UNIVERSITY OF AMSTERDAM

Institute of Interdisciplinary Studies

Master Forensic Science

Research Projects 2023-2024

MASTER FORENSIC SCIENCE

Research projects 2023-2024

The University of Amsterdam's (UvA) Master's programme in Forensic Science, offered by the Faculty of Science, is unique in the Netherlands. The programme distinguishes itself from most international Master's programmes in Forensic Science by building on a range of scientific disciplines, such as Chemistry, Computer Science, Life Sciences, Mathematics, Physics, and other exact sciences. The goal of the programme is to train good scientists, armed with forensic knowledge and skills.

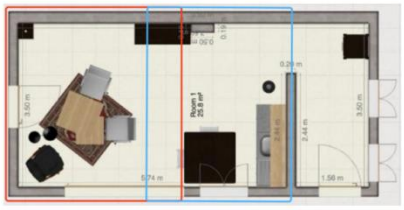
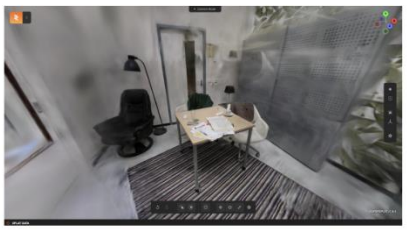
A part of the curriculum is a six-month internship during which scientific research is executed that is relevant to the forensic field. This document gives an overview of the capabilities of our students and the many ways in which a research project can be conducted.

For more information please contact:
fs-iis-science@uva.nl

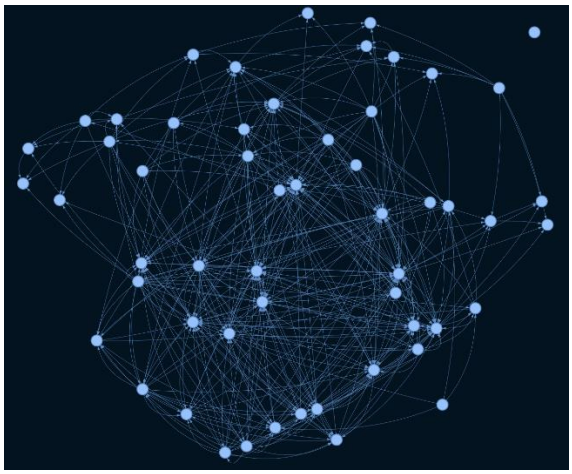
Title	Organisation	Student	Previous education
Crime Scene Science			
Integrating 3D Gaussian Splatting and Unreal Engine for Interactive Crime Scene Investigation Environments: A Forensic Approach	Saxion	Berry Chen	Computer Science
Digital Forensics			
Combining Detection Methods for Tool-Based Image Steganalysis: A Bayesian Approach	NFI	Giel Beuzel	Data Scince
Artifact-Based Steganalysis: Identifying Steganography Tools Through Characteristic Feature Distributions	NFI	Koen Elderhorst	Information and Communication Technology: Informatics
Optimizing forensic audio transcription: A domain-specific solution using Whisper and Large Language Models	Onderzoeksraad van de Veiligheid	Christiaan van Luik	Computer Science
Forensic Biology			
Application of Direct and Adaptive Nanopore sequencing: Targeting DNA methylation markers informative for Biological Age, Smoking Behavior and Tissue type, and HIrisPlex SNPs in a Single Comprehensive Assay	AUMC	Isis Beentjes	Biomedical sciences
Exploring the genetic similarity between individuals: effect of sex and multiple relationships on relationship inference	NFI	Joel Cacciola	Biology
Disrupting the illegal rhinoceros trade: Visualisation and detection of trace DNA on plastic transportation bags used to package rhinoceros horn material	Flinder's University, Australia	Sandra van der Meer	Liberal Arts and Sciences: (Cell) biology and neuroscience
'Shedder status' and self- and foreign DNA beneath the fingernails	NFI	Charlotte Müller	Forensics in the Natural Sciences
Forensic Biophysics			
A Comparative Analysis of Fluorescence and Reflectance Spectroscopy and Proteomics: Toward Improved Estimation of Time Since Deposition of Body Fluids	UAMC	Livia Gautel	Biomedical Sciences
Inkjet printing of bloody fingermarks	University of Lausanne	Elvire Sarton--Lohéac	Biology

Title	Organisation	Student	Previous education
Forensic Chemistry			
Understanding the Transfer Behavior of Perchlorate: Comparing Direct and Indirect Transfer and its Application in a Case Simulation	NFI	Marre Corver	Pharmaceutical Product Development and Biology
The Transfer Behaviour of Erythritol Tetranitrate	NFI	Andreea Isis Gergely	Chemistry with Forensic Science
Fingerprint visualisation using blue fluorescent carbon dots	Saxion	Bram Nanninga	Chemistry
Portable near-infrared spectroscopy for on-site qualitative and quantitative analysis of MDMA in ecstasy tablets.	HIMs, UvA	Daniel Osei-Nimako	Chemistry
Determining the nitration degree of nitrocellulose in smokeless powders by two-dimensional liquid chromatography	HIMs, UvA		Forensic Science and pre-master Chemistry
Development and validation of an ethyl chloroformate derivatization-based liquid chromatography-tandem mass spectrometry method for the quantitative analysis of saxitoxin	OPCW	Yue Wang	Molecular Biology and Philosophy
Forensic Medicine			
Validating The Morphology Of 3D-Printed Cranial Projectile Trauma As A Skeletal Alternative For Utilisation In A Court Of Law	University of Pretoria	Claudia Ibañez Martin	Biomedical Sciences
Further Insight into Ballistic Fracture Patterns in Human Long Bones – An Experimental Approach	Institute of Legal Medicine and Forensic Science of Catalonia (IMLCFC)	Doreen Jost	Biology
Validation and characterization of blunt injuries in reconstructed human skin models	GGD Amsterdam	Thijs van der Mark	Psychobiology
A novel method for the quantification of morphometric parameters in sub-optimal histological samples for future application in forensic taphonomy	AUMC	Serena Emma Paolini	Biological Science
Other			
Relationships between Chemicals in Groundwater and Land Use in the Netherlands	KWR	Dries Fransen	Artificial Intelligence
Automatic Identification of Forensically Relevant South African Insect Species	Wildlife Forensic Academy	Luca Nederhorst	Bèta-gamma, Biology minor programming

