

Editor's Commentary: Fingerprint Identification

Paul J. Campbell
 Mathematics and Computer Science
 Beloit College
 700 College St.
 Beloit, WI 53511
 campbell@beloit.edu

Introduction

Some problems from COMAP's Mathematical Contest in Modeling (MCM) and the Interdisciplinary Contest in Modeling (ICM) have arisen in very specific current situations, and it was not clear that specific ideas from the solution papers could have any immediate further application beyond the original setting. I am thinking here of MCM problems such as the

- Emergency Facilities Location Problem (1986),
- Parking Lot Problem (1987),
- Midge Classification Problem (1989),
- Helix Intersection Problem (1995),
- Velociraptor Problem (1997),
- Lawful Capacity Problem (1999),
- Bicycle Wheel Problem (2001),
- Wind and Waterspray Problem (2002),
- Gamma Knife Treatment Problem (2003), and
- Stunt Person Problem (2003).

The UMAP Journal 25 (3) (2004) 273–280. ©Copyright 2004 by COMAP, Inc. All rights reserved. Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice. Abstracting with credit is permitted, but copyrights for components of this work owned by others than COMAP must be honored. To copy otherwise, to republish, to post on servers, or to redistribute to lists requires prior permission from COMAP.

The same is true of some of the ICM problems, such as the Zebra Mussel Problem (2001) and the Scrub Lizard Problem (2002).

Other contest problems have arisen from situations that society faces chronically but have no urgency, yet the solution papers provide valuable ideas that could be put into practice. Here I include the

- Salt Storage Problem (1987),
- College Salaries Problem (1995),
- Contest Judging Problem (1996),
- Discussion Groups Problem (1997),
- Grade Inflation Problem (1998), and
- Quick Pass Problem (2004).

Finally, some problems have touched on issues of immediate concern, and the solution papers offer important insights:

- Emergency Power-Restoration Problem (1992),
- Asteroid Impact Problem (1999),
- Hurricane Evacuation Problem (2001)—eminently relevant in multiple-hurricane season of 2004,
- Airline Overbooking Problem (2002),
- IT Security Problem (ICM 2003), and
- Airport Security Problem (2004).

Perhaps no problem has been as aptly timed, however, as the Fingerprints Problem of this year's MCM [Giordano 2004].

Previous Developments

The Outstanding papers for the Fingerprints Problem [Amery et al. 2004; Camley et al. 2004; O'Ceallaigh et al. 2004] and the commentaries by contest judge Michael Tortorella [2004] and practitioner Mary Beeton [2004] note the recent questioning in U.S. courts of the reliability of fingerprint evidence. That questioning took place after the U.S. Supreme Court set forth standards for admissibility of scientific testimony and evidence, the so-called *Daubert* criteria:

1. that "the theory or technique" is one that "can be (and has been) tested";
2. that "the theory or technique has been subjected to peer review and publication";

3. "in the case of a particular scientific technique, the court ordinarily should consider the known or potential rate of error ... and the existence and maintenance of standards controlling the technique's operation"; and
 4. "general acceptance" in the "scientific community."
- 509 (1993) U.S. at 593–594.

The primary recent decisions about fingerprint evidence were made by Justice J. Pollak of the U.S. District Court for the Eastern District of Pennsylvania. In his first ruling, he agreed to the uniqueness and permanence of fingerprints and to allow the government to present evidence comparing latent prints and exemplars (in the terminology of Beeton [2004]) but disallowed any testimony that "a particular latent print is—or is not—the print of a particular person" [Pollak 2002, 49]. He found that only the fourth *Daubert* criterion was fulfilled ("general acceptance within the American fingerprint examiner community"), and that the difficulty with the *Daubert* criteria arises at the point that a fingerprint specialist uses subjective judgment and criteria to assert that two prints came from the same person [2002, 42–44].

Judge Pollak granted a subsequent hearing to reconsider his ruling and subsequently reversed his own decision, allowing such testimony. His change of mind resulted from being convinced by evidence presented that fingerprint identification does satisfy the "peer review" criterion of *Daubert* and also the "rate of error" / "standards" criterion ("there is no evidence that the error rate of certified FBI fingerprint examiners is unacceptably high" [2004, 36]). (Perhaps he would have a different opinion after reading the subsequent revelations by Heath [2004].) However, he still regarded the testing criterion as not met. Nevertheless, "to postpone present in-court utilization of this 'bedrock forensic identifier' pending ... research would be to make the best the enemy of the good" [2004, 49–50].

Developments Since the Contest

As the contest papers and the commentaries point out, fingerprint identification is not solely a scientific enterprise but takes place in an environment where human error can prevail. Various recent events pointedly identify some such sources of error.

DNA testing is subject to similar errors; and with DNA evidence, even further questions can be raised, about possible contamination and the interpretation of the "odds" offered by DNA analysts (see Wood [1991] for discussion of the latter).

Appeals Court Ruling

In an appeals ruling on a different case, the court found fingerprinting "testable" (though not completely tested), the error rate very low (though not

“precisely quantified”), but standards to be lacking. Nevertheless, it found in the case at hand (*U.S. v. Byron Mitchell*) that most factors in the *Daubert* principles supported admitting the government’s latent fingerprint evidence [Barry et al. 2004].

