ARE FINGERPRINTS REALLY UNIQUE? WHY IT MATTERS IN CRIMINAL CASES
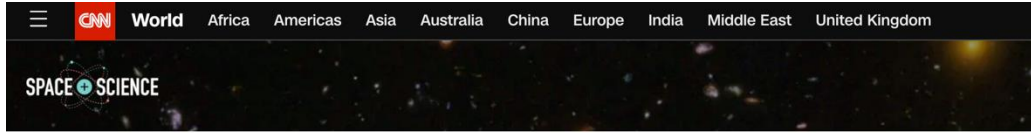
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February 28, 2025

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Are fingerprints unique? Not really, AI-based study finds

By Jacopo Prisco, CNN
5 minute read · Published 11:37 AM EST, Fri January 12, 2024

AI fingerprint-matching tool

(Image credit: Shutterstock)

A new technique to match fingerprints from separate digits belonging to the same person sparked controversy at the beginning of 2024. It's long been suspected that connecting prints from different digits could help solve criminal cases, but forensic methods so far haven't been able to do so accurately, only reliably linking fingerprints from the same digit.

- Calls from:
    - Friends and relatives
    - Media
    - Lawyers

TRENDING   AI 'brain decoder'   Water 'ripples' on Mars   Workplace diora

Human Behavior

The 8 most controversial science stories of 2024

Countdowns   By Sascha Pare published December 28, 2024

From a piece of cloth that may have belonged to Alexander the Great to an image of our galaxy's central black hole, here's our pick of controversial science stories in 2024.

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AI Discovers That Not Every Fingerprint Is Unique

Columbia engineers have built a new AI that shatters a long-held belief in forensics—that fingerprints from different fingers of the same person are unique. It turns out they are similar, only we've been comparing fingerprints the wrong way!

He added, "Even more exciting is the fact that an undergraduate student, with no background in forensics whatsoever, can use AI to successfully challenge a widely held belief of an entire field. We are about to experience an explosion of AI-led scientific discovery by non-experts, and the expert community, including academia, needs to get ready."

Peer review suppressing knowledge?

Study findings challenge-and surprise-forensics community

Once the team verified their results, they quickly sent the findings to a well-established forensics journal, only to receive a rejection a few months later. The anonymous expert reviewer and editor concluded that "It is well known that every fingerprint is unique," and therefore it would not be possible to detect similarities even if the fingerprints came from the same person.

The team did not give up. They doubled down on the lead, fed their AI system even more data, and the system kept improving. Aware of the forensics community's skepticism, the team opted to submit their manuscript to a more general audience. The paper was rejected again, but Lipson, who is the James and Sally Scapa Professor of Innovation in the Department of Mechanical Engineering and co-director of the Makerspace Facility, appealed. "I don't normally argue editorial decisions, but this finding was too important to ignore," he said. "If this information tips the balance, then I imagine that cold cases could be revived, and even that innocent people could be acquitted."

While the system's accuracy is not sufficient to officially decide a case, it can help prioritize leads in ambiguous situations. After more back and forth, the paper was finally accepted for publication by *Science Advances*.

The published paper

1. Did not attempt to rebut uniqueness

2. Did not rebut uniqueness

3. Found something already known . . .

4. . . . that is not very useful

Why?

- Not because defensive of the uniqueness of fingerprints
  - Unproven, but willing to assume it
  - Not very important
- . . . but illustrates something important that applies across all forensic identification disciplines
- Lessons for science communication

Fingerprints Proven by AI to Not Be Unique! – Episode 264

https://doublelooppodcast.com/2024/01/fingerprints-proven-by-ai-to-not-be-unique-episode-264/

Friday, January 12, 2024

What's Uniqueness Got to Do with It?

