IEEE Spark

IEEE

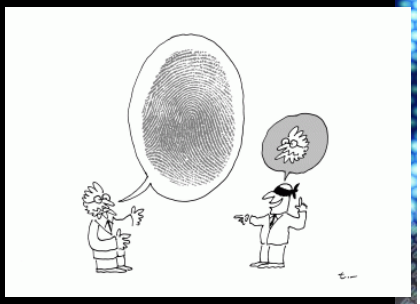
ENGINEERING INSIDE:
CRIME SCENE INVESTIGATION

2012, Issue 1

Engineering the Answer

January, 2012

It's a dark and stormy night. Red and blue revolving lights reflect off the wet brick and highlight the steam rising out of a sewer grate. As the camera pans down we see a sea of police cars and an area cordoned off with yellow police tape. Crime scene investigators snap pictures of every surface, collect samples of blood, paint, and other trace evidence, dust for fingerprints, and bag objects that might be relevant to the investigation.

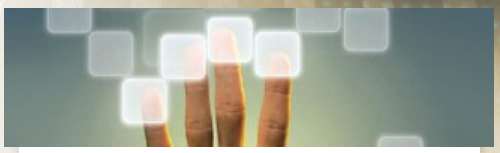


Meet Sargur Srihari

January, 2012

Have you ever wondered how scientists and crime scene investigators use handwriting to solve crimes? We've interviewed Professor Sargur Srihari about how handwriting can be used as evidence. He created an automated system that uses computers to identify patterns in handwriting and other forensic evidence. The system is used all over the world and has helped solve crimes and has been used to convict criminals!

Professor Srihari's research led to the first large-scale handwritten address interpretation systems in the world.



Try Your Hand at Biometrics!

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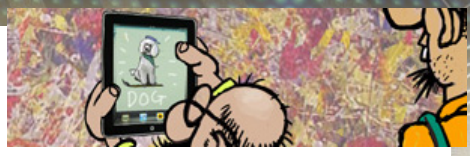
Have you ever wanted to solve a crime, or do detective work? There are many ways to get involved in sleuthing! One way is to explore some of the methods and technologies used by the experts who are trying to solve a crime. For example biometrics is now used in many areas to help identify a unique person by examining one or more of their physical or behavioral traits. There are two main types of biometric identifiers: physiological and behavioral.



Development of Forensic Software to detect original paintings is not easy!

The most expensive painting ever...

IEEE SPARK CHALLENGE

Think you know IEEE Spark? Test your knowledge of engineering, computing and technology with the IEEE Spark Challenge! Answer questions correctly to help your team move to the top of the leaderboard.

About IEEE Spark

IEEE Spark is an online publication intended to inspire students ages 14-18 to learn more about engineering, technology, and computing, and raise excitement about careers in these disciplines. *IEEE Spark* features articles on technological innovation, university preparation tips, professional career profiles, at-home activities, comics, and more! *IEEE Spark* is brought to you by IEEE with generous funding from the IEEE New Initiatives Committee.

About IEEE

IEEE is the world's largest professional association dedicated to advancing technological innovation and excellence for the benefit of humanity. IEEE and its members inspire a global community through IEEE's highly cited publications, conferences, technology standards, and professional and educational activities.

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Engineering the Answer

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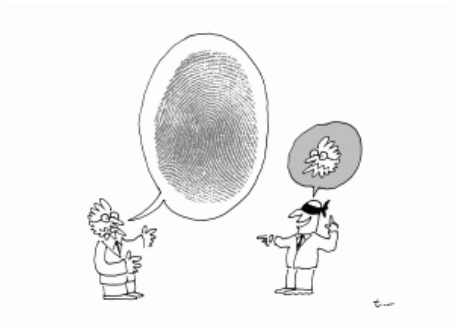
By Robin Hegg



Credit: Tayfun Akgul

It's a dark and stormy night. Red and blue revolving lights reflect off the wet brick and highlight the steam rising out of a sewer grate. As the camera pans down we see a sea of police cars and an area cordoned off with yellow police tape. Crime scene investigators snap pictures of every surface, collect samples of blood, paint, and other trace evidence, dust for fingerprints, and bag objects that might be relevant to the investigation. All of this evidence will be analyzed to help detectives piece together a picture of what happened here.

We see these investigations unfold on television dramas all the time. These shows highlight the exciting world of crime scene investigation and many of the roles involved in solving crimes. TV has highlighted detectives, CSI lab techs, medical examiners, forensic anthropologists, even entomologists. But what about engineers?

