A forensic photographer using a Lizard Q panoramic camera to capture a high-resolution 360-degree image of a crime scene

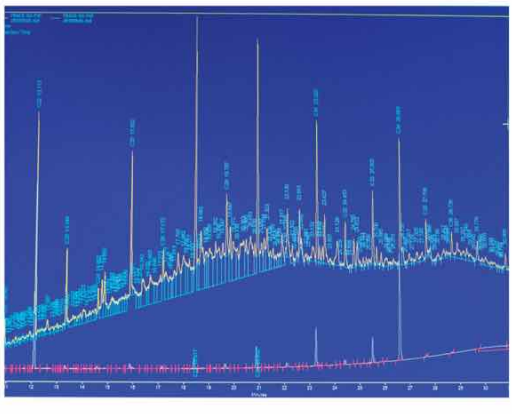
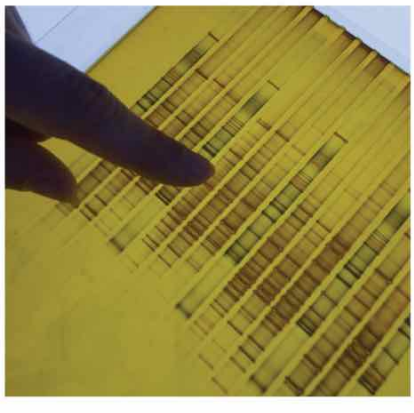
forensic science at

LOUISE MURRAY





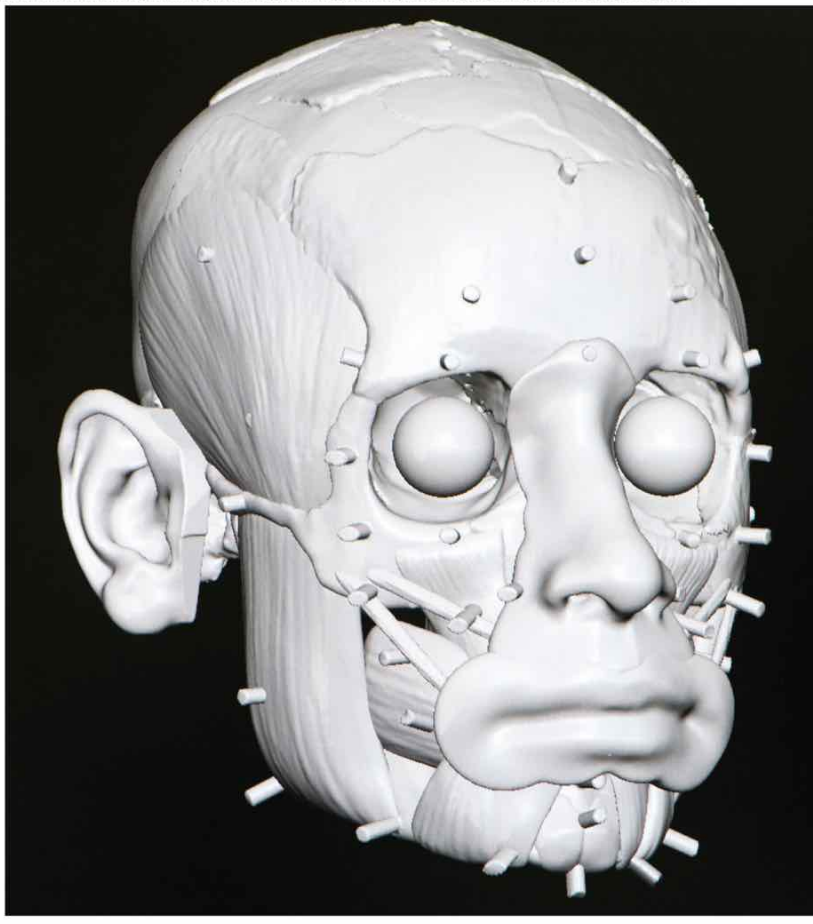

TV programmes often exaggerate what forensic science can achieve, but UK researchers are developing powerful new techniques. Two top centres open their doors to show why they're leaders in this morbid domain.
By **Louise Murray**

a crossroads

Forensic soil scientists take soil samples from the wheel arch of a car and a suspect's boot. Soil samples can provide important evidence in criminal investigations.
ERA Technology Ltd UK developed the first ground-penetrating radar to be used in forensics, firing pulses of radar into the ground to find bodies.
The soil samples from the car, boot and shovel are powdered to be prepared for X-ray diffraction. The diffraction patterns produced depend on the minerals present in the soil. DNA profiles are also taken.