Mistake

Stephen Cowans, convicted in 1998 of shooting a police officer on the basis of a fingerprint match from a glass at the crime scene, was freed from prison in February 2004; reanalysis of the latent print showed that it did not match his prints [Mnookin 2004]. Fraud? Incompetence? Just plain error?

Misfiling

Rene Ramon Sanchez was accused in an immigration court of being Leo Rosario and was arrested three times for Rosario’s crimes, spending two months in custody. The reason: Sanchez’s prints matched Rosario’s. And they did match, perfectly; at least, they matched the prints that were on Sanchez’s fingerprint card on record. That was because when police had fingerprinted Sanchez earlier on another charge (later dropped), they put Sanchez’s prints on a card with the name and data for Rosario. Finally, the authorities compared *photos* of the two. The aggrieved Sanchez says that he has never received an apology from any of the authorities involved [Weiser 2004].

Dueling Experts

Brandon Mayfield, a lawyer in Portland, OR, was arrested and jailed in connection with the bombings of trains in Spain in April 2004. The basis was discovery of a fingerprint on a bag of detonators at the bomb scene, which three FBI fingerprint examiners concluded was a match to Mayfield’s: a “100% positive identification.”

The FBI turned out also to be “100% wrong.” Despite contentions all along by Spanish fingerprint experts that the match was “conclusively negative,” the FBI maintained its position for five weeks. In a meeting of American and Spanish experts, the Americans maintained that the prints had 15 “Galton points” in common, while the Spaniards said there were only 7. (No specific minimum number of common “points” is required for an identification in the protocol used by the FBI.)

Only after the Spaniards matched the print to Ouhnane Daoud, an Algerian, did the FBI admit that theirs had been a faulty match; subsequently, despite the match by the Spaniards, the FBI claimed that the print was unusable in the first place (i.e., the latent print was of poor quality).

The Spaniards later expressed surprise at the FBI’s singleminded pursuit of Mayfield, who had converted to Islam and had represented in a custody

case an individual who was also a defendant in a terrorism case. "It seemed as though they [the FBI] had something against him, and they wanted to involve us." However, according to FBI authorities, the fingerprint examiners who made the mistaken match did not know Mayfield's name or anything about him [Kershaw 2004]. (Kershaw's article includes photos of the latent print and of Brandon Mayfield's; images are available at German [2004].)

This is going to kill prosecutors for years every time they introduce a fingerprint ID by the FBI. The defense will be saying "is this a 100 percent match like the Mayfield case?"

—U.S. Senate aide [Kershaw 2004, A13]

Philosophical Questions but Practical Implications

As Tortorella [2004] notes, this MCM problem raises philosophical questions.

No Sound Statistical Foundation?

One question that Tortorella mentions is about how to assign probabilities to the sample space of modeled fingerprints.

The calculations in the Outstanding papers admit assuming independence of features from one area of a fingerprint to another (thus enabling their multiplication of probabilities), despite obvious local dependence (ridges cross multiple cells).

However, more dangerously, implicit in the papers' calculations of the probability of a match is the assumption of a uniform distribution: that all the many fingerprints are equally (un)likely. As Mnookin [2004] puts it:

Fingerprinting ... currently lacks any valid statistical foundation.... The important question is how often two people might have fingerprints sufficiently similar that a competent examiner could believe they came from the same person. This problem is accentuated when analyzing a partial print. How often might one part of someone's fingerprint strongly resemble part of someone else's print? No good data on this question exist.

The growing size of computer fingerprint databases makes this issue still more acute. As a database grows in size, the probability that a number of people will have strikingly similar prints also grows....

The FBI called the resemblance between Mayfield and Daoud's prints "remarkable." What is truly remarkable is that we simply do not know how often different people's prints may significantly resemble one another, or how good examiners are at distinguishing between such prints.

Is Science Certain . . . Enough?

A second key issue is the status of scientific truth and of evidence obtained by technical means. In May 2004, Gov. Mitt Romney proposed a death-penalty statute for Massachusetts (the state does not currently have a death penalty). A death sentence would require “conclusive scientific evidence” of guilt.

Romney’s proposal highlights the philosophical question:

Can scientific evidence yield certainty? Should scientific evidence be regarded as more reliable than other evidence? Is it more reliable?

Those who believe that scientific evidence is more reliable need to confront that today’s science may be tomorrow’s alchemy—“today’s certainty is tomorrow’s question mark” [Daley 2004]. The last few years have seen DNA analysis bring many cases of wrongful conviction to light; but many of those wrongful convictions were based primarily on the best “science” of the time, including microscopic analysis of hairs and also fingerprints.

What we say in forensic science is the more certain the scientist is, the less reliable the scientist is [O]ur society can easily be taken in by science, and that is worrisome.