Engineers play a vital role in the investigation of crimes, both in creating technology that can help investigators get more accurate information from evidence and in using their engineering knowledge and reverse engineering skills to solve mysteries.

Advances in technology are helping to improve the types of evidence that can be found and the accuracy with which that evidence can be analyzed. Computer programs are used in the analysis of fingerprints, shoe prints, and handwriting. Each of these kinds of evidence has a large risk of human error—a partial fingerprint, mixed with an investigator's hunch, can lead to the wrong suspect. Computer software can make sure the initial analysis is done correctly, but it can also allow investigators to see how likely it is that two suspects would have a similar enough partial fingerprint to cause such a mistake. This information can help to ensure that the wrong suspect isn't successfully prosecuted on an unreliable piece of evidence.

Advances in computer technology have also helped in the processing and identification of DNA and in the extraction of data from computers and cell phones. Engineers have even developed virtual reality crime scene software that can allow investigators to revisit the crime scene in three dimensions. This can give them a more accurate picture of what happened than just looking at the limited photographs taken at the scene.

Brain mapping tests can let investigators know if a suspect is familiar with the crime. The test involves attaching sensors that monitor electrical activity in the brain to a suspect's head. The suspect is then shown images or played sounds, and the tester is able to observe what parts of the suspect's brain become active with each stimulus. Pairing our knowledge of how a person's brain responds to seeing familiar objects allows testers to conclude whether or not the suspect

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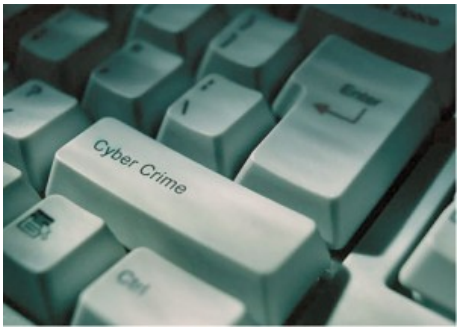
recognizes the images and sounds related to the case.



Voice recognition software can help solve crimes as well. Evidence sometimes presents itself in the form of a voicemail or recorded conversation. Investigators can use voice recognition software to compare the voice of a suspect to the voice in the evidence. The software allows them to analyze the sound patterns of the suspect's voice and of the voice on the evidence and see if the two match.

Knowledge and developments in chemical and materials engineering also aid investigators as they work to identify solids or liquids found at a crime scene, such as bullet lead and paint chips left from cars. They also help investigators to analyze trace evidence, like DNA or explosives residue, and to do toxicology screenings.

There's even an entire discipline within engineering devoted to investigations—forensic engineering. Forensic engineers are hired as expertise to determine the cause of structural failures, fires, traffic accidents, and engineering-related injuries. They can help to establish whether someone is at fault, and if the incidents were caused by malfunctions or human error or recklessness. They can use science and math to answer questions that come up in all sorts of criminal and civil investigations.

To do their jobs, forensic engineers analyze cases, looking at evidence, taking measurements, performing experiments, and making models to help them piece together what happened at the scene of the incident. They are often hired by attorneys to act as experts in their cases. They study the case, prepare expert reports, and sometimes testify in court as expert witnesses.

Forensic engineers study in a wide range of engineering fields, including civil, mechanical, electrical, materials, and traffic engineering. This broad scope of knowledge allows them to help out in many different kinds of situations, and to look at cases from a number of angles.

With any investigation, there's always the risk evidence that isn't conclusive is presented as fact, or that personal or political bias will influence how the data that's found is interpreted. That's why the role of engineers is so important to investigations. Through technology that can limit human error and bias, the use of data comparisons, and the application of scientific rigor to the analysis of evidence, crime scene investigators and detectives can come closer to the finding the truth, fewer people will be falsely accused, and more crimes will be solved successfully.

Whether behind the scenes, creating the technology that helps crime scene investigators analyze evidence faster and more accurately, or at the scene, analyzing the evidence themselves, engineers have an important role to play in the criminal justice system and the investigation of accidents, disagreements, and crimes.