Craniofacial anthropologist Chris Rynn reconstructs a face from the shape of a skull as an aid to identification



FORENSICS
UK STATISTICS

- In the UK, 50,000 offenders are identified each year from crime scenes using fingerprints
- There are 25,000 DNA matches between crime scenes and offenders each year
- Britain's DNA database holds the profiles of more than 3 million convicted criminals
- The national DNA database produces over 2000 DNA matches a month between offenders and a sample from a crime scene or a victim
- Seven out of nine of the highest-certified forensic practitioners in the UK are women

FORENSIC SCIENCE is at a critical crossroads, caught between the sky-high, unrealistic expectations of its capabilities amongst jurors and the judiciary, and – omitting DNA analysis – the reality that many techniques and technologies are decades old, based on minimal basic science. There is a vast dichotomy between fictional television dramas where crime scene investigators provide definitive answers in next to no time from minimal trace evidence and the capabilities of real forensics, where samples are often incomplete and analysis takes several weeks. It is therefore vital for forensic professionals to educate everyone in the criminal justice system about technology available to them today, as well as its limitations, while also working to develop the underpinning science and technology.

Professor Sue Black is an anatomist and forensic science professional based at the Centre for Anatomy and Human Identification (CAHID) in Dundee. "Forensic science is undoubtedly at a crisis point," she says, "right across the board of most evidence types, with the possible exception of DNA analysis. Our underlying science is just not good enough to give the judiciary the confidence needed in the courtroom."

Professor Black and her team have just been awarded a £10m grant from the Leverhulme Foundation to set up what will become Europe's largest research centre for forensic science. The aim of the new centre is to identify gaps and failings in current forensic practice and to plug them with research.

She points out one example. Fingerprint evidence dates back to the late 19th century and has been widely accepted in the courts as definitive, but several high-profile cases in the last decade have called its reliability into question, resulting in fingerprint evidence presented to the Scottish courts downgraded from 'evidence of fact' to the level of 'opinion'. There is simply no real underlying science to fingerprint evidence. However, techniques are now emerging that will strengthen the profession and its standing within the court system.

> 'Digital sculpture reduces the time to produce a likeness from about two weeks to less than 30 hours.' Chris Rynn, CAHID

