

Institution: University of Cambridge		
Unit of Assessment: 11 Computer Science and Technology		
Title of case study: Iris recognition technology transforms the speed and security of refugee aid distribution, and access to critical benefits and services		
Period when the underpinning research was undertaken: 2000-2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
John Daugman	Professor	1 Oct 1994 to present
Period when the claimed impact occurred: 1 Aug 2013 - 31 July 2020		
Is this case study continued from a case study submitted in 2014? No		
Summary of the impact (indicative maximum 100 words) <p>Professor Daugman's algorithms for automatically recognising people by their iris patterns are the basis of all publicly deployed iris recognition systems across the world. Since August 2013 an additional 800 million people have been enrolled onto iris pattern databases based on his research and standards. The global deployment of his iris recognition technology has had extremely wide-reaching economic and social impact by:</p> <ul style="list-style-type: none"> • increasing the accuracy and security of access and registration systems at hospitals, airports and schools. • making aid and food distribution to refugees fairer, faster and more efficient. • improving access to previously inaccessible benefits and services through biometric national identity programmes. 		
2. Underpinning research (indicative maximum 500 words) <p>Daugman's research has bridged computer vision, artificial intelligence, and statistical pattern recognition resulting in a unique set of algorithms (IrisCode) that provide an automatic and rapid method for determining a person's identity with very high confidence through mathematical analysis of the random patterns visible in the iris. No such method existed previously, nor has any equally robust method been discovered elsewhere.</p> <p>The research at the University of Cambridge began in the early 1990s, investigating the algorithms for measuring, characterising and matching iris patterns.</p> <p>From 2000 to 2001, the research concentrated on analysing thousands of iris patterns from trial systems, to understand the statistics of their variations, and quantify the degree of uniqueness of the patterns [R2]</p> <p>The encouraging statistical results resulted in the adoption of the IrisCode technology from 2001 at border crossings into the United Arab Emirates, which produced a much larger database (316,000 individuals) for the Cambridge research. Analysis of this database resulted in the 2006 paper [R1] that suggested that iris recognition would be able to identify individuals in databases 100,000 times larger than was feasible with face recognition.</p> <p>The research continued to develop methods to improve recognition from poorer image quality [R3], and investigated compression to limit database sizes, down to as little as 2,000 bytes without degrading performance [R4]. Both are important for commercial deployments, and are usable in all current systems thanks to their incorporation into international standards as follows:</p>		

- (a) Following extensive independent NIST confirmatory tests, the iris data format enabling severe compression [R4] became an international data format Standard, ISO/IEC 19794-6:2011, with Daugman as editor.
- (b) Daugman's general framework for iris image quality assessment as a predictor of matching performance led to the international Standard ISO/IEC 29794-6:2015 on Iris Image Sample Quality, which Daugman co-edited.

Daugman has also shown how information theory can help to explain the powerful resistance of iris recognition to false matches, using the concept of entropy as fundamental to understanding biometric collision avoidance [R5]. A 2016 paper [R6] investigated the universality of this statistical property among different persons of 152 nationalities. It demonstrated that whenever different persons (or eyes) are compared, the IrisCode produces relatively constant dissimilarity distances having an invariant narrow distribution, thanks to the large entropy which lies at the heart of this biometric modality. This makes it possible to predict the performance of much larger IrisCode databases, for example, the False Accept and False Reject rates for databases containing billions of Iris images, according to their image capture performance and the setting of matching thresholds.

For his iris recognition algorithms, Daugman was inducted into the USA National Inventors Hall of Fame (2013), awarded a Fellowship of the Royal Academy of Engineering (2015), and made a Fellow of the National Academy of Inventors by the US Patent Office (2015).

3. References to the research (indicative maximum of six references).

All research outputs have been through a rigorous peer-review process:

[R1] Daugman, J. (2006) "Probing the uniqueness and randomness of IrisCodes: results from 200 billion iris pair comparisons." Proceedings of the IEEE 94(11):1927–1935.

DOI: [10.1109/JPROC.2006.884092](https://doi.org/10.1109/JPROC.2006.884092)

[R2] Daugman, J. (2003, submitted 2001) "The importance of being random: statistical principles of iris recognition." Pattern Recognition 36(2):279–291.

DOI: [10.1016/S0031-3203\(02\)00030-4](https://doi.org/10.1016/S0031-3203(02)00030-4)

[R3] Daugman, J. (2007) "New methods in iris recognition." IEEE Transactions on Systems, Man, and Cybernetics, B, 37(5):1167–1175. DOI: [10.1109/TSMCB.2007.903540](https://doi.org/10.1109/TSMCB.2007.903540)

[R4] Daugman, J., and Downing, C. (2008) "Effect of severe image compression on iris recognition performance." IEEE Transactions on Information Forensics and Security 3(1):52–61. DOI: [10.1109/TIFS.2007.916009](https://doi.org/10.1109/TIFS.2007.916009)

[R5] Daugman, J. (2016) "Information Theory and the IrisCode," IEEE Transactions on Information Forensics and Security 11 (2): 400-409.

DOI: [10.1109/TIFS.2015.2500196](https://doi.org/10.1109/TIFS.2015.2500196)

[R6] Daugman, J., and Downing, C. (2016) "Searching for doppelgängers: assessing the universality of the IrisCode imposters distribution," IET Biometrics 5 (2): 65-75.

DOI: [10.1049/iet-bmt.2015.0071](https://doi.org/10.1049/iet-bmt.2015.0071)

4. Details of the impact (indicative maximum 750 words)

How research underpins impact

The Cambridge research on iris recognition since 2000 has included crucial work on the population statistics of iris patterns, and the information theory that underlies them. This has improved understanding of the properties of all iris recognition systems based on the Daugman algorithms, including the tradeoffs of false acceptance/rejection rates,

performance on collections of billions of IrisCodes, image quality requirements, and compression standards.

