

Crime Scene Science: Future research directions

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Goals of work

- Muse about purpose of crime scene examination
- Examine the forces shaping forensic science work
- Explore rationale for current research
- Examine current paradigm
- Suggest benefit of an additional (not different) direction



Goals of work

- Suggest modification to prevailing paradigm –add the origin of evidence
- Explore research into origin of evidence
- Propose the “Crime scene theater”
- Propose a use for the research – prediction that assists searching
- Detail how the crime scene examination might be different



A crime is committed

- An action or omission that constitutes an offense that may be prosecuted by the state and is punishable by law
- The state finds the action unreasonable and wants to know whether someone should be prosecuted and punished for it
- An investigation ensues that attempts to determine whether all of the elements that constitute the crime are present
 - The investigation includes identifying the person responsible



A crime is committed

- The investigation might include the use of science to identify elements and persons
- The goal of the investigation is to identify evidence relevant to an offense and bring that to a prosecuting officer
 - Not all information uncovered is evidence adduced at trial
- The role of science at the scene is to assist in finding physical evidence relevant to the criminal act
 - Finding objects related to the event in question
 - Excluding objects with no relationship to the event



A brief diversion: What is the purpose of a forensic science examination?

- Find out some legally important and useful information about a violent/criminal event that has occurred in the past
 - Forensic science attempts to reconstruct the past
 - Generate *expectation* of what we would see today if event had occurred as proposed
 - Requires explicit hypothesis formulation before beginning an exam, based on prior experience, scientific background knowledge, preliminary observations, and logic



A common pursuit: crime scene reconstruction

- Using all evidence to infer the
 - The relative time of each of many contacts
 - The absolute time of each contact
 - The relationship of the discovered evidence to the crime alleged



Forces affecting direction of forensic science research

- While labs originally tapped for investigative leads, in the early to mid 70's the drug avalanche forced a re-evaluation of priorities and shifting of resources
- Labs became overwhelmed with work; no increase in resources
- Analysis of large quantities of solid dose drugs and toxicology analyses
- ***Only cases with named suspects*** were accepted into the lab for other exams (FP, TM/FA, biology, trace)



Forces affecting direction of forensic science research

- Forensic science role became primarily that of assisting in prosecution by examining evidence obviously linked to the crime
- At the end of two decades of these forces, a paradigm emerged and became prevalent: a hierarchy of propositions
 - Source – Who or what left this material at the scene?
 - Activity – Were these two objects in contact with one another?
 - Event – Who engaged in an illegal act?



On the legal side

- Eyewitness accounts were found to be wanting
- More reliance on science by law and law enforcement
- Courts developed criteria for admissibility of scientific evidence
 - Daubert, et.al.



Result of all forces

- Laboratories turned to analyzing evidence in pursuit of legal prosecution...
- ...and much less on evidence discovery and investigative leads
- There was lots of evidence to examine
 - And too few analysts to examine it
- Few asked whether we were collecting the right stuff, or at least all of the right stuff



How did that affect research?

- Research currently geared towards validation studies designed to meet court admissibility requirements
 - Admissibility requirements are legal criteria + precedent with a little science thrown in
 - Goal is a safe conviction
 - In other words, the law wants/requires science to participate in safe convictions
 - Or at least not contribute to unsafe convictions
- And science has, wittingly or not, acceded to those requirements



How did that affect research?

- Lots of research on analyzing evidence
- But little to nothing about the variety and quantity of physical evidence produced during different kinds of violent events
 - Beating with blunt objects
 - Stabbing
 - Strangulation, manual and ligature
 - Shooting
- BSP has done some of this
 - e.g., what pattern results from impact, as opposed to transfer?



Is there some research on crime scene?