Crime Scene Science

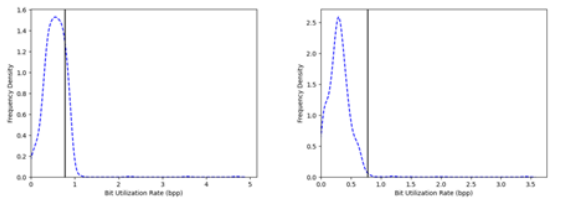
Student	Berry Chen
Research carried out at	Saxion
Supervisor	dr. Dimitar Rangelov
Title thesis	Integrating 3D Gaussian Splatting and Unreal Engine for Interactive Crime Scene Investigation Environments: A Forensic Approach
Abstract  (a) Floorplan of the mock crime scene  (b) Panorama photo of the mock crime scene  (c) Part1-v5 after optimization  (d) Part2-v3 after optimization	This thesis explores the integration of 3D Gaussian Splatting (3DGS) with Unreal Engine to develop an interactive environment tailored for crime scene investigation. Traditional methods of crime scene documentation, while foundational, often fail to accurately capture complex spatial relationships, potentially impacting investigative outcomes and legal proceedings. Leveraging 3DGS for rapid and efficient 3D scene reconstruction, this research enhances scene detail preservation and visualization. Key functionalities include evidence labeling, trajectory reconstruction, and movement pattern analysis, evaluated through scenario-based testing. A diverse group of participants assessed the system's usability, functionality, and forensic applicability. Findings indicate potential for training and hypothesis testing, despite technical challenges such as reconstruction clarity and computational demands. This study contributes a foundational framework for integrating advanced visualization technologies in forensic contexts, offering insights for future enhancements in digital forensic tools.

Digital Forensics

Student	Giel Beuzel
Research carried out at	NFI
Supervisor	Meike Kombrink MSc
Title thesis	Combining Detection Methods for Tool-Based Image Steganalysis: A Bayesian Approach
Abstract 	This research project explores the combination of multiple detection methods for tool-based steganalysis. A combination of fixed-position bit signatures, deep learning approaches, and feature-based detection, is used to improve accuracy for a tool-based steganalysis model. Results indicate that deep learning approaches are limited in effectiveness as a detection method. Specifically, the use of Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks trained on image header data shows poor performance. The generation of the fixed-position bit signatures produced 34 unique signatures consistently left by 50 different steganographic applications. Furthermore, this study explores the use of Bayesian Networks for the combination of results to ensure statistical validity and enhance detection accuracy. A new framework, Netmix, is proposed that has the ability to perform structure learning using the hill-climbing algorithm and model probabilistic distributions of a variable using multinomial logistic and OLS regression.

Student	Koen Elderhorst
Research carried out at	NFI
Supervisor	Meike Kombrink MSc
Title thesis	Artifact-Based Steganalysis: Identifying Steganography Tools Through Characteristic Feature Distributions
Abstract	Given recent successes by law enforcement agencies in breaking the encryption of privacy phones, the use of steganography — the act of hiding messages in digital media — is expected to increase. This surge in the clandestine use of steganography requires effective steganalytic methods. However, where the vast majority of research in steganalysis involves detecting the presence of steganography, the extraction of embedded content using the correct steganographic algorithm is largely unexplored. This research will investigate the possibility of determining which steganographic algorithm was used by analyzing several artifacts present in steganographic images. Our approach consists of measuring these artifacts in the questioned image and comparing them to known distributions of artefacts among different steganographic algorithms. The evidential strength of different artifacts is examined, both individually and in combination. The results of this research suggest that image complexity, average hue, and motion blur are not reliable artifacts for determining the correct tool. On the other hand, file size in relation to the number of pixels and color channels shows good average results but moderate sensitivity. Furthermore, quantization tables and signatures exhibit strong sensitivity in identifying the correct tool. Combining filesize, quantization tables, and signatures yields optimal results in determining the correct steganography tool. Our results demonstrate that by analyzing this combination of features, our method can accurately predict the correct tool out of 52 tools in nearly 42\% of the cases, with the average rank of the correct tool being 4,35. These findings underscore the practical value of our work, offering a state-of-the-art tool for forensic investigations that improves both efficiency and precision in multimedia evidence examination.

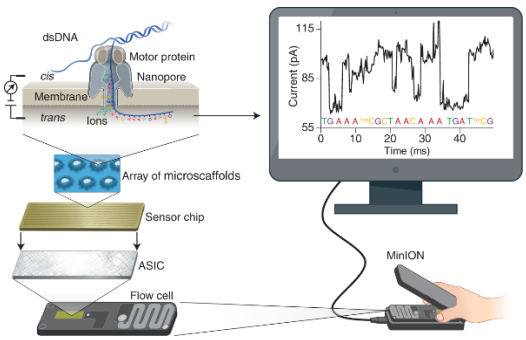
Figure 5: Intersection of the Bit Utilization Rate of a questioned image with different Bit Utilization Rate distributions



(a) Intersection with the correct tool's distribution (b) Intersection with an unrelated tool's distribution

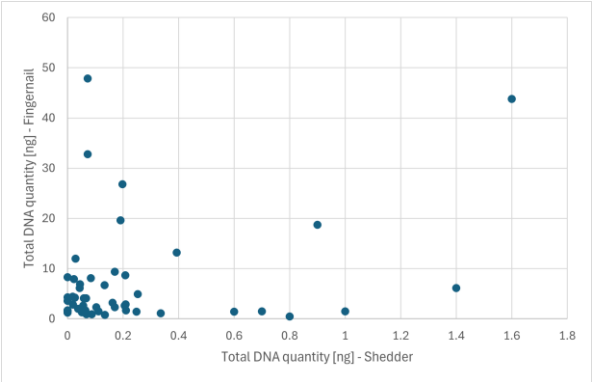
Student	Christiaan van Luik
Research carried out at	Onderzoeksraad van de Veiligheid
Supervisor	Floris Gisolf MSc
Title thesis	Optimizing forensic audio transcription: A domain-specific solution using Whisper and Large Language Models
Abstract	This research investigates the development of an automated and complete audio transcription solution tailored for forensic applications, using OpenAI's Whisper model and various enhancements. The study focuses on enabling the Dutch Safety Board (DSB) to efficiently process sensitive audio data, such as cockpit recordings and interviews, by implementing locally deployed, domain-specific automatic speech recognition (ASR). Enhancements were made to improve Whisper's accuracy on Dutch language audio, address challenges like noise and multi-language handling, and incorporate a large language model (LLM) for transcript correction and insight generation. I fine-tuned Whisper using both synthetic Text-to-Speech (TTS) and DSB interview datasets, achieving a notable improvement in Word Error Rate (WER). Additional modifications included using Voice Activity Detection (VAD), speaker diarization, and phoneme alignment with WhisperX to enhance timestamp accuracy and speech clarity. Furthermore, vocal separation techniques were tested to mitigate background noise in recordings. For analysis, local LLMs were integrated to correct transcription errors and generate insights, streamlining the investigation process by summarizing key information. This pipeline demonstrates a significant improvement in transcription quality, particularly in forensic contexts where accuracy is important. Future work includes refining language model tuning and expanding the dataset to cover more audio. Most code written in this study is available on GitHub at https://github.com/cvl01/forensic-audio-transcription.

