The Forensic Science program at Ontario Tech University strives to create an interdisciplinary learning environment dedicated to education in, research for, and contribution to the forensic community.

Specifically, the Forensic Science program at Ontario Tech University endeavours to:

- Advance the highest quality of knowledge, skills and abilities through excellence in teaching and a technologically-enhanced learning environment;
- Foster inquiry, critical thinking and scholarship in innovative research by providing access to state-of-the-art facilities and supervision by internationally recognized faculty and professional experts;
- Actively collaborate with industry to produce outstanding graduates who are consistently sought after and highly valued by professional partners and employers;
- Command next-generation leaders demonstrating integrity, ethical behaviour, and professional conduct in the field of forensic science;
- Contribute to society through community participation, leadership and outreach initiatives, with the goal of inspiring youth.

Forensic Science Program Accreditation

We are pleased to announce that our program was successful in obtaining re-Accreditation. It is the second such program in Canada granted this distinction by the American Academy of Forensic Sciences' Forensic Education Programs Accreditation Commission (FEPAC). Congrats!

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Ontario Tech Forensic Science

Schedule

8:45 **Welcome and Opening Remarks**
Kimberly Nugent, M.Sc.

8:50 **Keynote Address**
Renata Dziak, M.Sc.

Renata received her Master of Science degree from University of Waterloo in 2001. From 2001 to 2004 she worked in the Department of Molecular Biology and Genetics at the University of Guelph performing cancer related research. Renata joined the CFS Biology Section in 2004 as a Forensic Technologist and moved into a Forensic Scientist position in 2007. As a Forensic Scientist her principle duties are the interpretation of body fluid testing and DNA typing results in autosomal and Y STR systems, the preparation of forensic reports and the provision of objective and impartial expert testimony regarding body fluid identification and DNA analysis and interpretation including the deposition, transfer and persistence of body fluids and DNA. She has testified both in the Superior Court of Justice and the Ontario Court of Justice on numerous occasions. Renata has an active interest in research and has published in a number of journals including Journal of Forensic Science, Canadian Society of Forensic Science Journal, Journal of Biological Chemistry, Genetics and Journal of Bacteriology. Renata has partnered with OTU on and off for almost a decade on a number of different research projects.

Session I Mock Crime Scene Practicum Students & Directed Studies
Chair: Jeff Ward, BFI

9:10 **Hanin Aoudi, Samantha Cordeiro, Andrew Dallison, Matt Foat, Hamza Khan, Kanika Kumar, Isaac Leydl, Martina Maffei, Liam Murphy, Brasane Neelavannan, Sajanath Thavarajah**

Mock Crime Scene Practicum Course

The focus of the Mock Crime Scene Practicum is to *apply practical skills* to process a complex crime scene. This is accomplished by simulating all the associated events a person may encounter from crime scene to court. This includes extensive documentation of the scene, collection and identification of evidence, creation of detailed logs and forensic reports, and finally testifying as an expert witness in a mock court setting. Students selecting this capstone experience are expected to individually prepare a written report and collaborate on an oral presentation.

9:45

Amanda Phan

Dogs with a job: Exploring the world of detection dogs

Directed Studies

The focus of a Directed Studies Project is to *identify* gaps in the research literature. This is achieved by conducting a thorough literature review on a particular subject. Ultimately, the goal is to review the current state of the chosen field, leaving no stone unturned and putting current research into the broader context of forensic science. Students selecting this capstone experience have the opportunity to investigate more diverse subject matter where conducting original research may be difficult. Students are expected to prepare a written document and a 3-minute oral presentation.

Session II

Thesis Research Students

Chair: Dr. Theresa Stotesbury

The focus of a thesis project is to *fill the gaps* in the research literature. This is achieved by reviewing previous studies, designing an experiment and conducting original examinations. Ultimately, the goal is to contribute novel research to a relevant field of forensic science or broader natural science. Students work closely with either internal or external supervisors who mentor them throughout the course of their work. Students selecting this capstone experience are expected to prepare a written thesis and oral presentation.