- Reasonable amount on processing the scene and depicting the scene
 - One example: A Solution for Crime Scene Reconstruction using Time-of-Flight Cameras
 - <https://arxiv.org/pdf/1708.02033.pdf> (August 2017)
 - Less precise than environmental laser scanner
 - More practical and portable
 - Hardware cheaper



A Solution for Crime Scene Reconstruction using Time-of-Flight Cameras

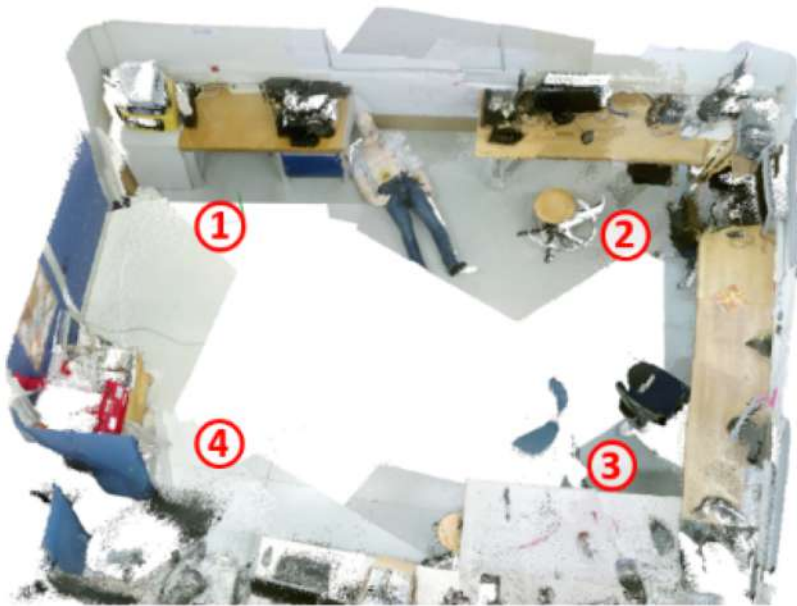


Figure 4. Reconstruction of surrounding environment.