Forensic Biology

Student	Isis Beentjes
Research carried out at	AUMC
Supervisor	dr. Peter Henneman
Title thesis	Application of Direct and Adaptive Nanopore sequencing: Targeting DNA methylation markers informative for Biological Age, Smoking Behavior and Tissue type, and HIrisPlex SNPs in a Single Comprehensive Assay
Abstract  	In forensic investigations, STR profiles are crucial for individual identification, but Forensic DNA Phenotyping can provide insights into an individual's external appearance when identity matching is negative or not available. Next-generation sequencing offers extensive genetic variant detection but often suffers from labor extensive procedures. Oxford Nanopore Technologies (ONT) addresses these issues with its adaptive sampling approach, which is fast, simple, and allows sequencing of different (epi)genetic markers in one comprehensive assay. This study evaluates the PromethION platform's effectiveness for forensic (epi)genetic markers related to external phenotype, biological age, and smoking behavior, and tackles challenges like low DNA concentrations and body-fluid identification. We validated the PromethION using conventional DNA (EPICv2) methods and phenotype data from seven anonymous donors. Predictions using the HIrisplex-S tool showed 84.2% concordance with validation results. Biological age prediction with ONT methylation data demonstrated Pearson correlations with chronological age between -0.71-1.00 and a Mean Absolute Error ranging 1.0-28.6 years, but was dependent on read depth per experiment. For other age-associated markers, correlations were high for ELOVL2 (r = 0.89-0.94) and MIR9B2CHG (r = -0.52 - -0.94) across all experiments. In body fluid identification, 89.4% of blood and saliva samples were accurately identified. ONT-based smoking behavior predictions showed consistency in 84.2% of samples using 120 CpGs. The PromethION platform showed strong potential for forensic applications, excelling in biological age prediction and body fluid identification. However, further improvements are needed for more accurate body fluid identification and smoking status prediction. Future research should concentrate on optimizing read depths for low-quantity samples and resolving technical challenges such as pore availability and DNA loss, highlighting PromethION's promise for advancing forensic sequencing.

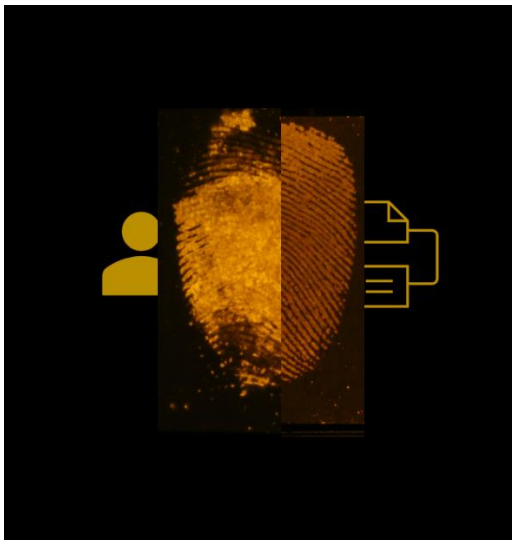
Student	Joel Cacciola
Research carried out at	NFI
Supervisor	Prof. dr. Klaas Slooten
Title thesis	Exploring the genetic similarity between individuals: effect of sex and multiple relationships on relationship inference
Abstract	Forensic Genetic Genealogy (FGG) is a rapidly advancing field that uses genetic data to infer familial relationships by analysing genetic relatedness between individuals. However, to my knowledge, two factors are often overlooked in relationship inference: the sex composition of the pedigree and the possibility of multiple relationships. This study aimed to investigate the impact of these factors using R, a statistical computing tool. A code was developed to simulate sex combinations for single cousin relationships up to the third degree and calculate their posterior probabilities when one combination's genetic data was provided as input. Additionally, a code for multiple cousin relationships was made, where each one's genetic data was compared against single relationships using posterior probabilities. The results revealed that, in the sex investigation, posterior probabilities were highest for the inputted sex combination's data up to half-second cousins. For third cousins and beyond, no clear patterns emerged. In the case of multiple relationships, posterior probabilities were higher when the kinship coefficient of the single relationship pedigree matched that of the inputted multiple relationship pedigree. These insights highlight scenarios where detailed genetic analysis is needed, particularly when background information is unavailable, and could enhance genealogical research by providing a deeper understanding of the genetic patterns underlying relationship inference.

Student	Sandra van der Meer
Research carried out at	Flinder's University, Australia
Supervisor	prof.dr. Adrian Linacre
Title thesis	Disrupting the illegal rhinoceros trade: Visualisation and detection of trace DNA on plastic transportation bags used to package rhinoceros horn material
Abstract	Rhinoceros horn trafficking is associated with low risk of prosecution. Horns are typically hidden in shipping containers and the container industry's size complicates effective interception of rhinoceros horn consignments. To increase prosecution rates, law enforcement needs to obtain evidence of trafficking for cases where no rhinoceros horn consignment was intercepted. This can be facilitated by a methodological pipeline based on trace DNA, which employs visualisation of DNA transfer followed by DNA-based species identification. Specifically, if rhinoceros horn transfers DNA onto packaging materials, visualising and recovering this DNA from discarded packaging materials would provide evidence of trafficking. To this end, this study describes a trace DNA transfer experiment that mimics common trafficking conditions. Using a nucleic acid binding dye, it successfully visualised that DNA transfer occurred onto packaging materials which previously contained rhinoceros horn. Looking into the effects of different transfer conditions, this study found structural integrity of rhinoceros horn materials trumped the effects of common transfer conditions such as time and pressure. Species identification was complicated by mitochondrial high copy number nature and a contamination contributed to inconclusive results. Overall, conclusions drawn from this study are promising for forensic investigators, as cellular material was indeed transferred onto packaging materials. Future endeavours should replicate these findings to confirm whether the transferred DNA came directly from rhinoceros horn, indirectly from human packagers, or from both.