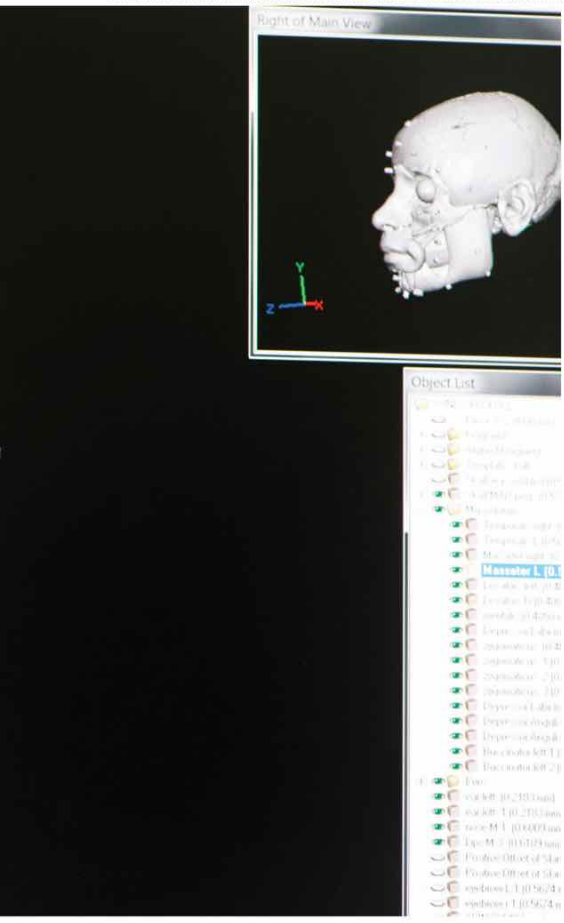
Analysing the patterns

Professor Black is often called upon to advise on child abuse cases. The perpetrators of these horrible crimes habitually film themselves in the act. "The back of the hand is often present in an image," she explains, "we can look at many different aspects of the hand in the image, from superficial vein patterning, the nail bed shapes, knuckle creases, to scarring and skin colour. Even identical twins can be differentiated." CAHID's database of enhanced images featuring hand patterns is now over 2000-strong. Black and the police forces that she works with believe the technique has great promise. Of the cases where imagery has been judged to be of sufficient quality by the team, 82 per cent have resulted in a change of plea by the defendant, saving time and money in the court system and obviating the need for traumatic court appearances by the victims and family.

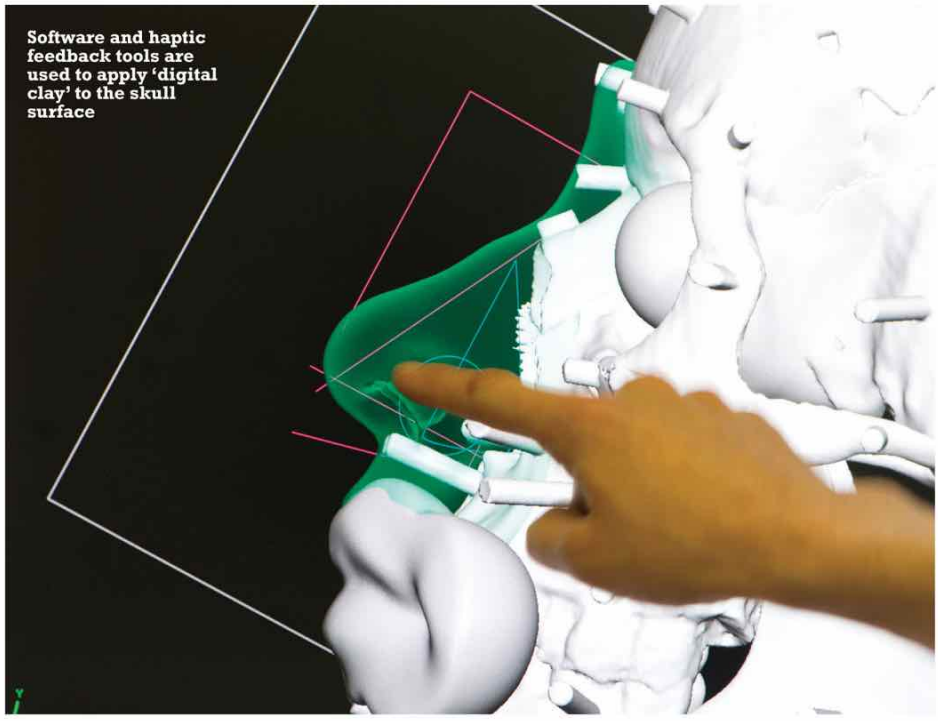
CAHID is in the process of producing algorithms to automatically generate pattern analysis from 2D images or video imagery. While cautious that scientists must not run ahead of themselves in the conclusions that can be drawn, Professor Black points out that the technology can also exclude people, which may be especially important in family court situations where uncles, fathers, stepfathers and brothers may all be potential suspects.

We have all seen examples of the work of the forensic artist who achieves the seemingly impossible by reconstructing a once-living face from the skull upwards. Once practised using clay to shape and mould the missing muscles over the surface of the bones of the skull to recreate the face, the process can now begin with a CT scan of the skull. Craniofacial anthropologist Dr Chris Rynn showed me the technique in his laboratory-cum-studio at Dundee University. Clay has been replaced by 3D digital imaging software that does the job with the aid of haptic or touch feedback tools, which help the artist to 'feel' the digital clay as it is placed on the skull. The device uses motors to create forces that push back on the designer's hand to simulate touch when the cursor interacts with the 3D model in virtual space. Originally developed for video gamers and used to train surgeons in laparoscopy techniques, haptic tools have now found a use in forensic science.