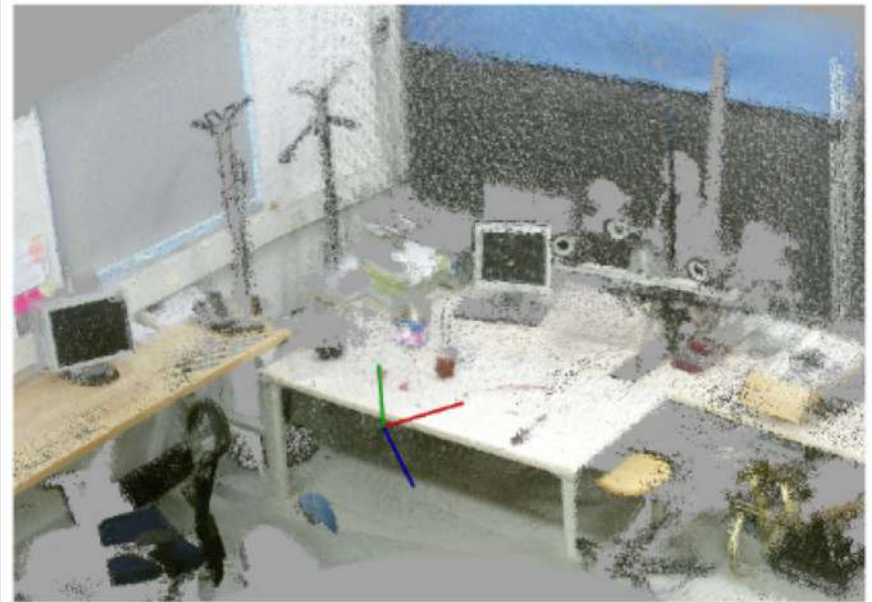


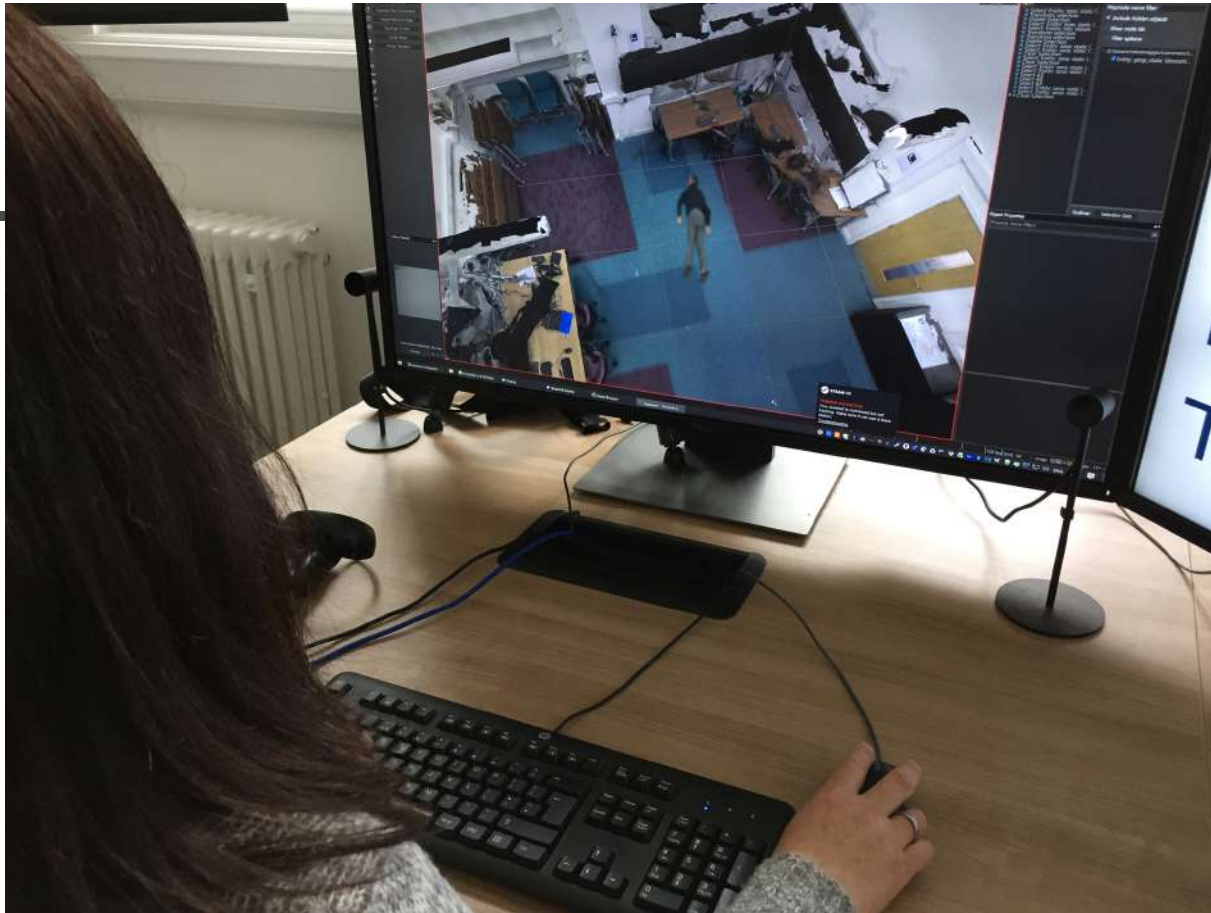
Figure 5. Focus on corner 3 part of the reconstruction.



Augmented Reality for crime scene documentation

- Roy Mudie and colleagues at University of Dundee
- EAFS 2018
- Ability to precisely locate evidence and update over hours, days or months as more information gathered





