Advances in forensic technologies and procedures are designed to produce more efficient policing for safer nations, but little is understood about how humans can interact with them effectively. Specifically, research into the judgement and decision-making processes that forensic examiners undertake when evaluating evidence can highlight how best to implement new technology and procedures. For this, experimenters need materials that approximate the realism of crime scene evidence, while ensuring the ground truth about the source of this information. These two goals are often incompatible. We discuss the development of an open-source biometric repository to address the issue of ground truth. This repository contains a range of crime related materials such as fingerprints and palm-prints, shoe-prints, faces, handwriting, voices, and irises. Our goal is to provide a large, open source repository of forensic information, where certainty of the source in built into the system, to help advance research on identification by humans and technology.

**INTRODUCTION**

Recent international commitments to facilitating responses to increased threats to individuals, society and associated infrastructures have led to changes in many Homeland Security and Policing technologies, legislation and communications standards. There has been a large effort in all countries to develop technology for surveillance infrastructures through millions of CCTV systems and biometrics for homeland security technologies (Welsh & Farrington, 2009). In the biosecurity area, sensor networks for environmental monitoring for critical resources such as water, soil, and the satellite monitoring of crops have also been deployed (Oliveira, Trezza, Holzapfel, et al. 2009; Ni-Meister, 2008; Wesseling & Feddes, 2006).

Although these technologies are increasingly being relied upon to capture and identify important information, they cannot effectively solve these threats without reliable, efficient, and timely interpretation. Often, the final decision is left to human judgement. Errors are to be expected, given the all-too-human foibles of distraction, lapses of attention, fatigue, rushes to judgement, less than perfect information, biases, and so on (Cole, 2005; Dror & Charlton, 2006), that cannot be avoided even by the most diligent professionals.

Forensic experts identify evidence on the basis of various features and rules that presumably aid classification and interpretation (Cole, 1998). Many of these encoding schemes, however, are leftovers from early, and perhaps deficient, systems. For example, fingerprint classification is based on the same general ridge formations proposed by Henry in 1900 (arches, loops, and whorls) and local features such as areas, angles and distances between ridge endings, bifurcations, forks, and enclosures (Cole, 1998). Fingerprint experts often describe prints in terms of the angle and distance between the delta and core markings, as it is assumed that these are important features for identification.

These patterns look very different from one another and they contain information that is extremely difficult, for novices and experts alike, to interpret or even verbalize. Similar arbitrary coding methods can be found in face or voice recognition, ballistics, footwear impressions and tyre tracks.

**The Importance of Ground Truth**

In order to investigate the judgement and decision making processes that underlie forensic identification, it is necessary to approximate the high degree of visual noise, similarity, and ambiguity that professionals face when deciding whether two pieces of evidence originated from the same source. Ideally, such investigations would make use of the very same evidence that is obtained from a crime scene. The problem, however, with using actual crime scene evidence as stimuli for examining identification accuracy, is the ground truth of the evidence. That is, how can we be sure that the crime scene evidence does in fact belong to a convicted suspect? If we use stimuli for which we can guarantee such matches, the stimuli could be seen artificial. But if we use “real” crime scene evidence, then we remain subject to the question of the ground truth of the evidence.

**The Solution**

Our solution to this conundrum is to work on both fronts; accessing authentic crime-scene evidence, and creating our own stimuli where ground truth is known. Our team is working with forensic professionals across Australia to gain access to the very same materials that they routinely use in their investigations and training, where the evidence has been independently confirmed by other examiners and corroborating evidence. At the same time, we are building a standardised set of forensic stimuli that varies
systematically in quality, where we have multiple pieces of biometric data that converge on a single source, and where the ground truth of the source is built into the system.

**Forensic Informatics Biometric Repository (FIBR)**

The term *Forensic Informatics* refers broadly to the science of processing crime related information, where the processing is conducted by humans and technology. The advantage of using technology is obvious, but its interaction with human forensic identification has been neglected. In order to facilitate and accelerate research in the area of forensic informatics, we are currently building an open source Forensic Informatics Biometric Repository (FIBR) that consists of a large, standardised set of biometric materials where the certainty about the source of the information is ensured.