10:00

Bloodstain Pattern Analysis

Bethany Heslinga & Madeline Lamont

Investigation of bloodstain pattern analysis experimental set-ups

10:20

Keegan Hirst

Determination of directionality of swipe patterns on different substrates

10:37

Forensic Biology

Natalia Robinson

Using touch DNA to identify the habitual vs recent wearer of clothing

10:54

Sophia Tucker

Analysis of DNA degradation in embalmed tissues over time: A continued study

11:11

Francis Turano

Developing a kit to optimally sample from interred human remains

Developing training materials for forensic biologists

- 10 minute break -

- 11:38 Forensic Chemistry
Brandon Giotis
The viability of creating an automotive carpet fibre database for forensic use in Canada
- 11:55 **Keegan Howden**
Synthesis of a larger linker and its effect on oligonucleotides tagged with carboxylic acids containing small molecules
- 12:12 **Meaghan Westerik**
Synthesis of an alginate-HRP-based biomaterial for forensic applications
- 12:29 Forensic Physics
Kyra Pratt
Accuracy study for bullet trajectory documentation using Recon-3D
- 12:46 Physical Evidence Analysis
Alexa-Maude Beaudin
Documentation of footwear impression evidence using portable structured light scanning
- 1:03 **Closing Remarks**
Dr. Hélène LeBlanc
- 1:05 **Congrats & Group Photo!**

CONGRATULATIONS TO THE GRADUATING CLASS OF 2024!
WE ARE ALL VERY PROUD OF YOU!

Thank you to everyone in attendance today. All of your support of our capstone projects is greatly appreciated!

Mock Crime Scene Practicum

Hanin Aoudi¹; Samantha Cordeiro¹; Andrew Dallison¹; Matt Foat¹; Hamza Khan¹; Kanika Kumar¹; Isaac Leydl¹; Martina Maffei¹; Liam Murphy¹; Brasane Neelavannan¹; Sajan Thavarajah¹; Jenna Comstock, PhD¹; Kimberly Nugent, MSc¹; Jeff Ward, BFI¹

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The Mock Crime Scene Practicum was a 12-week course that provided students the opportunity to apply their acquired crime scene and laboratory knowledge to a practical scenario. Students participated in all aspects of a simulated major crime scene, working in teams of three or four, and reporting to a Case Supervisor throughout the entirety of the investigation.

The scene examination took place at Ontario Tech University's Crime Scene House, with further analysis being conducted at the undergraduate teaching laboratory. Students maintained a paperless documentation record using OneNote software that allowed real-time data entry and collaboration among team members to record the scene, track evidence and maintain information logs. Identifiable evidence varied and included: footwear impressions, fingerprints, (mock) blood, firearms, (mock) explosive powder and material, and (mock) illicit substances.

Laboratory analyses included: recovery of writing indentations, bloodstain pattern analysis using Hemospat software, fingerprint enhancement and examination, physical matches, and footwear examination and comparisons. The investigation culminated with a case report summarizing the actions, findings, and conclusions, followed by a case review with the Case Supervisor. Throughout the duration of the capstone course, students honed the necessary skills required to be effective at a crime scene. Development of an individual's judgment, critical thinking, deductive reasoning skills, and teamwork, transpired through engagement with their team to solve challenges presented to them.

Dogs with a job: Exploring the world of detection dogs

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This directed studies paper is a literature review of the applications of detection dogs, predominantly in the fields of forensics and medicine. In forensics, detection dogs can be utilized to detect cadavers, explosives, illicit materials, missing persons, and participate in search and rescue investigations. Medical uses for detection dogs assist with early detection of diseases, such as lung cancer, that allow for early treatment to increase the longevity of humans. Canines are the preferred biological organism to use for detection purposes due to their olfactory abilities, which is much more sensitive than that of a human. Canine selection and training are important aspects that impact the success of a detection dog. True materials are preferred for training aid use, however this may not be ethical for all types of detection dogs, for example cadaver dogs. Thus, the use of pseudo-odours or material that has encountered the true material can be used. The main limitations that exist in the field relate to the standardization of training, and expenses related to care and training of the canine. Despite these limitations, canines show great promise and reliability for detection purposes in the forensic and medical fields.