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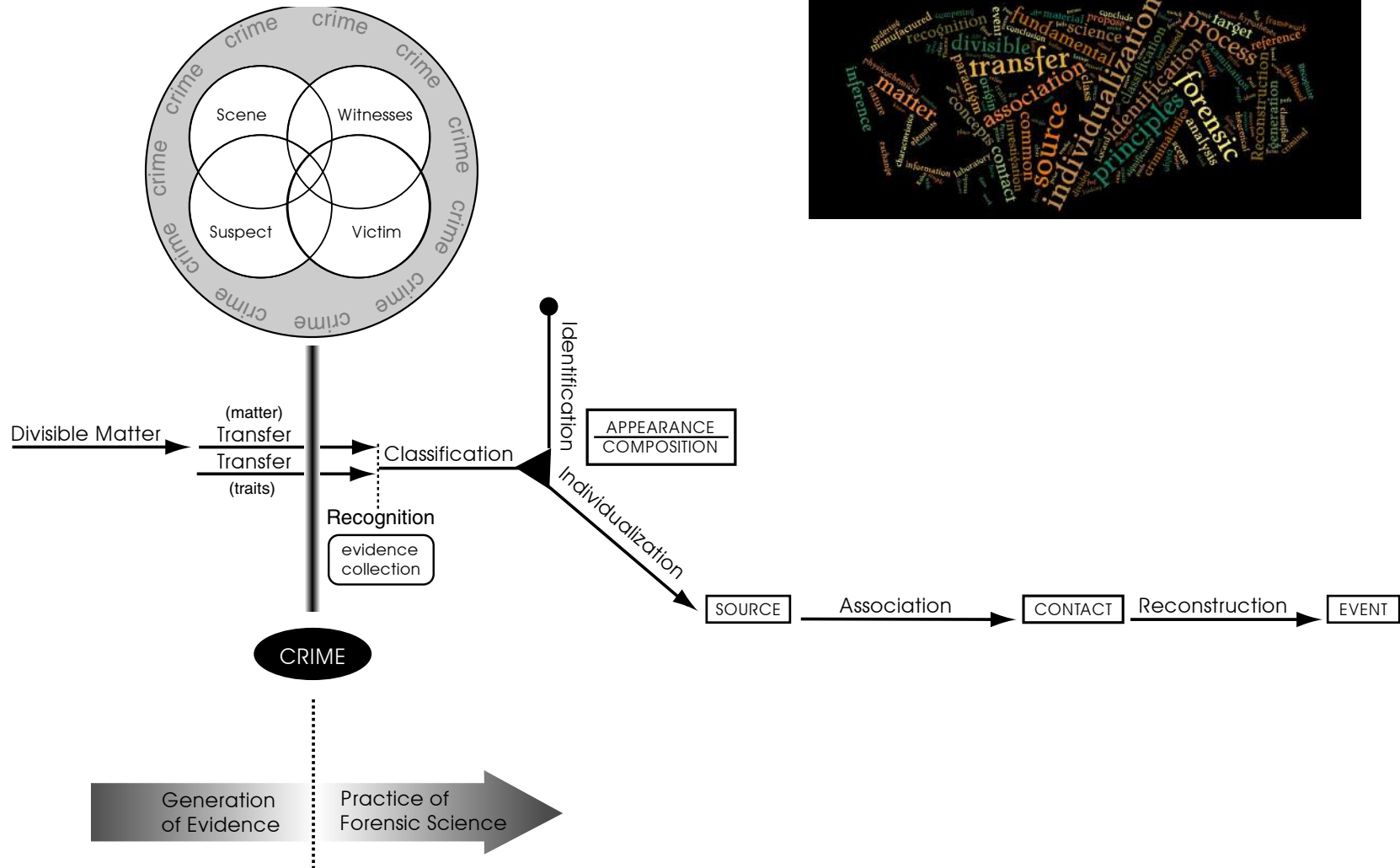


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Is there more to consider?

- Little research on discovering evidence
- A more expansive paradigm would assist in expanding the vision of research needed throughout forensic science
- A paradigm that includes a consideration of the origin of evidence would assist this effort
 - Forensic science paradigm
 - Shannon's information theory





