AMERICAN ACADEMY™
OF OPHTHALMOLOGY

Editorial

Iris Recognition Technology (or, Musings While Going through Airport Security)

James G. Ravin, MD - *Toledo, Ohio*

What is the best method of security screening? Can we do better than a photographic identity card combined with a metal detector and a search for explosives? Many methods of body measurement are available now and more are in development.

Photographs have been used for identification since the 1840s. In 1888, Alphonse Bértillon, a French police officer and pioneer in biometrics, standardized the process of mug shots. He was so well known that Sir Arthur Conan Doyle mentioned him in *The Hound of the Baskervilles* (1902). In that novel, one of Sherlock Holmes's clients says Sherlock was second only to Bértillon as an expert in detection.

Fingerprinting followed. The standard system of comparing 16 ridge characteristics to fingerprint impressions left at the scene of a crime is attributed to a paper by Bértillon that was published in 1912. One aspect of Bértillon's biometric system was the variation in configuration of the human iris, which he had documented earlier in *Tableau de l'iris humain*.[1]

Iris recognition, a means of recording an image of the iris photographically and storing the data electronically, is a recent development. It is based on the unique nature of the iris. The irises of our 2 eyes differ in appearance, even for identical twins. The unique features begin to occur in utero as degeneration of the anterior stromal leaf of the iris takes place and the pupil opens. The different features may not be noted when viewed under visible light since melanin can block the appearance of the underlying fibers. Photography using infrared light enhances the differences.

Iris recognition, a means of recording an image of the iris photographically and storing the data electronically, is a recent development. It is based on the unique nature of the iris.

For security purposes 3 types of identification can be used: something that you know (e.g., a password or PIN); something you have (e.g., an access card); something anatomic or physiologic (biometric).[2] Biometrics may be physical (e.g., iris or other ocular scans, fingerprints, facial scans, speaker recognition) or behavioral (e.g., signatures). The iris and and fingerprint biometrics are both reliable and accurate. However, fingerprints are missing in some people and can be duplicated. The iris is more than twice as accurate as fingerprinting and pupillary dynamics make duplicating impossible. The National Center for State Courts has published comparative data and similar results have been provided by the Institutes of Electrical and Electronics Engineers (IEEE) Computer Society.[3] The best measure for comparing biometrics is the equal error rate, the rate at which the false acceptance rate (specificity) approximates the false rejection rate (sensitivity).[4] According to one company, Iridian Technologies, the fingerprint false acceptance rate varies by vendor and is typically 1:100 000, while that of iris recognition is 1:1.2 million. The false rejection rate is 2%-3% for fingerprints and 0.1-0.2 for iris recognition.[5] Although fingerprint technology is widely accepted and will continue to be used, mainly forensically, the iris, being noncontact and more accurate, will ultimately replace fingerprints for most identification purposes.

Iris recognition has many applications. Particularly noteworthy are its uses in airport security, sensitive construction tasks, and military applications. It is also useful as a means of providing a unique identity for those who may not have a passport or other identity card and would like to apply for governmental benefits. In India, approximately 1 million people per day are being registered biometrically, and iris scans are an important aspect of this process. The algorithm used in India is proprietary (from Iris, ID, Inc) and modified from the work of John Doughman, PhD, Professor of Computer Vision and Pattern Recognition, University of Cambridge, England. However, newborns and infants cannot be examined and followed with this system. The system in India is continuously updated on its website, Unique Identification Authority of India (UIDAI).

Iris detection systems use software algorithms and a sensor that can analyze very small textures. They can be used to determine whether tissue is alive or not, and to deter potential fraud, and images can be compared with filed data very quickly. Images of conjunctival, scleral, and retinal blood vessels, although used biometrically, can be masked and/or duplicated photographically, but iris morphology with pupil dynamics makes the iris the preferred ocular biometric.

Consideration of iris biometry goes back several decades. James Hamilton Doggart, MD, an English ophthalmologist, drew attention to the iris in his 1949 book *Ocular Signs in Slit-Lamp Microscopy*: "Just as every human being has different finger-prints, so does the minute architecture of the iris exhibit variations in every subject examined… Therefore no open-eyed observer need complain that slit-lamp work is monotonous. He will never cease to find novelty in the iris."[6] Francis Heed Adler echoed this sentiment in the 1953 version of his textbook of ocular physiology: "the markings of the iris are so distinctive that it has been proposed to use photographs as a means of identification, instead of fingerprints."[7]