The presentation associated with this directed studies research, due to the interest of time, focusses on the comparison of the canine olfaction system to synthetic olfaction and their applications to forensics.

Investigation of bloodstain pattern analysis experimental set-ups

Bethany Heslinga¹; Madeline Lamont¹; Franco Gaspari, PhD¹; Kimberly Nugent, MSc¹

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Bloodstain pattern analysis (BPA), like most disciplines, relies on theories and methods identified through research. For impact pattern creation, researchers do not have a standard method for containing the blood to be impacted. Currently the most used method is soaking a sponge with blood and leaving it open to the environment, however, this does not account for the fact that blood is contained in real-life gunshot wound scenarios. Additionally, researchers may not have access to a real firearm in order to perform experiments. In this study, we endeavoured to determine the most realistic method to perform BPA experiments while using imitation firearms by testing different methods of containing the blood, and different types of guns. Two types of pellet guns were tested, one with spherical pellets and one with different shaped pellets such as pointed, hollow point, and flathead. The blood sources tested were condoms, water balloons, blood-soaked sponges, and gelatine cubes with an internal cavity. The patterns were collected with paper set up perpendicular to the blood trajectory, paper underneath the blood source, and high-speed cameras to fully capture the movement of the blood source during and after impact. These patterns were then compared with each other to determine the most accurate impact patterns. We found that gelatine acted as the most accurate blood source as it simulates the human soft tissue that a projectile must pass through before impacting the blood, and because it produced patterns that were the most characteristic of impact patterns. The paintball gun was able to produce the furthest spatter with the gelatine as a blood source since the projectiles were larger they were able to impart more energy on the blood and propel it to spatter. This is significant in the field of BPA as gelatine could produce more accurate patterns for studying BPA and implementing new methods and procedures in casework.

Determination of directionality of swipe patterns on different substrates

Keegan Hirst¹; Michael Watterworth, MHSc²; Cecilia Hageman, PhD, LLB¹; Theresa Stotesbury, PhD¹

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Bloodstain pattern analysis (BPA) is the interpretation of bloodstains and bloodstain patterns to understand the mechanisms of bloodshed. Forensic bloodstain pattern analysis uses this interpretation to address crime scene and evidence questions regarding how blood came to be where it was found. Swipes are a type of transfer pattern where a bloodied object or surface contacts a non-bloodied object or surface resulting in a bloodstain with characteristics indicative of relative motion between the two. The current studies contain information regarding swipe directionality, generation of controlled patterns, and the vocabulary use for the qualitative features of swipes. These studies point towards the difficulties and potential for error within the current interpretative criteria used for these topics.

The goal of this study is to increase the objectivity, and therefore reliability, of swipe pattern classification and directionality determination by investigating qualitative features and quantitative approaches. This was achieved by creating sets of swipe patterns in five directions: Arched Left to Right (ArchLR), Left to Right (LR), Right to Left (RL), Top to Bottom (TB), and Bottom to Top (BT), across four substrates: cardstock, acetate sheets, semi-taut and taut cloth. The substrates were mounted on top of a force plate to record the ForceZ (Fz) applied during the swipe. The mean Fz applied within the substrates were 6.8 ± 1.6 N, 6.8 ± 1.3 N, 3.3 ± 1.2 N, and 6.5 ± 1.4 N, for cardstock, acetate, semi-taut cloth, and taut cloth, respectively. General trends within the quantitative methods and the frequency distributions of the qualitative features were observed within the force range of 3 N – 12 N. The normalized distance throughout the swipe where the minimum gray value occurred was used in a logistic regression model to classify the direction of the swipe. A classification model using a 50:50 training:test split, achieved 95% accuracy, with robust sensitivity and specificity. This classification model demonstrates the use of gray value across the swipe as a quantitative approach to swipe directionality determination. Additionally, defined features were recorded for the 296 swipe patterns and included striations, pooling at last point of contact, pooling at first point of contact, tapering, spine-like features, diminishing volume, blotched edge, and continuous. The frequency distribution of these features suggest that they were not conserved across all substrates. This research provides new qualitative descriptors and quantitative methods to provide information about swipe pattern directionality.