Columbia University has announced that "AI Discovers That Not Every Fingerprint Is Unique"! The subtitle of the press release of January 10, 2024, boldly claims that

About DHK

DH Kaye

Professor & Author
ACI Scholarly Blog interview

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JAN 10 2024 | BY HOLLY EVARTS | PHOTO CREDIT: MARCO-MARCIL MONTAÑO, COLUMBIA ENGINEERING, GENERATED WITH DALL-E

EMBARGOED UNTIL 2:00 PM US ET FRIDAY, 12 JANUARY 2023

SCIENCE ADVANCES | RESEARCH ARTICLE

COMPUTER SCIENCE

Unveiling intra-person fingerprint similarity via deep contrastive learning

Gabe Guo[1]*, Aniv Ray[1], Miles Izydorczak[2], Judah Goldfeder[1], Hod Lipson[3], Wenyao Xu[4]

Fingerprint biometrics are integral to digital authentication and forensic science. ==However, they are based on the unproven assumption that no two fingerprints, even from different fingers of the same person, are alike.== This renders them useless in scenarios where the presented fingerprints are from different fingers than those on record.

unique

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In this work, our main discovery is that fingerprints from different fingers of the same person share strong similarities; these results hold

1. Linguistic sleight of hand in claiming to rebut "uniqueness" with "strong similarities"
   - Finding "strong similarities" does NOT disprove uniqueness
2. The purpose of the research was not to disprove uniqueness but to search for similarities.
3. That "different fingers of the same person share strong similarities" was already known.
   - E.g., researchers on heritability of fingerprint patterns who found that an individual's fingerprint patterns were more similar to their identical twin's pattern than to the patterns of other people also found that an individual's fingerprint patterns were similar to *their own* fingerprint patterns than to the patterns of other people (and their twin's).
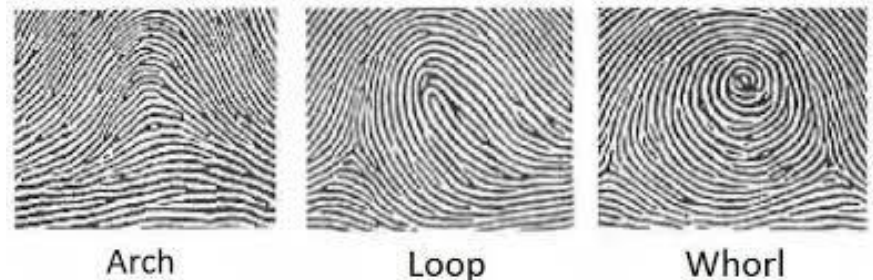4. Intra-person similarities are not very useful

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- "unproven assumption that no two fingerprints . . . are *alike*"
- Obviously "two fingerprints even from different fingers of the same person are alike." They are both fingerprints. And see pattern types.
- The actual claim was "no two fingerprints are exactly alike."
- Supposedly disproven by showing that fingerprint from different fingers . . . share very strong *similarities*."
- Again, *uniqueness* is supposedly disproven by showing mere *similarity*, not *identicality*.

Arch   Loop   Whorl

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Lies, damn lies, and statistics

SCIENCE ADVANCES | RESEARCH ARTICLE

COMPUTER SCIENCE

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- Main finding: Presented with 2 fingerprint images and asked to guess whether from same-person-different-finger or different-person, AI guesses correctly 75-80% of the time
  - under ideal conditions.
- 99.99% is confidence that this result did not come about by chance

Uniqueness disproven by similarity?

- Just because two things are *similar* does not mean they are not *unique*.

- The word they seem to be looking for is *identical.*

- Two things that are *identical* cannot also be *unique.*

- But the press release does not even claim the researchers have shown *identicality*.

- They claim to have disproven *uniqueness* by proving mere *similarity*.

- Therefore, the term *discriminability* is more useful than *uniqueness*

- If you make statements about *uniqueness* or *identicality,* I want to know what your *observation system* is
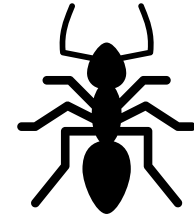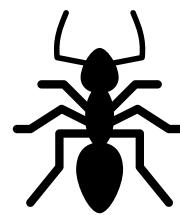
"Different fingers of the same person"

Columbia University in the City of New York

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Already known

he said. "I think they have oversold their paper, by lack of knowledge, in my view. I'm happy that they have rediscovered something known, but essentially, it's a tempest in a teacup."