The purpose of a reconstruction is to generate a likeness that will create leads to aid in the identification of an individual. "The beauty of the virtual sculpture



Reconstruction starts with pegs placed on the skull used to guide the depth of covering muscle and tissue



Software and haptic feedback tools are used to apply 'digital clay' to the skull surface

approach is that it is possible to backtrack: to double-check the relationship with the underlying bone by making the shape of the nose, the layers of muscle and skin transparent. The skull can tell us a lot about the face; for example, the angle of projection and shape of the nose can be estimated from the shape of the nasal aperture, and the dental occlusion indicates a lot about the lips," explains Rynn, one of the pioneers of this approach. "There is very little subjective artistry in the process until the finishing and texturing of the skin surface. Using digital sculpture, rather than manually sculpting in wax or clay, certainly speeds up the process, reducing the time to produce a likeness from about two weeks to less than 30 hours."

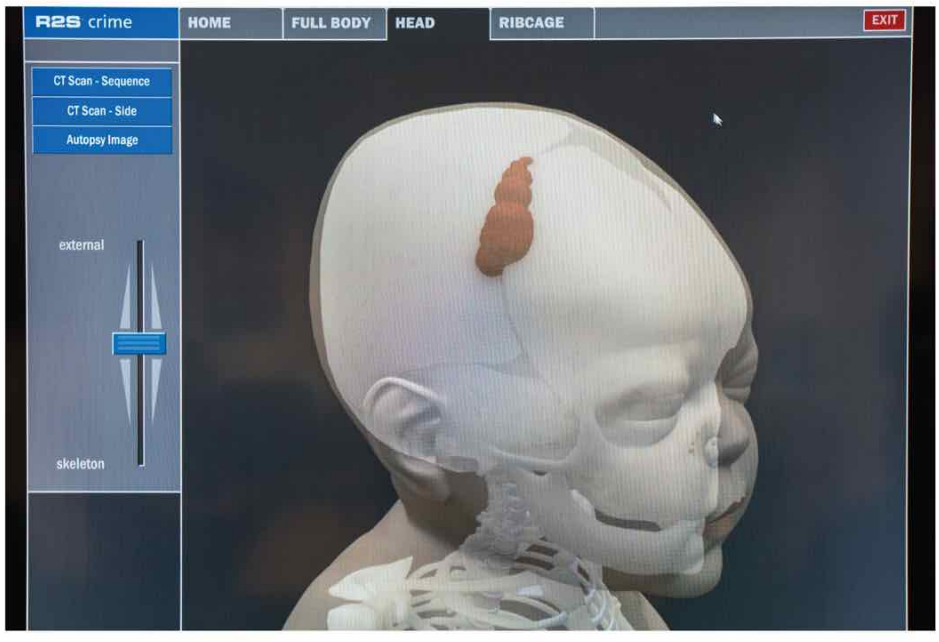
You might imagine that the need for such skills is rare, but in the high-water-table soils of Scotland, bodies that have deteriorated beyond the possibility of identification by other means are relatively common.

Panoramic views

The manipulation of visual imagery is key in two other aspects of the use of new technology in forensics – the virtual autopsy and in crime scene reconstruction and mapping. Jurors often find it troubling to examine pictures from the morgue, especially where dead children are involved.

Aberdeen-based Return to Scene Ltd (R2S) has developed sophisticated layered-imaging toolkits that represent the corpse and relevant injuries as a neutral 3D model while retaining the anatomical detail of the autopsy in hidden layers. A representation of a baby's body as a 3D mannequin can be used to show a history of old and healed repeat injuries or fractures. These can then be separated using colour from recent, fatal injuries and be presented graphically to a jury. "Jurors are more likely to be able to dispassionately examine this kind of imagery, when they might turn their attention away from conventional autopsy photographs. We find that this kind of visualisation of injury helps the court," says Laura Fairley, lead forensic consultant at R2S.