Using touch DNA to identify the habitual vs recent wearer of clothing

Natalia Robinson¹; Renata Dziak, MSc²; Kimberly Nugent, MSc¹; Stacey Sainte-Marie, MSc¹

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Wearer DNA is touch DNA obtained from a garment that belongs to the individual that wore the garment. Multiple DNA contributors may be detected within a mixed profile derived from a single item that has been worn by multiple individuals. The individual who wears a clothing item more regularly is referred to as the habitual wearer, while the person who has worn an item of clothing most recently is referred to as the recent wearer. Differentiating between these two kinds of wearers is particularly useful when attempting to identify suspects using clothing that has been found at a crime scene. This study aimed to determine if a recent and habitual wearer could be differentiated through the analysis of DNA profiles generated from clothing items worn by two different people for varying durations. This study also aimed to investigate if sampling technique affects which wearer is detected as the major or minor contributor of the DNA profile. The study examined 180 samples which were obtained from six clothing items and ten pairs of volunteers. Cut outs and swabs were collected from each clothing item at various sampling locations and processed using DNA analysis. The results demonstrated that fabric gloves and winter hats were the most likely to have the habitual wearer as the major contributor followed by the sweatshirt and jogging pants. For both the T-shirt and the athletic tops, the average percentages of the relative DNA profile contributions of the habitual and recent wearers were almost equal. No difference was observed in the major vs minor contributor amounts when cuttings vs swabs were compared for each clothing item. Future studies should examine additional sampling techniques, such as tape lifting, compared to cut-outs and swabs. The washing of clothes in between habitual and recent wear could also be examined to determine how that would affect how much DNA recovery.

Analysis of DNA degradation in embalmed tissues over time: A continued study

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Embalming is a procedure performed on a deceased body using various compounds, such as formaldehyde, to prevent decomposition and to stiffen the tissues. Consequently, as the formaldehyde interacts with the tissue, the DNA in the tissue begins to degrade. This research is a continuation of an on-going study that seeks to determine the timeframe within which a usable DNA profile can be generated from various types of tissue from a deceased body after embalming. Tibia, trapezius, quadriceps, liver, and brain samples were taken at seven different time intervals post-embalming. DNA extraction and quantification were performed on each sample to determine if sufficient DNA was present for subsequent testing. Samples with a quantification value exceeding 0.05 ng/μl underwent amplification and STR analysis to produce an identifiable DNA profile. The quantification values and the quality of the DNA profiles were examined and compared across sampling sites and time points. It was found that prolonged exposure of tissues to the embalming solution resulted in a notable decrease in sample quality, leading to less discernible DNA profiles. Additionally, a statistically significant decrease in DNA quantity was observed over time for each tissue type and between different types of tissue. Liver samples had the highest quantity of DNA pre-embalming and retained the most DNA over time. Furthermore, no statistical difference was found between the DNA quantity of compressed and non-compressed tissue types.

- 1. Developing a kit to optimally sample from interred human remains**
- 2. Developing training materials for forensic biologists**

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This thesis is concerned with two issues in forensic biology – the efficient sampling of human remains for forensic DNA purposes and improving the current options for on-line training in forensic biology.

Section one of the thesis reviewed journal articles and other relevant documentary materials, to develop a kit and protocol for optimally sampling from interred human remains. The decomposition of remains, which is dependent on various factors such as soil chemistry, temperature, age, and other environmental factors, influences the state of tissue left behind for potential sampling of DNA. From this analysis, a decision tree and kit contents have been proposed, and explained, for effectively sampling human remains.