The open-source nature of the repository will likely prove to be an important feature. While we capture and provide biometric stimuli for other researchers, we also provide protocol/instructions for others to collect their own standardised materials and contribute to the repository for the benefit of others in the field.

**METHOD**

Initially contrived to facilitate research in fingerprint examination, we decided to expand the scope of our repository to include biometric materials useful to other areas in forensic decision-making. First, our collection of biometric material includes fingerprints and palm-prints, shoeprints, faces, handwriting, voices, and irises. Second, we collect the biometric data in as controlled a manner as possible while using advice from forensic professionals to simulate the nature of the evidence commonly found at a crime scene. This will allow researchers to create experiments that effectively simulate the information that forensic examiners and technologies routinely process. Finally, we collect biometric information from participants over two sessions to approximate the natural variation that is commonly found in forensic evidence (e.g., change in facial hair, clothes, shoe decay, etc.).

**Participants**

Participants are first-year psychology students who participate in one hour of biometric data collection for course credit. Participants received informed written consent.

**Stimuli Design**

*Fingerprints and Palms.* Fingerprints have been used for over 100 years as a means of identification and is often regarded as the “gold standard” of forensic science (Schwinghammer, 2004). Computer algorithms designed to aid fingerprint identification continues to advance (Alam, Akhteruzzaman, & Cherri, 2004). The final decision, however, is made by a fingerprint examiner, so it is important to approximate the same materials that they encounter. Because experts routinely match crime scene latent prints to full rolled ten-print cards, we are collecting both forms for the repository.

Latent prints vary along a number of dimensions, including quality, size, amount of useful information, and surface that they are found on. In consultation with local fingerprint examiners, we chose to use five surfaces on which latent prints are commonly found. Almost all of these surfaces are found near points of entry to a building, and include gloss-painted timber (doors, window frames), smooth metal (door handles, knife blades), glass (windows), paper, and smooth plastic. As there are no reported figures on the variability of latent quality, latent size, and amount of useful information, we devised a protocol for collecting simulated latents, which we call “freedom latents”. We instruct our participants to interact with the latent surfaces by asking them, for example, to “push on the gloss-painted timber to open the door” or “safely grab the knife by the blade.” By interacting with objects in this way, participants will leave the most realistic latents, controlling for real-world variability in latent quality, size, and amount of useful information.

We also collect standardised 10-print cards and palm-prints. The 10-print cards use ink to capture each fingerprint, rolled fully from nail-edge to nail-edge, as well as “slap impressions” (pressing, not rolling, the fingers on the card). We separately capture fully rolled palm-prints.

*Shoeprints.* Criminals must enter and exit a crime scene and therefore it is natural that they would leave traces of their footwear. Hilderbrand (1999) argues that when properly collected and preserved, shoeprints can provide the type, make, description, approximate size, number of suspects, path through and away from the crime scene, the involvement of evidence and the events that occurred during the crime. Consequently, the importance of footwear impression evidence should not be underestimated.

Shoeprint identification can be classified at a class and individual level. Bodziak (2000) defines a class characteristic of a shoe as an intentional or unavoidable characteristic created during the manufacturing process and is shared by one or more other shoes. He further explains that any single class characteristic will be shared by many other shoes. Individual characteristics occur when something is randomly added to or taken away from a shoe outsole that either causes or contributes to making that outsole unique. For example, cuts, scratches, tears, rocks
wedged in the outsole, chewing gum, holes and air-bubbles. Bodziak (2000) argues that when sufficient, individual level characteristics are present in the impression and correspond with those on the shoe outsole, that outsole can then be positively identified as having made the impression.