Claude Shannon: Transmission of Information

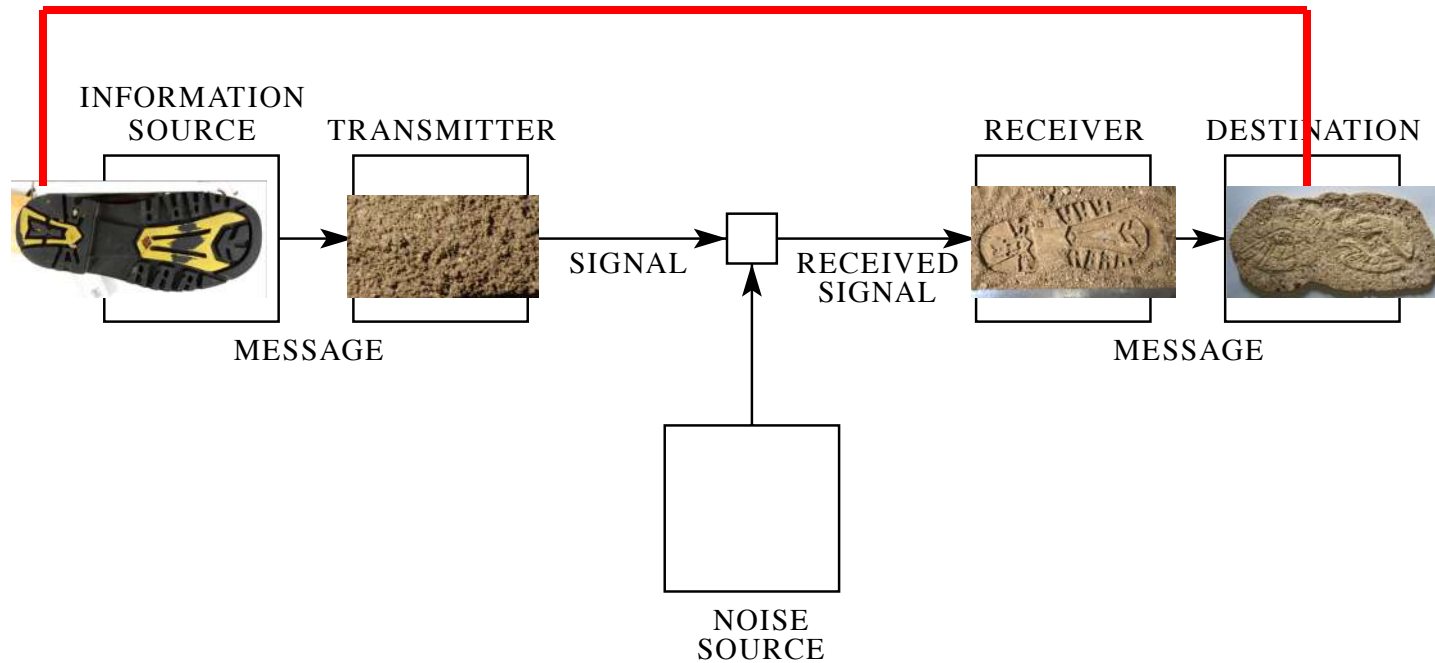


Fig. 1 — Schematic diagram of a general communication system.



Suggestion: Research focused on evidence creation

- Most stand in the crime scene and look around and ahead: what do I see that will help me understand what happened?
- Look in the opposite direction of the crime scene, back to the crime event, and ask:

What would have been created during the event?

What expectation should I have if X happened?

What expectation should I have if Y happened



In practice:



Observation:

Multiple blunt force injuries to face

- Hypothesis:
 - Bludgeoned to death
- Prediction:
 - Numerous bloodstain patterns;
 - Lots of blood
- Search for blood



Obvious Example...