— Christophe Champod, University of Lausanne

C. H. Lin,[1] LL.M.; J. H. Liu,[1] Ph.D.; J. W. Osterburg,[1] M.P.A.; and J. D. Nicol,[1] M.S.

Famous FBI "black box" study (Ulery et al. 2011) used same-person-different-finger pairs to create challenging comparisons

Fingerprint Comparison. I: Similarity of Fingerprints

ABSTRACT: Fingerprints from 61 pairs of male monozygotic twins (MZ), 47 pairs of female MZ, 40 pairs of same-sex male dizygotic twins (DZ), 44 pairs of same-sex female DZ, 4 pairs of opposite-sex DZ, and 28 brothers and 31 sisters of those twins are used for the study of fingerprint similarities. Similarities of fingerprint pattern, ridge count, and minutiae are evaluated for two population groups genetically related to each other in different degrees. It is concluded that fingerprint similarities, including pattern, ridge count, and possibly minutiae, between MZ individuals are significantly higher than those between other population groups, including DZ twins.

KEYWORDS: criminalistics, fingerprints, human identification, pattern, ridge count, minutiae, monozygotic twin, dizygotic twin

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Heritability studies

STUDIES ON PAPILLARY PATTERNS
OF HUMAN FINGERS

By KRISTINE BONNEVIE,

Institut for Arvelighetsforskning, University of Kristiania, Norway.

TABLE XIII. Range of variation of quantitative values.

It seems evident, from this table, that there exists some coincidence between the quantitative values of the various fingers of one and the same individual, the patterns representing either relatively low, or relatively high values. The individual values may, therefore, *be considered as characteristic of the individual itself* not only as the sum of the varying finger-values.

Utility

finger (*8, 21, 22*). This renders them useless in crime scenes or authentication scenarios where the presented fingerprints are from different fingers than the fingerprints on record.

ferent list of 1000 potential suspects is available for scene B. Given the current information, traditional fingerprint biometrics are unable to discern whether the fingerprints from scenes A and B are related and involve the same person unless all fingerprints of all suspects are readily available on file. However, if intra-person fingerprint similarity can be established,

because this similarity could help improve the ability to find leads for investigations when the fingerprints obtained from crime scenes are from different fingers than the fingerprints already on file. We

Far-fetched scenario?

- Useful for all those cases in which the police have the legal authority to seize fingerprints, but don't seize them all

- Usually the fingerprints on file are from *all fingers*

- Exceptions?
  - Poor quality impression for one finger?
  - Spoofing?
  - Bandaged finger?

FORENSIC FEATURE-COMPARISON TECHNIQUES AND UNIQUENESS

Missing the point

Fingerprint biometrics are integral to digital authentication and forensic science. However, they are based on the unproven assumption that no two fingerprints, even from different fingers of the same person, are alike. This ren-

- Fingerprint examination is not "based on" uniqueness
    - Though this is widely held belief
- It's true fingerprinting would be useless if fingerprints were identical.
- But it is "based on" the claimed ability to determine whether two *unique* impressions derive from the same source skin

Roughly speaking, to say of two things that they are identical is nonsense, and to say of one thing that it is identical with itself is to say nothing at all.
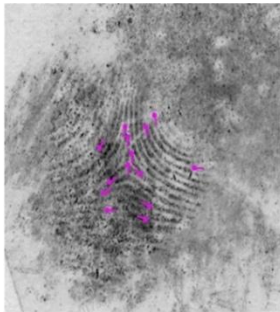*– Ludwig Wittgenstein (1922)*

- No two objects are identical
    - Depending on the observation system
- All objects are unique
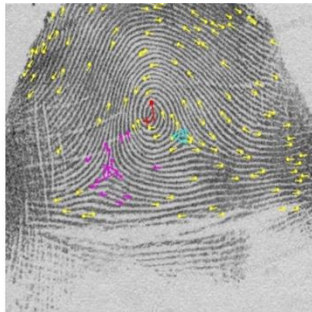   - Depending on the observation system

The Task – Multiple impressions

Same source?

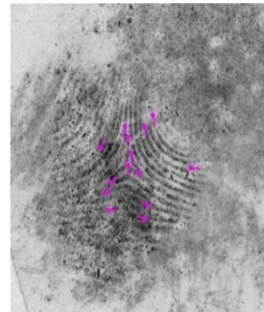- Same source, despite some differences

Fingermark   Same Source

Different source?