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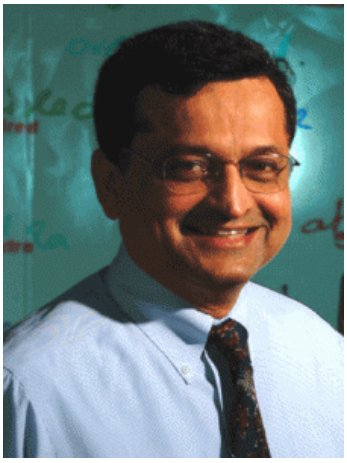

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Professor Srihari's research led to the first large-scale handwritten address interpretation systems in the world. Postal services such as the U.S. Postal Service, Australia Post, and UK Royal Mail use his system to fight crimes! His work has also encouraged the acceptance of handwriting testimony in court, along with new software that is used all over the world by forensics specialists working to solve crimes.

Sargur Srihari is a SUNY Distinguished Professor in the Department of Computer Science and Engineering at the University at Buffalo, The State University of New York. With support from the United States Postal Service for over 20 years, he founded CEDAR, the Center of Excellence for Document Analysis and Recognition, in 1991.

Q: What is computational forensics and how is it used today in solving crimes?

Srihari: Computational forensics is the development of mathematical and software techniques to assist the forensic scientist. It's used today for fingerprint matching in a system known as **IAFIS (integrated automatic fingerprint identification system)** used by the FBI and other law enforcement agencies. It includes not only fingerprints, but also criminal histories; mug shots; scar and tattoo photos; physical characteristics like height, weight, and hair and eye color; and aliases. It is the largest biometric database in the world!

Q: How does automation and computing improve traditional forensics work, such as fingerprinting, handwriting analysis, and DNA sampling?

Srihari: It allows quantitative measurement that would be otherwise difficult or infeasible. For instance it is now possible to quantitatively determine the strength of forensic evidence, such as a given configuration of small parts of a fingerprint, by stating the probability of finding it in a population of a given size.

FIND OUT MORE:

Read more about Professor Srihari's work in **IEEE's Spectrum Magazine** and explore other articles to find out more about work that is being done by other IEEE members in other issues of Spectrum!

USEFUL LINKS:

Department of Computer Science and Engineering at the University at Buffalo, The State University of New York

Center of Excellence for Document Analysis and Recognition

EDUCATIONAL BACKGROUND:

Srihari received a B.Sc. in Physics and Mathematics from the Bangalore University (National College) in 1967, a B.E. in Electrical Communication Engineering from the Indian Institute of Science, Bangalore in 1970, and a Ph.D. in Computer and Information Science from the Ohio State University, Columbus in 1976.

Q: Are you surprised to find that your work is focusing on forensics?

Srihari: It was surprising that there was lack of scientific rigor in many forensic disciplines despite the techniques used being over a hundred years old. Methods used were quite subjective and susceptible to human bias. Software to solve many common-place problems has become available only in the last few decades. Techniques from artificial intelligence, machine learning and pattern recognition can play a role in performing many tasks of the forensic examiner.

Q: Many people wouldn't think that a degree in engineering would point them to a CSI career – did your educational background prepare you for this field?

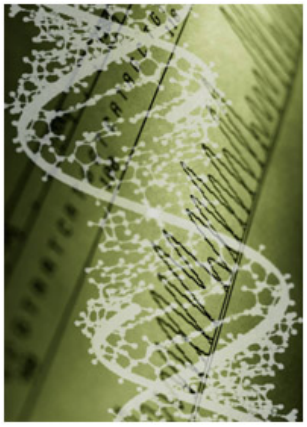
Srihari: A degree in engineering is useful to develop systems for many different applications. Forensics is one of them.

Q: Is everyone using computational forensics around the world?

Srihari: Computational forensics is not yet mainstream. But lots of research goes on in academic settings, such as at my own lab at the State University of New York at Buffalo, and eventually the courts may allow these techniques to be applied in criminal trials.

Q: How long have you been a member of IEEE? What prompted you to join?

Srihari: I joined as a graduate student 40 years ago. I wanted to keep informed of new developments through IEEE publications. It was well before the internet and hard-copy magazines were the only way.



Q: What is the most rewarding thing about the work you do?

Srihari: It is learning about new things or ideas and seeing how they can be further developed.

Q: Can you share a story about how a criminal has been prosecuted as a result of the work you do?

Srihari: I was asked to testify in a federal court case about the validity of forensic handwriting comparison. It involved a government official who had claimed that her handwriting and signatures on some documents had been forged. I testified that experiments with handwriting comparison software showed that handwriting in course of business writing is sufficiently individualistic so as to be allowed in court. The defendant pleaded guilty.

Q: What advice would you give a student who was interested in working in forensics as related to engineering and computing?