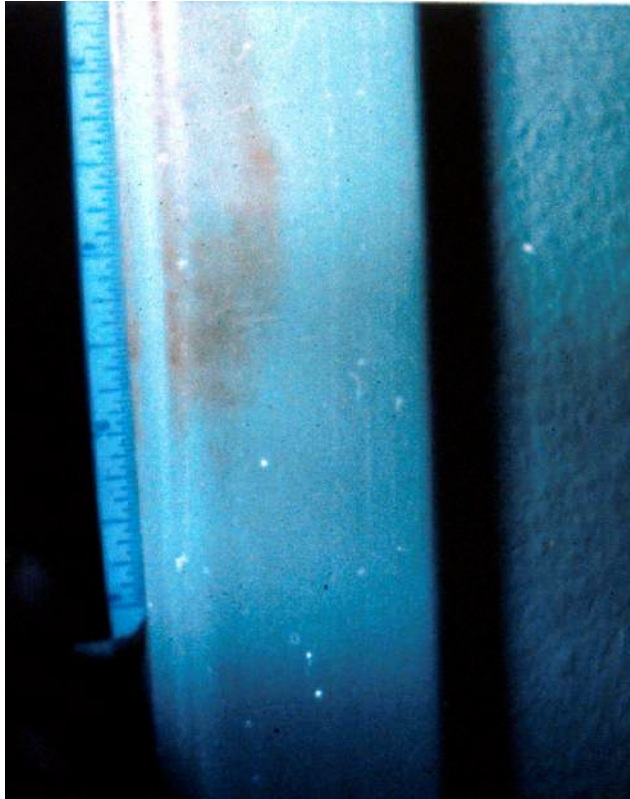
- Is there other evidence for which we should search?
 - Only some idea of the range of evidence created during a prototypical bludgeoning will answer that question (in a scientific manner)
- Do we also expect the instrument to have struck one of the walls?
 - How often?



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- Should some trace of the wall be found on the instrument?
 - How long would such a trace be expected to persist?
 - What factors would cause it to be lost?
 - What factors would cause it to degrade (give trait values that differ from its original state)?

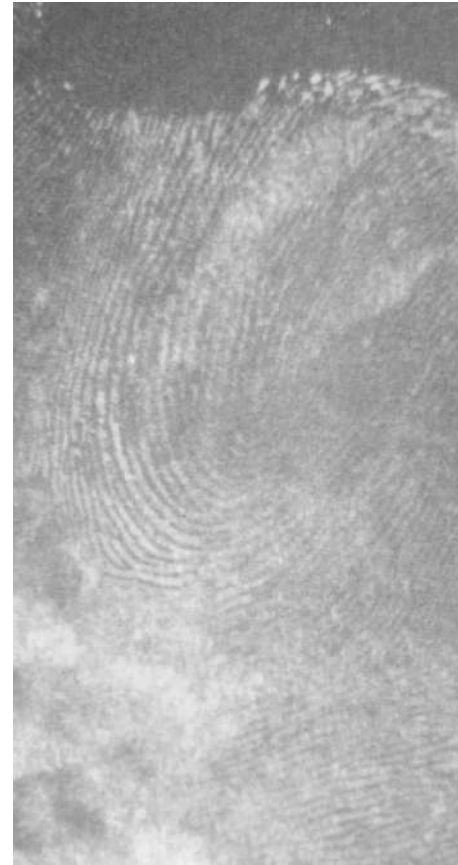
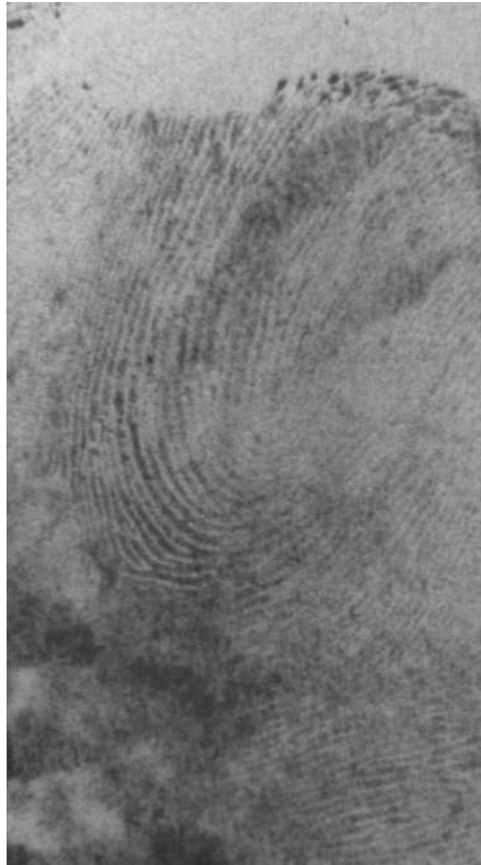


Not so obvious...