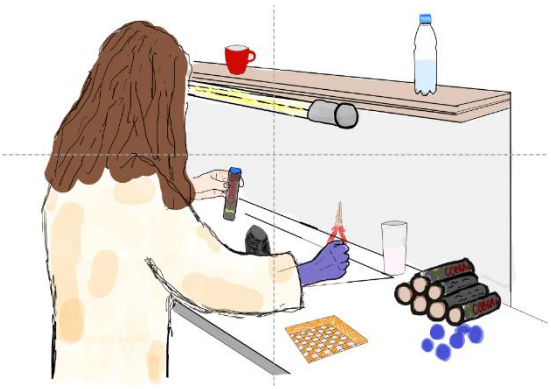
Student	Charlotte Müller
Research carried out at	NFI
Supervisor	Jaimy Meeuwissen MSC
Title thesis	'Shedder status' and self- and foreign DNA beneath the fingernails
Abstract 	Fingernails are commonly searched for foreign DNA during forensic investigations, due to the tendency for debris and DNA to accumulate beneath the nail. However, to correctly assess whether DNA evidence from beneath the nails is related to a crime, it is necessary to be aware of possible innocent background presence of self- and foreign DNA found under fingernails. Furthermore, this study tries to find a possible relationship between the accumulation of DNA under nails and a person's shedder status. Shedder status is described as an individual's tendency to deposit more or less self-DNA on surfaces. This tendency can vary drastically between individuals and can therefore possibly influence the composition of background DNA under the fingernails. In this study, samples of 17 participants were taken from their dominant hands and beneath their fingernails in three replicates. Of the fingernail samples between 6% and 29%, depending on the method used to assess the presence of foreign DNA, were determined to contain foreign DNA, comparably higher than previous literature. To determine the impact of a person's shedder status on the presence of self- and foreign DNA beneath the fingernails, the DNA quantities from the shedding and fingernail samples were compared. It was determined that a moderate to strong positive correlation can be observed between a person's tendency to shed and the amount of self-DNA recovered from beneath the fingernails. No correlation could be observed between the amount of DNA that was shed and foreign DNA quantities under the fingernails. The results of this study indicate that less than a third of fingernail scrapings contain detectable amounts of foreign DNA. Furthermore, no measurable relationship between a person's shedder status and the quantity of foreign DNA beneath the fingernails could be identified.

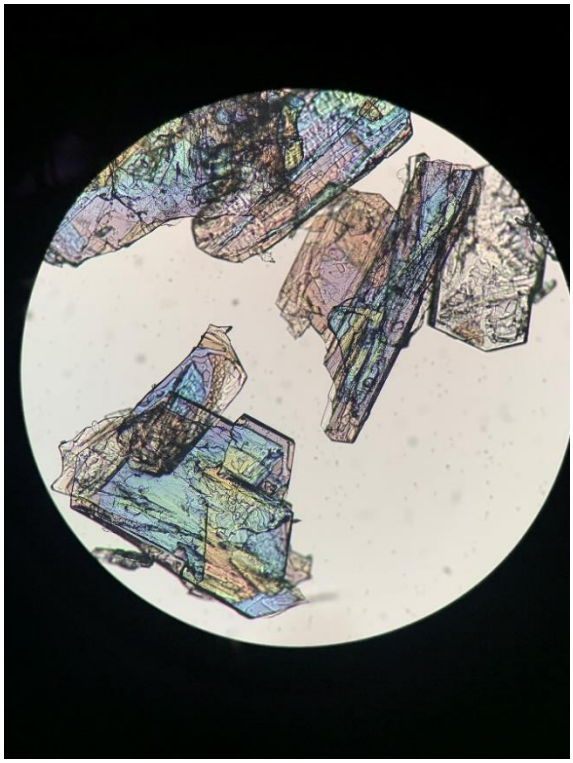
Forensic Biophysics

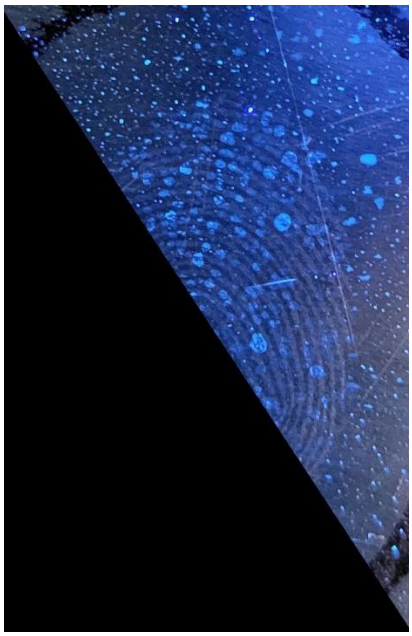
Student	Livia Gautel
Research carried out at	AUMC
Supervisor	Dr. Annemieke van Dam
Title thesis	A Comparative Analysis of Fluorescence and Reflectance Spectroscopy and Proteomics: Toward Improved Estimation of Time Since Deposition of Body Fluids
Abstract 	Bloodstains and vaginal fluid are two of the most commonly encountered body fluids in sexual assault and therefore considered important pieces of evidence in forensic investigations. Recently the same fluorescence-based technique has been developed to monitor temporal changes in blood serum, and accurately determine the Time Since Deposition (TSD) of semen traces, and a reflectance- based technique to accurately determine the age of bloodstains. Even more recently, state-of-the-art proteomics technique has been developed to monitor fingermark ageing on the protein level with selectivity to differentiate potential age markers between body fluids. The biomolecular constituents of blood and vaginal fluid may provide a more accurate means for age determination. In this exploratory study, the aim is to further investigate temporal changes in bloodstains and vaginal fluid by (i) using fluorescence spectroscopy to observe temporal patterns in the fluorescent spectra of blood supernatant, with a focus on temperature variations (2℃, 21℃, and 40℃) and (ii) identifying protein and post-translational modification (PTM) site changes for vaginal fluid over time using LC-MS- based proteomics. A significant decrease in fluorescence intensity in parts of the spectra attributed to protein and an increase in parts attributed to fluorescent oxidation products (FOX) was observed at 40℃ in a low-oxygen environment. From the LC-MS-based proteomics results, several potential PTM markers for the ageing of vaginal fluid could be identified on proteins HBB, SPRR3 and FABP5, of which FABP5 (fatty acid-binding protein, epidermal) may contribute to fluorescent behaviour of vaginal fluid. This study confirms that the fluorescent behaviour of ageing blood shows temporal changes similar to those known in other body fluids, and suggests that this behaviour is temperature dependent. This study also illustrates the potential use of PTMs as markers for the monitoring of vaginal fluid ageing using LC-MS-based proteomics techniques.