—James Starrs, Prof. of Law and Forensic Science,
George Washington University [Daley 2004]

Subjectivity

Fingerprint experts maintain, and the FBI agrees, that in the final analysis declaring a match of two fingerprints is a subjective decision, made by a human being based on training, experience, and all of the circumstances involved in the comparison. But what science is without subjective decisions, at some level? Judge Pollak found that the techniques in fingerprint identification have not been subjected to sufficient testing—so it is high time that the work be done to put fingerprinting on as unimpeachable a scientific basis as it deserves!—but nevertheless he was willing to consider such matching as “scientific” evidence.

However, caution about subjectivity is in order, and not just in the realm of fingerprint matching:

[F]ingerprints are valuable forensic evidence. . . . But when the evaluation of that data rests on a because-I-said-so analysis, the door is wide open for injustice. And as Brandon Mayfield’s case amply demonstrates, taking the government’s say-so as definitive simply isn’t enough. And when pseudoscience is turned loose in the context of the war on terror, the results may well terrify.

—David Feige [2004]

References

- Amery, Steven G, Eric Thomas Harley, and Eric J. Malm 2004. The myth of "the myth of fingerprints." *The UMAP Journal* 25 (3): 215–230.
- Barry, Becker, and Greenberg, Circuit Judges. 2004. Precedential. 29 April 2004. United States Court of Appeals for the Third Circuit. *United States of America v. Byron Mitchell*. No. 02-2859. caselaw.findlaw.com/data2/circs/3rd/022859p.pdf .
- Beeton, Mary. 2004. Practitioner's commentary: The outstanding fingerprints papers. *The UMAP Journal* 25 (3): 267–272.
- Camley, Brian, Pascal Getreuer, and Bradley Klingenberg. 2004. Not such a small whorl after all. *The UMAP Journal* 25 (3): 245–258.
- Daley, Beth. 2004. Foolproof forensics. *Boston Globe* (8 June 2004).
http://www.boston.com/news/globe/health_science/articles/2004/06/08/foolproof_forensics .
- Ellement, John. 2004. Scientist rebuts reliance on fingerprints. *Boston Globe* (18 May 2004). http://www.boston.com/news/local/massachusetts/articles/2004/05/18/scientist_rebuts_reliance_on_fingerprints .
- Feige, David. 2004. The inexact science of fingerprint analysis. *Slate* (27 May 2004). <http://slate.msn.com/id/2101379/> .
- German, Ed. Problem idents: Madrid erroneous identification. Last updated 23 September 2004. <http://onin.com/fp/problemidents.html#madrid> .
- Giordano, Frank. 2004. Results of the 2004 Mathematical Contest in Modeling. *The UMAP Journal* 25 (3): 189–214.
- Heath, David. 2004. Bungled fingerprints expose problems at FBI. *Seattle Times* (7 June 2004). http://seattletimes.nwsource.com/html/localnews/2001949987_fingerprints07m.html .
- Kershaw, Sarah. 2004. Spain and U.S. at odds on mistaken terror arrest. *New York Times* (5 June 2004) (National Edition): A1, A13.
- Mnookin, Jennifer L. 2004. A blow to the credibility of fingerprint evidence. *Boston Globe* (2 February 2004).
http://www.boston.com/news/globe/editorial_opinion/oped/articles/2004/02/02/a_blow_to_the_credibility_of_fingerprint_evidence .
- _____. The Achilles' heel of fingerprints. *The Washington Post* (29 May 2004): A27.
<http://www.washingtonpost.com/wp-dyn/articles/A64711-2004May28.html> .
- O'Ceallaigh, Seamus, Alva Sheeley, and Aidan Crangle. 2004. Can't quite put our finger on it. *The UMAP Journal* 25 (3): 231–244.

- Pollak, J. 2002a. Opinion. 7 January 2002. United States District Court for the Eastern District of Pennsylvania. *United States of America v. Carlos Ivan Llera Plaza, Wilfredo Martinez Acosta, and Victor Rodriguez*. Cr. No. 98-362-10, 11, 12. http://www.dartmouth.edu/~chance/chance_news/for_chance_news/ChanceNews12.05/Pollak.pdf.
- _____. 2002b. Opinion [reversal]. 13 March 2002.
http://www.dartmouth.edu/~chance/chance_news/for_chance_news/ChanceNews12.05/PollakReverse.pdf.
- Snell, J. Laurie. 2003. The controversy of fingerprints in the courts.
http://www.dartmouth.edu/~chance/chance_news/recent_news/chance_news_12.05.html#item11.
- Tortorella, Michael. 2004. Judge's commentary: The outstanding fingerprints papers. *The UMAP Journal* 25 (3): 261–265.
- Weiser, Benjamin. 2004. Can prints lie? Yes, man finds to his dismay. *New York Times* (31 May 2004) (National Edition): A1, A17.
- Wood, John B. Paternity probability: An inappropriate artifact [with commentaries]. *The UMAP Journal* 12 (1): 7–42.

About the Author



Paul Campbell graduated summa cum laude from the University of Dayton and received an M.S. in algebra and a Ph.D. in mathematical logic from Cornell University. He has been at Beloit College since 1977, where he served as Director of Academic Computing from 1987 to 1990. He is Reviews Editor for *Mathematics Magazine* and has been editor of *The UMAP Journal* since 1984.