http://dx.doi.org/10.1016/j.ophtha.2016.07.021
ISSN 0161-6420/16

Two American ophthalmologists, Leonard Flom, MD, and the late Aran Safir, MD (1926−2007), were intrigued by biomicroscopy and computer technology. They were familiar with the texts of Doggart and Adler. They considered the eye an ideal biometric source because of its detailed information, its singularity, and the possibility of matching scanned images with previous data. They knew that photography could be performed more quickly and more easily than fingerprinting. They worked on the project for several years and in 1985 submitted a patent for iris biometry with 32 claims. In 1987, the United States Patent Trademark Office examiner initially rejected all their claims. However, their attorney was undeterred and believed that the examiner did not understand the concept. He asked for reconsideration by the reviewer's superior officer. Flom and Safir appeared before both of them. The original examiner said he had rejected the patent based on the fact that the criterion of usefulness was impossible because the many colors of the iris. In addition, he made the bizarre comment that the iris colors change in times of emotion; for example, they turn green with envy (personal correspondence, Leonard Flom, November 7, 2015). Two weeks later, the patent was granted including all the original claims.

Having obtained the patent, their first approach to writing a computer algorithm was to Rafael Advanced Defense Systems, an Israeli company that has many staff members who are members of the faculty of Technion University. Rafael is the defense contractor that developed the Iron Dome antimissile system. The CEO of Rafael asked for answers to 2 questions before agreeing to undertake the project: (1) is the iris unique? and (2) is the iris stable over many years? Flom and Safir went to David Donaldson, MD, a well-known ophthalmologist at the Howe Laboratory of Harvard Medical School, who is particularly remembered today for his classic 5 volume *Atlas of External Diseases of the Eye*, St Louis, MO: Mosby, 1966-76. Donaldson had photographed more than 36 000 patients with diseases of the anterior segment of the eye.[8] They studied photographs taken over several decades and found the iris was stable over long periods of time. Flom and Safir returned to Rafael with the data. The project was reviewed by a computer scientist who photographed her own irises and wrote an algorithm. However, Rafael had an internal dispute over credit for the research. Facing what appeared to be an intractable problem, the 2 ophthalmologists returned home.

Safir was at Harvard Healthcare and knew a man he thought might be able to solve their computer problem: John Daughman, PhD, who was then an assistant professor of computer science at Harvard, and is now at the University of Cambridge, England. In 1994, Daughman obtained a patent for an automated iris recognition algorithm.[9,10] The first commercial products became available in 1995 and the importance of this work was recognized quickly. Iris scans were introduced in airports around the world, in automatic teller machines, and in sensitive construction and industry. The iris biometric has been used for many years to identify volunteers at many airports, notably Schiphol in the Netherlands and Heathrow in England, as well as others in the United Arab Emirates, the United States, and Canada.

Flom, Safir, and Daughman were inducted into the United States Patent and Trademark Office's National Inventors Hall of Fame in 2013. (The only other ophthalmologist in the Hall of Fame is Charles Kelman, for his work on phacoemulsification.) The patent covering the basic concept of iris recognition expired in 2005, which allowed other companies to develop their own algorithms and a large amount of work is taking place in this rapidly changing field. For example, Flom and his colleagues have just received a patent for a triple biometric algorithm (iris, fingerprint, and ear) as an accurate and practical way to identify newborns and infants and replace the ancient method of footprints.

References

1. Bértillon A. Identification anthropometrique. Melun, France: Imprémerie administrative; 1893.
2. Dunker M. Don't blink: iris recognition for biometric identification. SANS Institute, 2004. Available at: https://www.sans.org; Accessed July 6, 2016.
3. Biometrics comparison chart. NCSC Court Technology Lab. Accessed November 7, 2003. Available at: http://ctl.ncscdni.us/biomet%20webb?BMComparehtml. Cited in Dunker.
4. Morimoto H. Biometrics. Online Powerpoint presentation. Accessed July 6, 2016.
5. Iridian Technologies. Biometric Comparison Guide. Available at: www.idose/wp-content/uploads; Accessed July 6, 2016.
6. Doggart JH. Ocular Signs in Slit-Lamp Microscopy. London: Henry Kimpton; 1949:27.
7. Adler FH. Physiology of the Eye, Clinical Application. St Louis: Mosby; 1953:143.
8. Brockhurst RJ, David D, Donaldson MD. Trans Am Ophthalmol Soc 1994;92:3–5.
9. Doughman J. Biometric personal identification system based upon iris analysis. US Patent 5,291,560. March 1, 1994. US Patent Office, Washington, DC.
10. Doughman J. New methods in iris recognition. IEEE Transactions on systems, man, and cybernetics − B. Cybernetics 2007;37:1167–74.

Footnotes and Financial Disclosures

Financial Disclosure(s): The author(s) have no proprietary or commercial interest in any materials discussed in this article.

Presented at: Cogan Society (American Ophthalmic History Society) Annual Meeting, April 2016, St. Louis, Missouri.

Correspondence:
James G. Ravin, MD, 3000 Regency Court, Toledo, OH 43623. E-mail: jamesravin@bex.net.