Student	Elvire Sarton--Lohéac
Research carried out at	University of Lausanne
Supervisor	prof.dr. Andy Bécue
Title thesis	Inkjet printing of bloody fingermarks
Abstract 	This research project presents how a blood-like solution was designed to be printed with an inkjet printer, to produce artificial bloody fingermarks. These marks are crucial in forensic investigation, as they can link suspects to crime scene, especially in violent crimes. Artificial blood solutions described in the literature were mostly created for blood pattern analysis. If their physical properties are similar to blood, they are not printable as they do not meet the physicochemical properties necessary for a printer to accept a solution as an ink. This project builds on previous research that successfully printed synthetic fingermark secretion with an inkjet printer in a reliable and reproducible manner. Various formulations were developed and compared, to assess their printing and reactivity potential. In parallel, the optimum settings for the chosen inkjet printer were explored, including output quality and paper type setting. Ideal characteristics for the printing consumables, paper and cartridges, were also investigated. Compared to real bloody fingermarks, a mixed solution of genuine ink and biological material was the most promising, in terms of printability, details, reactivity to common enhancement techniques (Ninhydrin and 1,2-Indandione/Zinc), and contrast intensity. However, results obtained after the blood-sensitive reagent amido-black were inconclusive, indicating a need for further investigation into inkjet printing mechanisms and inkjet ink requirements. Despite remaining issues with visual appearance and stability of the solution, the gathered results lay the foundation for the development of a controllable and reproducible method for printing bloody patterns using a modified inkjet printer. This methodology could lead to a reliable tool usable in forensic research, quality control, and training

Forensic Chemistry

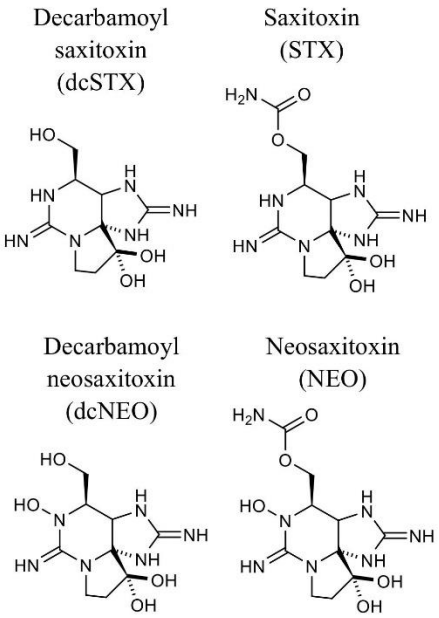
Student	Marre Corver
Research carried out at	NFI
Supervisor	drs. Irene van Damme
Title thesis	Understanding the Transfer Behavior of Perchlorate: Comparing Direct and Indirect Transfer and its Application in a Case Simulation
Abstract 	This study investigates the transfer behavior of perchlorate to enhance forensic investigations involving explosive trace analysis at the activity-level. Two indirect transfer scenarios were simulated: contamination via handshaking and contact with a contaminated object and compared with the direct transfer from hands saturated with perchlorate to objects. These items were swabbed and analyzed with Ion Chromatography – Mass Spectrometry to quantify perchlorate. The results confirm that secondary and tertiary transfer of perchlorate occurs, but it leads to significantly smaller amounts on objects compared to direct transfer. Transfer ratios to hands and objects varied across participants, objects, and the type of flash powder used. A more controlled method was developed to study transfer through fingerprints, revealing that interpersonal hand characteristics may influence transfer. In a real-world IED construction scenario, perchlorate was observed to transfer through the air, contaminating multiple different objects and persons. Significantly higher levels were found on participants directly involved in the construction compared to those entering the environment afterwards. A case simulation using the hand transfer data demonstrated that high perchlorate levels on objects may provide strong evidential value, while low levels have limited forensic relevance. This research highlights the importance of understanding perchlorate transfer dynamics and provides a foundation for future studies to establish activity-level interpretation.

Student	Andreea Isis Gergely
Research carried out at	NFI
Supervisor	drs. Irene van Damme MSc
Title thesis	The Transfer Behaviour of Erythritol Tetranitrate
Abstract 	This study investigates the transfer behaviour of erythritol tetranitrate (ETN) as a representative of nitro organic explosives. Such studies are necessary to gain more awareness of the transfer behaviour of homemade explosives to provide useful information on which surfaces they are likely to be retained and identify what factors are likely to influence transfer. A transfer scenario is performed through fingerprints involving the primary transfer of ETN from an individual to a target surface and the secondary transfer of ETN from the target surface to a second individual. This transfer scenario is repeated with flash powder and a different crystal structure of ETN with a smaller particle size. A depletion series is performed through fingerprints by a person touching 5 glass microscope slides consecutively. The depletion series is executed with and without gloves being worn by the participants. These surfaces and fingers are swabbed and analysed using High Performance Liquid Chromatography equipped with a variable wavelength detector to quantify ETN. Ion Chromatography coupled to Mass Spectrometry is utilised for the quantification of perchlorate (analytical marker for flash powder). The results confirm that primary and secondary transfer of ETN occur. The percentage of ETN transferred was generally higher for secondary transfer than for primary transfer. The transfer of perchlorate and ETN were only comparable for transfer to glass. When ETN has a smaller particle size, the percentage of ETN transferred for all target surfaces increases except for the textile surface. Nitro organic explosives are more efficiently transferred from a vinyl glove to the first surface of contact than from bare hands. Wearing gloves was seen to remove interpersonal variations responsible for outliers in the transfer of the explosive material to the participant in a direct contact. This research highlights the importance of elevating activity level insights into the transfer dynamics of pre-blast explosives and provides a foundation for future studies that resemble real-life scenarios more closely.

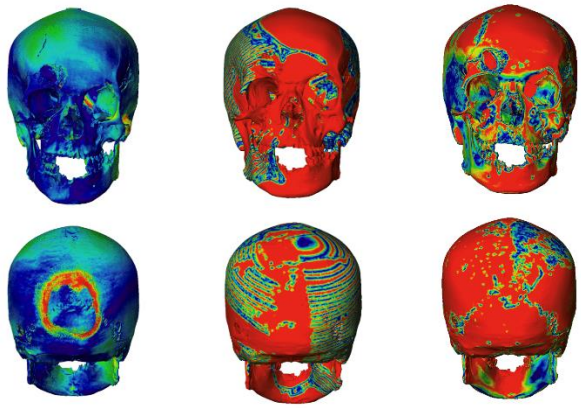
Student	Bram Nanninga
Research carried out at	Saxion
Supervisor	Dr. Ruud Peters
Title thesis	Fingerprint visualisation using blue fluorescent carbon dots
Abstract 	The goal of this research is to visualise fingerprints on different surfaces using carbon quantum dots, also called carbon dots. To accomplish this, fluorescent carbon dots were synthesised using a microwave assisted method. The carbon dots were analysed for excitation and emission wavelengths using fluorescent spectroscopy. Fourier-transform infrared spectroscopy was used to identify bonds present within the carbon dots and atomic force microscopy was used to analyse the size of the carbon dots. Subsequently the carbon dots were dispersed in an aqueous solution to be able to spray the carbon dots onto latent fingerprints. Fingerprints were placed on six different surfaces: wood, metal, ceramic, two different polymers and glass. A visualisation protocol using fluorescent carbon dots was proposed and performed. Visualisation was also done using magnetic powder to compare the proposed method to a more traditional method. Images were taken and assessed by a fingerprint expert. The synthesised carbon dots show emission at 440 nm when exciting with 345 nm. However, the results show it is difficult to get a complete image of the molecular structure and size of the carbon dots. Visualising fingerprints using carbon dots is possible, but does not perform much better than the blank, in which no carbon dots were applied, and fingerprints were visible through auto-fluorescence and/or reflectance of light. Visualisation using carbon dots only succeeded on the ceramic and metal surfaces. Results show promising outcomes and show possibilities in visualising fingerprints using fluorescent carbon dots. However, improvements to the proposed method still need to be made.