Section two examined publications relevant to the body of standards within the field for training forensic biology scientists. This review examined the previous and present examples of required and proposed training found within the field, and in particular, highlighted the areas that could benefit from enhanced development. For example, the review found that the training programs could benefit from improvement in particular areas including the ethical principles surrounding decedent care/handling, the modern statistical approaches behind DNA profile interpretation (Hierarchy of propositions in terms of separating source and activity level propositions, and Bayes theorem), as well as new technologies (Probabilistic Genotyping, and Massively Parallel Sequencing). Both sections of this thesis go hand in hand; it is important to sample from remains in as non-invasive manner as possible, while obtaining an optimal DNA sample to use for generating a profile. It is vital to avoid the overly invasive sampling due to the ethics behind care and respect for the decedent and the surviving family. The improved training in forensic science should take this into account; it uses the field standards, research, education, etc. to assist forensic biologists with the using these samples, new technology /techniques to produce, and interpret a DNA profile for Disaster Victim Identification, cold cases, or paternity cases.

The viability of creating an automotive carpet fibre database for forensic use in Canada

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The feasibility of creating a vehicle carpet fibre database was explored by attempting to distinguish between various carpet fibres from foreign and domestic vehicles. The 29 samples that were previously selected were examined using Raman spectroscopy to analyze the dye compounds and fibre materials to attempt to distinguish between various makes, models, manufacturing location, and years of vehicle. Fibres were initially classified partly with the aid of previous works, as well as with subsequent visual examination using stereomicroscopy and polarized light microscopy (PLM). Upon review of the spectra, very few distinguishing features could be found, as a high fluorescence of the fibres interfered with much of the results. Of the 57 fibre types analyzed, 55 were polyester fibres, and the remaining 2 were both made from nylon. Very few dye peaks could be seen, resulting in a very low distinguishing rate, as only 3 of the 57 fibres could be excluded as unique. Additionally, no difference was found between foreign and domestic fibres. Whether this is because there truly is no difference or because Raman spectroscopy was insufficient in detecting dye peaks is unclear. At this point it is unlikely that the creation of a Raman spectroscopy database is worthwhile, as there was significantly more distinguishing power available through visual examination of physical characteristics. However, Raman spectroscopy was very effective for identifying the polymer type of an unknown fibre. Raman spectroscopy remains useful as a comparison tool and showed the ability to make exclusions, just not at a high enough rate to warrant the creation of a database.

Synthesis of a larger linker and its effect on oligonucleotides tagged with carboxylic acids containing small molecules

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This project focuses on the synthesis of an extended triazole linker that can bind RNA to folic acid or other carboxylic derivatives. Ribonucleic acid interference is a natural pathway of a cell which stops gene expression. If the sequence of a gene is known, the complementary RNA sequence can be produced to interfere with the mRNA before translation occurs. Folic acid is of interest in RNA drug therapeutic research since it allows a targeting method for cancer cells due to the over expression of folate receptors. The ability to attach siRNA to folic acid will minimize off target effects and ensure cancer cells are the target of the RNA interfering pathway. A DMT protected triazole linker compound that takes advantage of the copper-catalyzed azide alkyne click reaction has shown the ability to successfully connect folic acid to RNA. The effects of linker length are relatively unknown, and this study aims to look at stability of an extended compound and the effects it has on cellular uptake and gene silencing.