Shoeprint impressions are commonly found in soft surfaces, such as mud or dust deposits. Representative latent shoeprints can be difficult to capture in a quick and clean manner. We chose to only use inked impressions to collect standardised whole and partial prints. Shoeprints vary in many dimensions. We chose, however, to vary our shoeprints along dimensions similar to fingerprints; quality, size, and amount of useful information. We vary our shoeprints by instructing participants to stand in each of the configurations listed in Figure 1.

Our repository also includes photographic images of each shoe that we obtain prints from. These photos are taken from multiple angles, including photos of the sole.

Figure 1. Partial shoeprint images.

**Faces.** Face recognition and eyewitness testimony have been studied extensively, and a large, high quality repository of face images and video footage is in high demand. Our repository was designed with this literature in mind and so includes images of faces from multiple angles and contexts. We collect standardised face stimuli as “mug-shots” and crime-scene face stimuli as context face capture and mock crime footage. Our face capture protocol is divided into six stimuli types; mug-shot face capture, context face capture, phoneme capture, emotion capture, gaze direction, mock crime:

- Face capture: Standardised, mugshot-style photograph of a participant’s face from one of 9 angles (see Figure 2.)
- Context face capture: Photograph of participant in an real world setting (e.g., office hallway).
- Phoneme capture: HD video footage of participants verbalising a set of phonemes.
- Emotion capture: HD video footage of participants displaying some of Ekman’s (1999) universal emotions (contempt, anger, disgust, fear, joy, sadness, and surprise) while looking forward.
- Gaze direction: HD video footage of participants displaying some of Ekman’s (1999) universal emotions while looking away from the camera at a 45° angle.
- Mock crime: SD security camera footage of participants engaging in a mock theft.

Figure 2. Angles of face capture

**Handwriting.** Forensic document examiners perform similar duties to those of fingerprint examiners, where they compare the visual features of handwriting associated with a known writer to those of an unknown writer, and then make a decision about whether the two samples belong to the same source. Handwriting samples are classified as either questioned handwriting or known/specimen handwriting. We will collect known/specimen handwriting for the repository. The nature of possible future experiments, however, means that our known/specimen handwriting samples can also be used as questioned handwriting samples when testing naive document examiners. Our handwriting protocol is divided into three sections: London Business Letter, handwriting specimen, and signature specimen:

- London Business Letter: A ‘catch-all’ paragraph that contains all 26 letters of the alphabet (upper and lower case) and numerals 0-9 (see Figure 3.)
- Handwriting specimen: Common English letter associations acquired through names, addresses,
quantities, and words with double letters (e.g., ‘succeed’)

- Signature specimen: 10 samples of participant’s signature plus 10 attempts of forging a fake signature

Figure 3. Example sentence from London Business Letter

Voices. Speaker-recognition is a unique area of biometrics where examiners deal with auditory noise, rather than visual noise, and so is included in our repository. The time constraint on our collection sessions, however, restricts us to only collect a short voice sample. Accordingly, participants’ voices are recorded as they read out the London Business Letter.

Iris. Iris-recognition is a powerful method of biometric identification because of its high reliability (Daugman, 2004). False matches are incredibly rare because the iris-pattern variability among different persons is so vast (Daugman, 2004). Whereas extensive research has been conducted on automated forms of iris-reconition, there has been no work investigating the ability of humans to discriminate or match irises. We envision our iris stimuli could be used to test human ability for discriminating or matching human irises. We use a simple iris scanner to capture two standardised images of participants’ irises.

CONCLUSION

In order to conduct experiments on the perceptual and cognitive processes underlying forensic identification, it is essential that researchers use materials in which the ground truth of the source is guaranteed. By creating our own repository, we have complete control over the method in which the materials are collected. On two separate occasions (separated by several weeks), we collect digital photos of participants’ face and video footage of them committing a crime, latent and full-rolled fingerprints, shoe prints, voice samples, handwriting and signature samples, and scans of their irises. In order for research in this field to progress, it is critical that all researchers in the field working on computer and human identification have free access to a large database of standardised forensic materials. The Forensic Informatics Biometric Repository (FIBR) will, therefore, be made freely available for research purposes.

REFERENCES