Student	Daniel Osei-Nimako
Research carried out at	UvA
Supervisor	Ing. Tom Aalbers
Title thesis	Portable near-infrared spectroscopy for on-site qualitative and quantitative analysis of MDMA in ecstasy tablets.
Abstract	The increasing synthesis and consumption of MDMA in ecstasy tablets has raised concerns for public health organisations due to variations in purity and dosage. Currently, consumers can submit an ecstasy tablet for analysis to determine the MDMA dosage in the tablets. However, these analyses are time-consuming, making on-site drug testing techniques crucial for law enforcement and harm reduction efforts. This study explores the development and application of portable near-infrared spectroscopy (NIRS) for the qualitative and quantitative analysis of MDMA in ecstasy tablets. Validating the NIRS results requires optimising a gas chromatography-mass spectrometry (GC-MS) method as a reference technique. Before applying this optimised method, sample preparation with liquid-liquid extraction was necessary due to its consistent recoveries across a range of sample weights, which improved MDMA detection. Homogeneity testing of the ecstasy tablets showed that machine-grinding the tablets enhanced the repeatability of MDMA content estimation. The measurements of 44 ecstasy samples showed promising results for non-destructive, on-site analysis. However, the quantification of MDMA in ecstasy tablets requires further improvement, as some coloured tablets encountered detection issues. For the quantification of MDMA using NIRS, a Partial Least Squares (PLS) model was developed, yielding a prediction error of 3% and a misclassification rate of 11.9%. This suggests that further refinement is needed. In conclusion, portable near-infrared spectroscopy shows potential as a tool for rapid, on-site quantification of MDMA in ecstasy tablets. This instrument would be suitable for both forensic and public health applications, but further research is necessary to improve its accuracy.

Student	
Research carried out at	UvA
Supervisor	Rick van de Hurk MSc
Title thesis	Determining the nitration degree of nitrocellulose in smokeless powders by two-dimensional liquid chromatography
Abstract	Smokeless powders (SPs) are often used as the main explosive charge of modern ammunition, but can also be employed in improvised explosive devices (IEDs) involved in criminal activities such as terrorist attacks. They primarily consist of nitrocellulose (NC) and various additives. Conventionally, NC is excluded during sample preparation due to its analytical complexity. Therefore, identification and comparison of SPs is focused instead on obtaining an additive profile. However, adding information on the chemical characterization of NC to the additive profile would significantly improve evidentiary value. Two-dimensional liquid chromatography (2D-LC) is successful in obtaining the molecular-weight distribution of NC besides an additive profile. In this study, another 2D-LC method was developed to determine the nitration degree of NC in SPs, while also acquiring the MWD and an additive profile. The nitration degree is a measure for the number of nitrate esters present in NC. The analytical set-up composed of a trap column, which retains the NC while the additives are transferred to a reversed-phase liquid chromatography (RPLC) column, where they are separated. Consequently, the MWD of NC was determined by size-exclusion chromatography (SEC). Ultraviolet (UV) and refractive index detection (RID) were employed to provide the UV/RID ratio of NC, which was directly related to the nitration degree. Issues related to the stability of the RID led to inaccurate and imprecise determination of the nitration degree. Therefore, the developed method should be further optimized to tackle such issues. Moreover, the RPLC method in which the additives are analyzed is compatible with mass spectrometry (MS), which could be implemented to identify the additives and further increase the evidentiary value of forensic comparison of SPs.

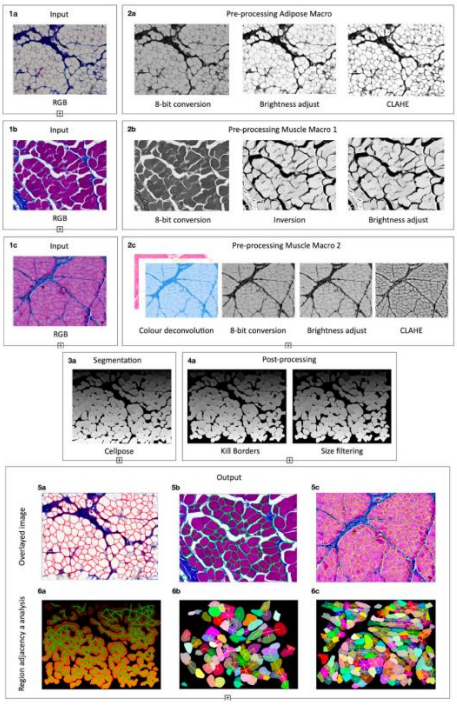
Student	Yue Wang
Research carried out at	OPCW
Supervisor	Karina G. Vignati MSc
Title thesis	Development and validation of an ethyl chloroformate derivatization-based liquid chromatography-tandem mass spectrometry method for the quantitative analysis of saxitoxin
Abstract 	This thesis reports the development, optimization, and validation of a derivatization-based liquid chromatography-tandem mass spectrometry (LC-MS/MS) method for the unambiguous identification of saxitoxin (STX) using ethyl chloroformate (ECF) as the derivatization reagent. STX, a Schedule I Chemical under the Chemical Weapons Convention (CWC), is subject to stringent verification by the Organization for the Prohibition of Chemical Weapons (OPCW). At the same time, STX contributes to paralytic shellfish poisoning (PSP) following the consumption of contaminated food or water, making its monitoring critical for food and environmental safety. However, current methods adopted for STX identification lack the selectivity or applicability required for OPCW verification. For example, the pre-column oxidation LC-fluorescence detection method produces shared products for both STX and its analogue neosaxitoxin (NEO), failing to satisfy OPCW's requirement for an unambiguous identification of STX. This study offers a solution to both selectivity and applicability. A range of derivatization reagents were evaluated for STX and its analogues NEO, decarbamoyl saxitoxin (dcSTX), and decarbamoyl neosaxitoxin (dcNEO). ECF is considered by this study as the ideal reagent because it provides an efficient and accessible derivatization procedure that produces distinct derivatives for each toxin. Various derivatization products from each toxin were found. STX tri-derivative, NEO tri-derivative, dcSTX tetra-derivative, and dcNEO tetra-derivative were chosen as target analytes for subsequent method optimization and validation. The optimization of the derivatization reaction focused on achieving the highest yield and stability for each analyte, particularly STX tri-derivative. LC-MS/MS instrument parameters, including the ion source and tandem mass spectrometry settings, were fine-tuned to maximize the signal of the selected fragments for each analyte. The method was validated by assessing linearity, limit of detection (LOD), limit of quantification (LOQ), within-day and between-day accuracy, repeatability (precision), and reproducibility (intermediate precision). This novel method enables the detection of STX at 4.35 µg/L and quantification at 14.51 µg/L. Additionally, recovery rates were assessed using certified reference material (CRM) oyster homogenates containing STX, yielding a recovery rate of 102.4 ± 6.6%, and apple juice spiked with STX, yielding a recovery rate of 123.4 ± 6.6%.