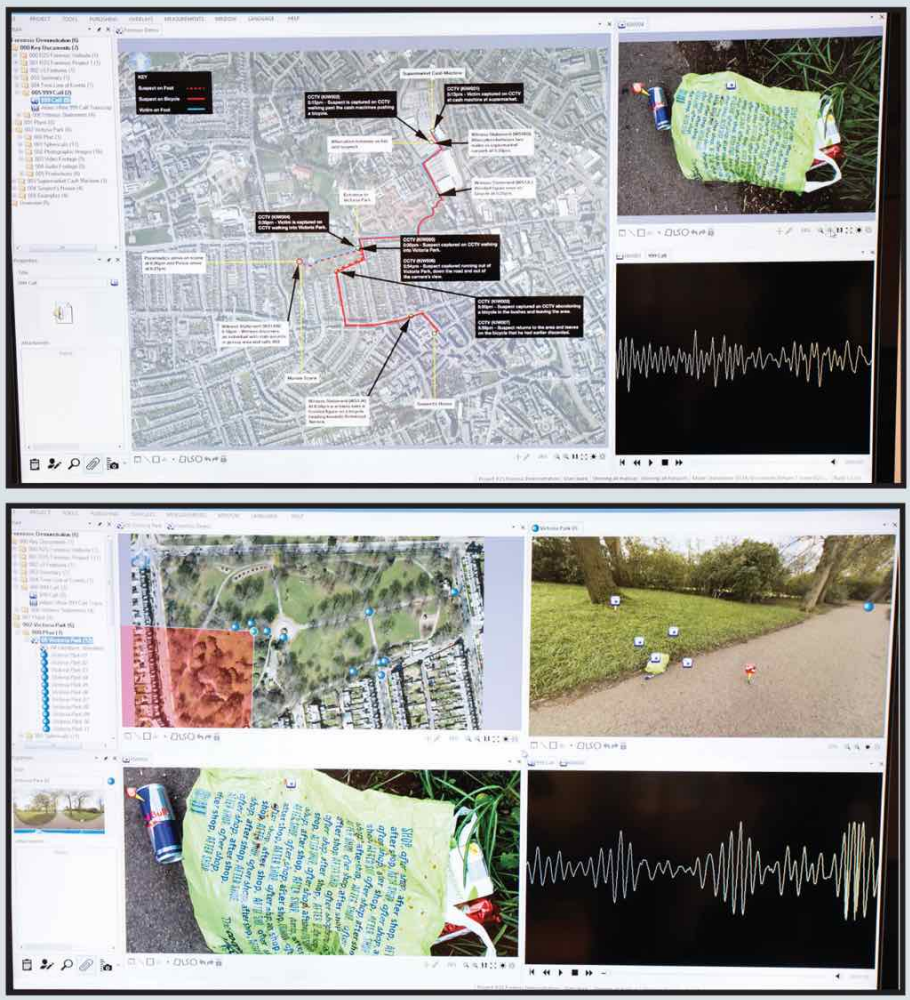
R2S's proprietary software is also used in crime scene reconstruction and mapping. First a 360-degree image of the crime scene is made using a panoramic camera and multiple images are stitched together. These are then integrated with a high resolution aerial image or plan of the area. After elimination of lens distortion, this allows the creation of a measurement-accurate depiction of a scene. From this it is possible, through a technique called photogrammetry, to determine the height of a suspect from CCTV footage by comparing fixed points such as window ledges, floor tiles and doors against the 360-degree image. The system can also calculate whether a witness could have seen what they claim to have seen from any particular viewpoint in the area. The result is an interactive and walkthrough crime scene that can be explored visually but virtually, eliminating visits and possible contamination. R2S software is a platform on which case information can be collated, managed and presented. Embedded >



Representation of anatomical injuries using a virtual autopsy,

SOFTWARE

CREATING A VIRTUAL CRIME SCENE



Crime scene management software from R2S Forensic allows the integration of many different kinds of tagged data, including maps, 360-degree photography, 999 call recordings, CCTV footage, fingerprints, eyewitness accounts and forensic evidence. This gives investigators, jurors and lawyers a visual overview of all the crime scene elements.