- Prediction:
 - That amount of bloodshed results in bloody assailant
- Search:
 - For transfer from assailant
- Find:
 - Bloody dermal ridge print
- Predict:
 - Bloody prints are frequently reverse prints





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- This perspective requires us to perform research that predicts what evidence would be found
 - It would be useful to conduct research on what physical evidence is produced during violent criminal events: the origin of physical evidence
 - Use in practice:
 - From an initial observation(s) propose a hypothesis for the event
 - Inquire of the intelligence database: what physical evidence is created when this event occurs?



Origin of evidence

- Interested in the dynamics of what and how physical evidence is produced and dispersed during an act of violence
- The results of such research would be not only an understanding of what could be produced, and where it might be deposited
 - But can ultimately be modeled for how much of any evidence could be produced
 - How long such evidence would persist, and what factors lead to its absence
 - What changes such evidence would undergo, and what factors would hasten and mitigate such changes



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- Research into the decay or degradation of evidence would be an integral part of such research
 - How long does each item last?
 - What are the factors producing degradation?
 - How much of the individuality of a trace is lost over time, and how is the process delayed or accelerated?



When research used properly...

- Promotes multiple hypothesis formation at the scene
- Resulting in the search for a wide variety of types of evidence: science provides a predictive element to the scene processing
- More relevant evidence collected at the scene narrows the later inferences that are reasonable, both in terms of source and activity.



When combined with lab analysis

- A degree of uncertainty can be expressed without regard for admissibility issues:
 - A degree of belief that equals 10%, for example, is a perfectly reasonable investigative lead, for the detective can incorporate such uncertainty into his evaluation of the value of the information in pursuing a person or a scenario.
 - There's nothing inherently unreliable with a 16% chance that the person leaving this biological trace has blue eyes
- It's actually better than most of what is communicated in laboratory reports
- More science, less law, is used in such a process



Crime Scene Theater

- A facility equipped with
 - High speed still and video cameras
 - Sensors capable of detecting a range of applied forces
 - Kinetic energy generators - Instruments capable of delivering reproducible force for the study of violent acts
 - Sound sensors capable of measuring the amount of sound generated by a wide range of causes from bumps to gunshots
 - Mobile walls to produce rooms of a variety of sizes



How might that be accomplished?

- Crime Scene Theater
 - Violent acts repeated
 - Recorded as for computer game development
 - Math modeling + computer simulation/gaming
 - It is very inter-disciplinary



Crime Scene Theater

- Multi-disciplinary, potentially involving faculty and students from
 - Chemistry
 - Physics
 - Mathematics and statistics
 - Computer science (simulations and gaming)
 - Theater and drama



Goal of research into the origin of evidence

- Produce a “horizon of expectations” for any hypothesized event
- This can assist in directing attention (not focusing to the exclusion of other evidence) to searching for the expected evidence
- The more such evidence is found, the more likely is the hypothesis to be approximately correct.



Goal of research into the origin of evidence

- The expectations would include
 - Production (through knowledge of manufacture and division)
 - Dispersion (through transfer/Locard)
 - Persistence
 - Degradation



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- The validation of such a model should have a different goal than validation of methods for court admissibility
 - Court decisions are made with a set of legal rules and criteria involved
 - Goal of techniques and methods for examining a crime scene are to understand what happened and who was involved
 - Reliable investigative leads are produced



Not all leads are correct

- Like eyewitness ID's, or circumstantial evidence, they may lead in the wrong direction
- Training on use is vital
- Understanding inference and balance of probability a must for detectives to properly use the evidence found through prediction as leads



This model could fail

- This is the closest thing to basic science research that one could conceive for forensic science
- At the end of 5 or 10 years, it may all come to naught
- But if it succeeded, or parts of it succeeded, it would change the way that crime scenes are processed.



Summary of Research

- Basic research into the finding of relevant legal physical evidence
 - How generated during real acts of violence
 - Modeling or simulating acts of violence
 - How long does physical evidence persist/what is the decay rate of various kinds of physical evidence
 - What time constraints are present
 - Best practices for evidence discovery and collection
 - Generation of probabilistic models of reconstruction based on either repetitive testing or boot-strap models