Forensic Medicine

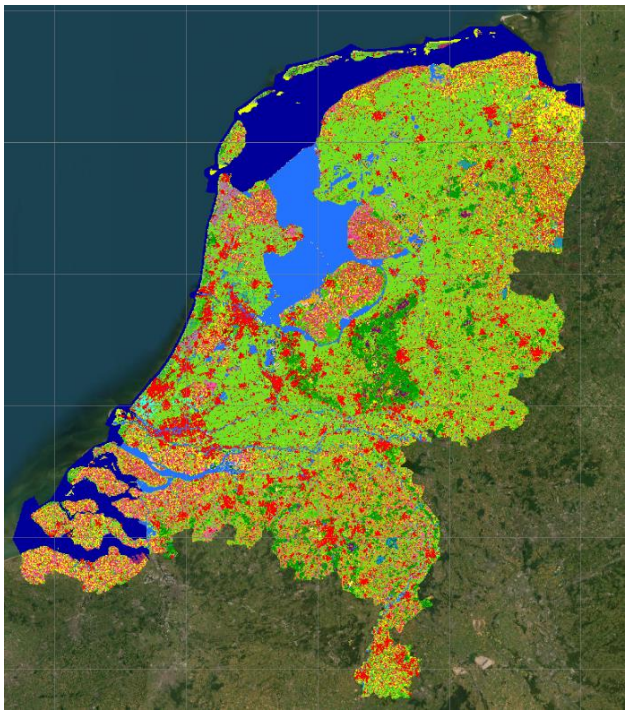
Student	Claudia Ibañez Martin
Research carried out at	University of Pretoria
Supervisor	Dr. Alison Ridel
Title thesis	Validating The Morphology Of 3D-Printed Cranial Projectile Trauma As A Skeletal Alternative For Utilisation In A Court Of Law
Abstract 	In South Africa, firearm-related homicides are prevalent, resulting in a significant number of skeletonised remains. As a result, forensic anthropology is increasingly crucial in the country, particularly in cases involving firearm-related injuries. Although skeletal evidence can provide valuable insights, its presentation in court can pose several challenges. Specifically, the use of biological material may re-traumatise families or lead to biased responses that could influence the verdict. To mitigate these risks, the adoption of 3D printing technologies has been on the rise. These methods offer a means to handle and analyse human remains without the drawbacks associated with presenting biological evidence in legal proceedings. This study aimed to validate the use of 3D-printed skeletal materials—specifically powder-based, resin, and PLA filament prints—as alternatives for courtroom evidence, with a focus on cranial and femoral bullet wounds. The samples were initially scanned using a micro-XCT scanner, and the resultant prints were also subjected to scanning. This process facilitated the creation of a colour map for the visual inspection of discrepancies up to 1 mm. The results indicated that powder-based prints demonstrated the highest overall accuracy for representing the entire skull or cranium. Conversely, PLA filament prints were found to be superior for examining smaller surfaces, while resin prints exhibited lower accuracy levels. In conclusion, 3D-printed skeletal materials can be effectively utilised in legal settings, particularly when accompanied by a colour map to elucidate potential discrepancies. While powder-based prints are generally preferred, other materials may be suitable for specific applications. Further research is necessary to evaluate the impact of these 3D-printed models on judicial decision-making and to refine 3D printing techniques for specialised forensic anthropological applications.

Student	Doreen Jost
Research carried out at	Institute of Legal Medicine and Forensic Science of Catalonia (IMLCFC)
Supervisor	prof. dr. Ignasi Galtés
Title thesis	Further Insight into Ballistic Fracture Patterns in Human Long Bones – An Experimental Approach
Abstract 	Skeletal trauma assessments have become an important part of medico-legal investigations, particularly in cases where the skin and soft tissue are absent or unsuitable for extracting forensic evidence. However, interpreting ballistic fracture patterns specifically in long bones can be challenging due to a lack of reliable and conclusive data. This study explored the variability of ballistic fracture patterns in human long bones by investigating the influence of the angle of the shot, and the bone orientation. To achieve this, twenty femurs were embedded in Clear Ballistics Gel® and shot in four different shooting scenarios: (1) an angled shot on the anterior aspect of the shaft (with a 70° impact angle proximal), (2) a perpendicular shot on the lateral and (3) posterior aspect of the shaft, and (4) a perpendicular grazing shot on the posterior aspect of the shaft. The resultant fracture patterns were macroscopically examined and compared across the groups. The findings suggest that certain general fracture characteristics are shared among all groups and independent of the tested variables. It was observed that the impact angle primarily influenced entrance traits such as tip fragmentation and ring defect, as well as the location of the exit hole. Furthermore, the bone orientation also influenced the fracture pattern, particularly when the bullet entry was near the linea aspera. The grazing shots produced a distinct fracture pattern that exhibited traits which could potentially be misleading regarding the derivation of pertinent forensic information. These findings highlight the variability of ballistic fracture patterns in long bones and provide guidelines for proper interpretation.