Srihari: Prepare yourself with knowledge of probability and statistics which are important to all forensic specialties. While the job market in forensics is not large, that preparation can serve you very well wherever you end-up. To work with impression evidence such as fingerprints and footwear, knowledge of computer image processing will be useful.

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Try Hand Geometry Biometrics at Home

Hand geometry is a biometric that identifies users by the shape of their hands. Hand geometry identification devices have been available since the early 1980s, making hand geometry the first biometric to find widespread computerized use! Hand geometry is very reliable when combined with other forms of identification, such as ID cards or personal identification numbers.

Here's how it works:

The shape of your hand is somewhat unique, and by tracing your hand's shape and comparing it with others, you'll find that in a small group of people, yours is probably unique. The shape of the hand really isn't as unique as fingerprints or retinas, but it can be useful as another layer of security, or to keep track of a time when someone arrives at work or school. Why not find out your own personal hand geometry code!

Step One:

1. Trace your right hand on a piece of paper, keeping the pencil as close to your skin as possible.

2. Using a ruler, measure the following in centimeters (see diagram below):

A: Distance from index fingertip to bottom knuckle _____cm

B: Width of ring finger, measured across the top knuckle _____c

C: Width of palm across 4 bottom knuckles _____cm

D: Width of palm from middle knuckle of thumb across hand _____cm

DID YOU KNOW?

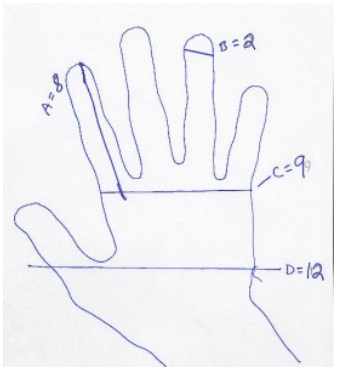
1. Since the beginning of the 20th century, Brazilian citizens have used ID cards that incorporate fingerprint-based biometrics.
2. Microsoft has introduced a fingerprint reader that prevents computers from being used by unauthorized people.
3. Some countries have implemented biometric passports that combine paper and electronic identity - using biometrics to authenticate the citizenship of travelers. The passport's critical information is stored on a tiny computer chip.
4. Many buildings use biometric devices as part of a security system that identify people - such as employees - who are allowed to enter.

FIND OUT MORE:

You can also visit **TryEngineering.org** to explore other activities and resources to explore engineering. Other activities and lessons can be found **here**.

Record the 4 numbers in A, B, C, D order, which is your personal hand geometry code.

Step Two:
Compare your personal hand geometry code with the one to the right which has the code 8, 2, 9, 12, and consider the questions below. Or, work with family or friends to see what their code is – how does it differ from your own?



Questions:

1. How does your hand differ from the sample hand geometric image? Do you think you could access their office through a security system using your hand?
2. How does your hand differ from those of your friends or family members?
3. Do you think that hand geometry would need to be recalculated every few years or as a person grows older?

(Note: Some biometric information in this article is provided by and used with the permission of The National Biometric Security Project (NBSP). Duplication is permitted for educational purposes only.)

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Join Camps and Competitions!

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One of the best ways to explore a career in science, technology, engineering, or mathematics is to get involved! All around the world there are great student programs that will help you learn more about these fields and allow you to meet with other students who share your interests. Through competitions, camps or projects, you'll work in teams and do everything from building a robot to designing a new water treatment system for a needy area. Best of all, you'll gain great experience, have fun, and get a first-hand idea of what engineers do!

There are many great ways to get involved. Your school counselor may have a list, or your school may already be involved in some projects. There may be a math club, a robotics team, or a programming group right at your school. But don't stop there! Find out if there are regional teams or events you can participate in. You can explore a list of student opportunities on TryEngineering.org, but also check with local universities to see what they offer. Most universities with strong engineering programs do offer summer, after-school, weekend, or online resources for pre-university students. When you find a project or competition that looks interesting, suggest it to others at your school. Talk with other students, your teachers, or your counselors and see if your school can get involved.

If you are the only one at your school that is interested, don't give up! Many national and international competitions or online programs will set up a team for you with other solo students.