< markers link to multiple information types such as the location and audio recording of a 999 call, DNA and other trace evidence samples with their attached forensic expert reports, relevant CCTV footage, crime-scene photographs, incident locations and routes travelled by suspects through the scene. In its simplest form it can deliver a visual reference to jurors, avoiding an expensive and time-consuming site visit. Viewed at all levels it is a complex case management system and is used in murder enquiries.

"Essentially R2S is a hugely more sophisticated, permanent, 21st-century version of the TV detective's whiteboard stuffed with photographs of suspects, arrows and links to the deceased," says Fairley. It also delivers a permanent, navigable visual record of that location over time, long after the original crime was committed. The company's software is used by over 15 police forces in Europe and North America and in many solicitors' offices. Approaches like this can also help in countries where violent crime is rare and police lack expertise in homicide investigations, by permitting remote crime scene access to international forensic experts, who can advise on procedures like appropriate sample gathering and processing.

Digging for dirt

Lars Ebert and his team at the Institute of Forensic Medicine in Zurich, Switzerland, are taking this approach one step further, testing whether Oculus Rift virtual reality headsets could transport an entire courtroom to the crime scene in a 3D reconstruction. In some incidents like gun crime, bullet trajectories can be vital evidence. In court, these would be conventionally presented in 2D. "What you have is a line on paper, and it's difficult to get an idea of how it moved in space," says Ebert. "But the second you see it in 3D, you know where it originated, where it goes, how close all the people and objects are." The team call their system the 'forensic holodeck' after the Star Trek immersive gaming environment.

Perhaps even the legendary Sherlock Holmes would have found the concept of some of these technologies difficult to grasp, but the basis for Professor Lorna Dawson's work at the Hutton Institute in Aberdeen would be surprisingly familiar to the fictional detective, as his creator Sir Arthur Conan Doyle used soil evidence as a plot device in a Holmes book, 30 years before it was ever used in practice. Dawson specialises in soil as an evidence type.

The 2015 Glasgow murder of 24-year-old Irish nurse Karen Buckley illustrates just how far the science of geoforensics has advanced in recent years. Analysis of soil samples from the suspect's boots using X-ray diffraction identified the mineral components in the soil and narrowed the area where the suspect had been. When combined with gas chromatography of organic components of the soil, it was confirmed that the suspect had visited a farm in north-west Glasgow, where the nurse's body was found dumped in a barrel. "We also analysed trace plant materials from pine needles and plant fragments found on his vehicle after it had been valeted," explained Dawson. "These were comparable to vegetation types found at the farm." The suspect, Alexander Pacteau, also dumped Karen's handbag in a park. "Soils from the verges surrounding the park were sampled and the characteristic pollutant hydrocarbon curve in the gas chromatograph trace image compared to soil samples secured from Pacteau's vehicle, proving that he had stopped his car in that area." said Dawson. Overwhelming forensic evidence combined with CCTV footage resulted in Pacteau changing his plea to guilty and being sentenced to life imprisonment with a minimum of 23 years in jail.

As for future advances in geoforensic technology, Dawson believes that DNA information from the microbial component of soils has a great future potential, adding to the arsenal of soil characteristics that can be used to pinpoint a location. Compact analytical machines may appear in police stations and mobile crime labs as these are becoming faster, quicker and smaller; though quality control and the chain of evidence would have to be rigorous. She adds: "A new understanding of the chemistry of death, the volatile organic compounds that are produced as a corpse decays, combined with better hydrological information – the flow of water through soil – could help lead us to long-buried bodies. Plus our ability to extract so much information from ever smaller samples is already making it possible to reopen cold cases. New technology can help us to re-examine evidence from cases that were abandoned decades ago, secure convictions, and allow victim's families vital closure."

Dawson has been brought in to help the investigation team searching for the body of Moira Anderson, an 11-year-old schoolgirl who disappeared in 1957. New searches for the remains of the young girl will start in 2016. "There should be no time limit on care and compassion for the unfortunate victims of violent crime and their friends and relatives," says Dawson passionately. New developments in forensic science will surely help support that resolve. *