Student	Thijs van der Mark
Research carried out at	GGD Amsterdam
Supervisor	Dr. Maartje Goudswaard
Title thesis	Validation and characterization of blunt injuries in reconstructed human skin models
Abstract 	Domestic violence is often difficult to prove due to the lack of witnesses. Injuries originating from domestic violence together with the statements of the involved parties, are the only evidence in these cases. Injuries are investigated and reported by forensic doctors. Experts in forensics and justice report the need for a more extensive injury assessment and the addition of medical information. A method to determine the age of sustained injuries in living individuals is not available. A common soft injury in domestic violence is bruising of the skin. This research aims to characterize and validate a reconstructed human skin (RhS) blunt injury model and investigate potential markers for injury dating. RhS slides are stained with hematoxylin and eosin for morphological characterization in the epidermal and dermal layer after injury infliction. In addition, the expression patterns of fibroblast activation protein (FAP) and phosphorylated ribosomal protein S6 (prps6) are analyzed with immunohistochemistry. After the infliction of blunt injury, RhS showed a decrease in organized keratinocytes. The dermal layer in RhS were predominantly lacerated after the infliction of injury. Over time, the infliction of blunt injury resulted in a decrease of keratinocyte nucleus size. Also, some RhS were perforated by the infliction of blunt injury. In these RhS samples, regeneration of the epidermis around the edges of the dermis was found. FAP expression is observed in the entire dermis. Expression of prps6 does not differ in control and injured RhS. The results of the morphological analysis validate the construction to inflict bruises in RhS. Further research, including next-generation sequencing, is proposed to identify novel markers for injury dating.

Student	Serena Emma Paolini
Research carried out at	AUMC
Supervisor	Dr. Tristan Krap
Title thesis	A novel method for the quantification of morphometric parameters in sub-optimal histological samples for future application in forensic taphonomy
Abstract 	Histological characterisation of autolytic and putrefactive changes resulting from freeze-thaw cycles and the decomposition is relevant in taphonomic research and forensic casework. Remains might experience freeze-thaw cycles when deposited outdoors or in concealment attempts in domestic settings. Morphological aspects of muscle and adipose tissues are currently analysed qualitatively or semi-quantitatively. These methods lack standardisation, are prone to subjectivity and only consider a limited number of morphological features. In this study, an analytical framework for the quantification of histomorphometric parameters in sub-optimal histological samples is proposed. Integration of Cellpose, a deep-learning segmentation algorithm, into tissue-specific customisable Fiji Macro scripts, allowed the automation of the pre-processing, segmentation, post-processing and quantification steps of microscopic digitalised images. A new set of mathematically definable parameters to describe the geometrical aspects and spatial distribution of the adipocytes and myofibers in tissues was quantified. To test the method performance, 440 RGB images acquired with a brightfield microscope at 4x and 10x objective magnification from two longitudinal taphonomic studies on Sus scrofa dom were analysed. A total of 38 between fresh (F) and frozen-thawed (FT) hind limbs were buried for 6, 18, 26, 30 and 60 days, exhumed and processed into histological slides stained with HE and AZAN. Evaluation metrics were computed to investigate the pre-processing effects on the Cellpose outcome. Unpaired two-sample t-test statistics were calculated for F and FT treatment samples within and across burial intervals. Cellular segmentation of sub-optimal samples with Cellpose was accurate for both tissues up to 26 days post-burial. A dependency on the pre-processing strategy of muscle tissue for the correct identification and segmentation was observed. Morphological and morphometric results obtained for the control group supported the hypothesis of an extracellular matrix (ECM) enlargement in FT samples. Preliminary results for the buried remains indicated a possible masking effect of the taphonomic progression over the FT effects. The results demonstrated the successful application of a quantitative semi-automatic workflow for the parametric analysis of sub-optimal taphonomic samples. This proof-of-concept study offers promising outcomes for the potential future application of quantitative histomorphometric analysis in forensic taphonomy and casework.

Other; Environmental Forensics

Student	Dries Fransen
Research carried out at	KWR
Supervisor	Dr. Tessa Pronk
Title thesis	Relationships between Chemicals in Groundwater and Land Use in the Netherlands
Abstract 	This thesis researches chemical pollution in groundwater wells in the Netherlands, and the relation this pollution has to land use, soil type, traffic, industry, urbanisation and cemeteries. This is done by processing a large dataset containing data on chemicals in groundwater measuring wells in the Netherlands, and relating this dataset to the aforementioned categories using Geographical Information Systems (GIS) and several analytical techniques, namely random forest models, t-tests, linear regression and ANOVA. These tests show that it is indeed possible to gather relations between the chemicals and the other datasets, and that many of these relationships are statistically significant. However, more data is needed on the chemicals in the groundwater to create a clearer picture of these relationships, as there are many chemicals that have been measured either below detection limit or not at all. This study shows that a nation-wide groundwater pollutant source allocation analysis is feasible and can yield results that can help the drinking water sector in the Netherlands determine what course to take with respect to policy makers and polluters alike.

Other; Forensic Entomology

Student	Luca Nederhorst
Research carried out at	Wildlife Forensic Academy
Supervisor	Thomas Shehata MSc
Title thesis	Automatic Identification of Forensically Relevant South African Insect Species
Abstract 	Wildlife crime is a significant issue in South Africa. Improving the conviction rates of perpetrators is identified as a key strategy to reduce this crime. This conviction rate is dependent on the evidence collected from crime scenes where animals have been poached. However, the scientific methods available for investigating wildlife crime scenes are currently limited. This study aimed to improve the scientific methods available by enhancing the role of forensic entomology in estimating the post-mortem interval (PMI) in animal-related crimes in South Africa. PMI can be beneficial in reconstructing events, validating alibis, and identifying suspects. While the decomposition status of a carcass provides a tool for PMI estimation within the first 72 hours post-mortem, entomological evidence becomes increasingly valuable beyond this time frame, particularly in wildlife crime cases. Currently, it is challenging to efficiently apply entomological knowledge in forensic investigations for PMI estimations. Most first responders and investigators at wildlife crime scenes have limited training in forensic entomology. A potential solution to this knowledge gap is the automatic identification of entomological data collected from carcasses. Implementing such methods as automatic identification could significantly improve wildlife crime investigations in South Africa, as no specialized entomology knowledge is required at the crime scene. Therefore, this study aimed to advance the role of forensic entomology in non-human PMI estimation by collecting and identifying maggots and adult insects from animal carcasses. Furthermore, it also aimed to develop, train, and evaluate classifiers for automatic insect identification. The research discussed the accuracy of various artificial intelligence classifiers in identifying insect species on baboon carcasses in South Africa. Using a dataset that included three adult classes (Chrysomya albiceps, Chrysomya megacephala, and Synthesiomyia nudiseta) and two larval classes (Chrysomya albiceps and Synthesiomyia nudiseta), the following accuracies were achieved: naive Bayes (58.9%), support vector machine (69.4%), K-nearest neighbour (81.7%), non-pre-trained convolutional neural network (CNN) (90.6%), and pre-trained CNN on EfficientNetB0 (97.0%). Consequently, the pre-trained CNN showed the highest accuracy and is recommended for further training to improve its ability to identify additional forensically relevant insect species in South Africa.