- Difference source, despite some similarities

Fingermark   Close Non-Match

The important question

- NOT: Is all friction ridge skin unique?
  - Assumed to be true
  - **Stipulated** to in *US v. Mitchell* (1999), first admissibility challenge to fingerprint expert evidence under *Daubert v. Merrell Dow.*
- IS: Are these impressions from the same source or different source
  - How often are these conclusions correct and incorrect?
  - Or, what is the probability they are from the same source compared to the probability they are from different source?

Forensic pattern recognition . . .

- . . . Is NOT about establishing uniqueness
- It's about establishing one's ability find similarities, despite differences
- The Guo et al. paper illustrates this in that it is an effort to establish whether they can attribute impressions of different fingers to the same source person
- Uniqueness is assumed and irrelevant to this question

Lawyers' questions for fingerprint examiners

- Q: When examiners reach conclusions of identification, how often are they correct and how often are they incorrect?
  - A: Never incorrect.
    - Position is now disavowed by International Association for Identification (among others)
  - A: Very rarely incorrect.
    - I'll be the judge of what's rare. Can you quantify that, please? And how do you know?
  - A: Incorrect 1 in 300 times (PCAST Report)
    - How many fingerprint examinations did you say you did in your career again?
  - A: The error rate is unknowable. It is improper to apply error rates from studies to individual examiners or cases.
    - So then there is no error rate?

Lawyers' questions for fingerprint examiners

- Q: What is the probability that these two impression derive from *different* sources?
  - A: Zero
    - Defies laws of probability; disavowed by OSAC, DoJ (among others)
  - A: It's very, very small
    - Why don't you just tell me the probability, and I'll decide how to characterize it?
  - A: It's unknowable
    - Why is this evidence admissible?

Forensic identification techniques

- DNA profiling
- Friction ridge ("fingerprint") examination
- Firearms & toolmark examination
- Questioned documents
- Shoe, tire, etc. impressions
- Microscopic hair comparison analysis
- Voice analysis
- Bitemark analysis

Microbiome forensics

Forensic identification using skin bacterial communities

Noah Fierer[a,b,1], Christian L. Lauber[b], Nick Zhou[b], Daniel McDonald[c], Elizabeth K. Costello[c], and Rob Knight[c,d]

[a]Department of Ecology and Evolutionary Biology, [b]Cooperative Institute for Research in Environmental Sciences, and [c]Department of Chemistry and Biochemistry, University of Colorado, Boulder, CO 80309; and [d]Howard Hughes Medical Institute
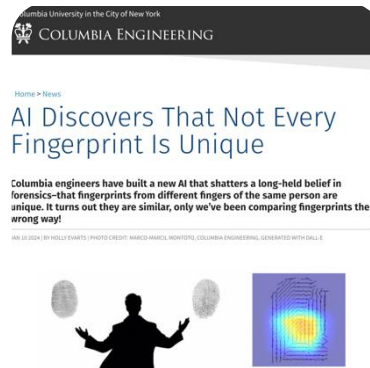
Recent work has demonstrated that the diversity of skin-associated bacterial communities is far higher than previously recognized, with a high degree of interindividual variability in the composition of bacterial communities. Given that skin bacterial communities are personalized, we hypothesized that we could use the residual skin bacteria left on objects for forensic identification, matching the studies that combine recent developments in phylogenetic community analyses (10) with high-throughput pyrosequencing methods (11). First, we compared bacterial communities on individual keys of three computer keyboards to the communities found on the fingers of the keyboard owners. Second, we examined the similarity between skin-associated bacterial communities on objects stored at −20 °C

of over 1,400 bacterial 16S rRNA gene sequences per sample. We found that bacterial communities on the fingertips or keyboard of a given individual are far more similar to each other than to fingertips or keyboards from other individuals (Fig. 1 and Fig. 2). Likewise, the

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Science communication

Article

Press release

Media

SCIENCE COMMUNICATION ISSUES

Problems in contemporary science and science communication

- Pressure to publish

- Pressure to overstate findings from university communications offices

- Pressure on institutions and and individuals to show impact and relevance

  – Elevator pitch competitions for students

  – Every study expected to change the world

  – Reaching for impact

Problem with the hype

- Misleads public (and lawyers) into thinking the important question is whether uniqueness of friction ridge skin is true or false

- The real important questions are:
  - How accurately can systems (human or machine) determine whether two *unique* impression derived from the same source skin?
  - Given the observations, how probable is it that the impressions come from the same source or from different sources?