The best advice is to follow your instincts in terms of the project or competition you pick — but be sure to get involved. Find a project or competition that looks really interesting to you and join in. For example, through the **Botball Educational Robotics Program** students from around the world work in teams to design, build and program a pair of autonomous robots for regional and international competitions. Also, through the **IET Faraday Engineering Challenge Days**, young engineers aged 12 and 13 in the U.K. research, design and build solutions to a real engineering problem. And, **eCYBERMISSION** is a web-based science, technology, engineering and mathematics competition for 6th, 7th, 8th and 9th grade teams. More ideas are **online**!

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IEEE Members Reach Out To Students

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Did you know that IEEE members all around the world like to reach out to students to share what it's like to be an engineer? Members do this in many ways — speaking at a career fair at a high school, contributing to student competitions, arranging site visits at research labs or manufacturing facilities, and by being a mentor. Recently, IEEE celebrated its second annual **IEEE Day**, where technical professionals from around the globe celebrated the theme, "Empowering Members to Create the Future." The day encouraged professionals and students to work together to explore engineering through fun activities, competitions, and other events. More than 100 celebrations took place around the world and information was shared through Facebook and other media too. From India to Brazil to Pakistan to the United Kingdom and the United States, the day brought together students and IEEE members – but this was just one day. IEEE members reach out to students 365 days a year!

To find out what IEEE is doing to support students in your part of the world, select your country from our **world map**. Then explore the student programs IEEE has developed for you! At IEEE student events, you'll meet engineers and other students and find out more about how engineers are helping our world.

This was one of the photo award winners from IEEE Day's photo contest! Tech-Crash, IEEE day Celebration. Student Branch, Universidad de la Sabana, Chia, Colombia.

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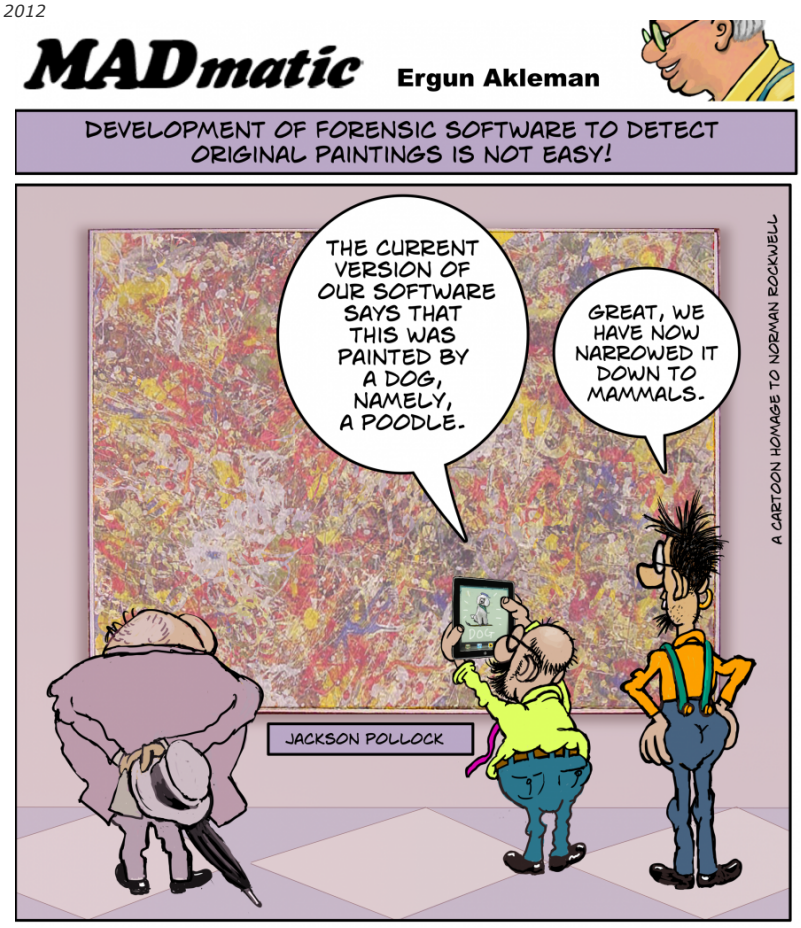

Credit: Ergun Akleman

The most expensive painting ever created is No.5 by Jackson Pollock, which was sold for $140M. In his December 2002 scientific American article, Richard Taylor from the University of Oregon shows that fractal analysis can be used to authenticate Pollock Paintings. Taylor mentions that a Pollock style painting can be created by a bush connected to a tree branch during a storm. The painting here is, in fact, fake, and was created using a mixture of several Pollock & Rockwell paintings. For my homage to Norman Rockwell, search for Rockwell's "Connoisseur" in Google images.