Synthesis of an alginate-HRP-based biomaterial for forensic applications

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Forensic blood substitutes (FBS) are material alternatives to whole human blood for research and training purposes. One important feature of an FBS is its ability to react with common chemical enhancement and searching reagents, such as luminol. Luminol is used to search and detect latent blood stains through chemiluminescence. This visible reaction results from the oxidation of luminol catalyzed by the hemoglobin found in red blood cells. This thesis explores the encapsulation of horseradish peroxidase (HRP), an enzyme capable of catalyzing the oxidation of luminol, in an alginate-based FBS. Covalent immobilization of HRP to alginate was achieved using carbodiimide chemistry and the resulting gel was characterized using rheology and ATR-FTIR spectroscopy. The material's ability to oxidize luminol was characterized using a Cytation5 microplate reader and compared to the chemiluminescence of whole bovine blood dilution standards dried in two different environments (fumehood and temperature chamber). Environment-based changes in chemiluminescence were observed between blood standards. The maximum chemiluminescence and half-life of alginate-HRP gels at low (100 U/mL) and high (1000 U/mL) HRP concentrations demonstrated chemiluminescence between a 1:100,000 and 1:1,000,000 at low concentrations and between 1:10,000 and a 1:100,000 dilution at high concentrations. Statistically significant differences in chemiluminescence profiles were also observed when the gels were compared to the bovine blood standards ($p < 0.0001$, Kolmogorov-Smirnov test). Finally, ionically crosslinked microparticles (MPs) were created using electrospray ionization (ESI) and included in a hydrogel FBS system. The fluid properties of the final HRP-FBS materials were measured and compared to the physiological range of whole human blood. Lastly, transfer patterns were made using the HRP-FBS materials and enhanced with luminol to assess the material's suitability for crime scene simulations. Overall, we present a new suite of FBS biomaterials capable of replicating the chemiluminescence of latent bloodstains at crime scenes.

Accuracy study for bullet trajectory documentation using Recon-3D

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Currently, photogrammetry and terrestrial laser scanning are considered traditional methods for bullet trajectory documentation. These methods can be time-consuming, and laser scanners are expensive. This research focuses on the validation and application of a mobile app, Recon-3D, as a suitable replacement for traditional bullet trajectory documentation. The angular accuracy of Recon-3D and its ability to document bullet trajectories were compared to a FARO Focus laser scanner with a known angular accuracy. The results from both the angle measurement tests and the bullet trajectory analysis demonstrated that Recon-3D is capable of documenting angles with less than one degree of error on average. Differences between the angular averages for Recon-3D and FARO were statistically insignificant. This study aligned with past validation studies, demonstrating the success of Recon-3D in forensic documentation. Future work should be performed to further validate the use of Recon-3D in bullet trajectory documentation, as well as other disciplines in forensic science, such as bloodstain pattern analysis, and vehicle collision reconstruction.

Documentation of footwear impression evidence using portable structured light scanning

Alexa-Maude Beaudin¹; Amanda Lowe, MSc²; Kimberly Nugent, MSc¹; Jeff Ward, BFI¹

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The current methods of documenting footwear impressions at crime scenes include photography and casting. Casting allows a forensic footwear examiner to obtain 3-dimensional (3D) depth characteristics of a footwear impression, but it is a destructive method with various risks associated. This study qualitatively compared the use of a portable structured light scanner to document footwear impressions with the current methods used to determine if this technique may be a viable or complementary alternative. A total of 16 footwear impressions were created in a mixture of sand and topsoil using four different footwear (two right shoes and two left shoes). All footwear impressions were documented and collected using photography, casting, and structured light scanning using the Artec Space Spider scanner. The examinations were conducted by qualified forensic footwear examiners from a Canadian Police Service Forensic Identification Services Unit. The qualitative examinations revealed that the 3D scans obtained with the Artec Space Spider scanner provided quality results with better detail as compared to the photographs and casts. The forensic footwear examiners observed the highest number of randomly acquired characteristics (RACs) using the 3D scans compared to photographs and casts. This study demonstrated that the use of 3D scans, in conjunction with examination quality photographs, was determined to be a viable method for the documentation and examination of footwear impressions. Future research may explore the use of the Artec Space Spider scanner for footwear impressions documentation in various substrates and environments. A quantitative assessment on the precision and accuracy of the measurements obtained using the 3D scans is also necessary before this method is implemented in case work.