Widespread impact

The size of the global iris recognition market is estimated at USD 2.3 billion in 2019 [E1], and almost all of this is based on the Daugman algorithms.

There are hundreds of systems deployed for access control at building or organisational scale (e.g. hospitals [E2], airports [E3], schools [E4]) that have built upon the research results and the resulting international standards, supported by dozens of specialist development companies.

Specific examples

Thanks to the Daugman research from 2003 onwards on the statistics of iris patterns, it is possible to tailor the matching parameters to the required image qualities and database sizes from thousands to billions of individuals. This makes it possible to confidently deploy iris recognition to improve the accuracy and effectiveness of aid distribution, and identity verification programmes, in situations where suitable documentation is unavailable or unreliable, as follows.

Iris recognition technology based on Daugman's research makes UN refugee aid fairer, faster and more efficient.

Between January-June 2015, The United Nations High Commissioner for Refugees (UNHCR) completed its registration of nearly 110,000 Myanmar refugees in Thailand's border camps using a new Biometrics Identity Management System (BIMS) [E5]. UNHCR's Associate Biometrics Deployment Officer in Geneva spoke of the benefit for refugees. "It ensures that once they've been through the system and enrolled with their fingerprints and irises, we'll always know who they are...If they lose their documentation, they can always come back to us" [E5].

In early 2017, the World Food Programme (WFP) "Building Blocks" programme was developed, combining iris authentication technology with blockchain as a means of making regular cash transfers simpler, more efficient, and more resistant to fraud. It was deployed in Jordan at the *King Abdullah Park*, *Azraq* and *Zaatari* Refugee Camps, where more than 100,000 Syrian refugees can pay for food in camp supermarkets with only a quick scan of their iris, and without the need for additional cards or identification checks [E6; E7]. More than USD 23.5 million worth of entitlements have been transferred to refugees through 1.1 million blockchain transactions, saving 98 percent of bank transaction fees, and offering aid donors better value for money [E6].

Since 2018, the WFP has deployed iris recognition in its refugee food distribution system in Uganda. Refugees can have their family's monthly food allowance from WFP verified biometrically (iris and fingerprint) in less than a minute. One Burundian refugee in Oruchinga Refugee Camp commented "when my eyes and card are scanned, my photo comes up on the screen. I know it's fair because WFP will give food to the right person ...[before] it was always a fight and a scramble—a real challenge when I had my baby on my back. It is now a lot less hectic" [E8]. In 2019, new food assistance collection procedures were rolled out by WFP, UNHCR and OPM (Office of the Prime Minister). Under this new system, each person to receive assistance is confirmed against biometric data in the verification exercise. The WFP welcomed these changes claiming "the new procedures mitigate the risk of fraud, ensuring that assistance is well managed" [E9].

Iris scanning algorithms and technology improve access to benefits and services in India

In India, the biometric national identity programme *Aadhaar* was established by the Unique Identification Authority of India (UIDAI) in 2011. It uses biometrics, including two IrisCodes,

to validate identities and to exclude duplicates. The detection of duplicates requires matching each new iris scan against the entire database, which is aided by the advanced techniques and standards developed by Cambridge University, for example, concerning image quality [R3] and compression [R4]. In 2014, 389 million people had been enrolled in UIDAI and by 2019, this had risen to 1.2 billion, covering 90% of the adult population [E10]. The Cambridge algorithms convert an iris pattern into a binary code in just a few milliseconds. The algorithms then measure the amount of dissimilarity between the new iris code and every other iris code by counting the bits that disagree. The bit-parallel logic in the Cambridge-developed matching algorithms allows 64 bits of two IrisCodes to be compared in a single clock cycle, so that even an average CPU core can perform around one million iris comparisons per second. When dealing with the trillions of comparisons that now take place every day in India, only a moderately-sized server farm is required to search and compare against the entire database [E11].

The biometric identity check enables access to benefits and services which were previously inaccessible because of the lack of any means to prove one's identity – only 4.2% of Indians hold a passport [E11], and fewer than half the population hold a bank account. The Observer Research Foundation reported in 2019 that “the *Aadhaar* number allows women to directly receive transfers under the National Rural Employment Guarantee Scheme and has helped many apply for SIM cards” [E10]. Before *Aadhaar*, the ration card was a common identification document issued at household level, typically in the name of the male head. This provided household-level identity, but not an individual identity that could be used to access other services [E10]. With *Aadhaar*, women are given an official individual identity, the first step towards improving access to services they need.

5. Sources to corroborate the impact (indicative maximum of 10 references)

[E1] Size of the global iris recognition market <https://www.marketsandmarkets.com/Market-Reports/iris-recognition-market-141994093.html>

[E2] Use of iris recognition at hospitals https://www.cmi-tech.com/wp-content/uploads/2020/05/Reference-site_hospital-access-control_final.pdf

[E3] Use of iris recognition at airports <https://www.schiphol.nl/en/page/how-the-iris-scan-works/>

[E4] Use of iris recognition in schools <http://www.iritech.com/biometric-education-Kenya>

[E5]. “UNHCR’s new biometrics system helps verify 110,000 Myanmar refugees in Thailand:” <https://www.unhcr.org/uk/news/latest/2015/6/55926d646/unhcrs-new-biometrics-system-helps-verify-110000-myanmar-refugees-thailand.html>

[E6]. “The World Food Program: Fighting Hunger With Blockchain.” <https://foodtank.com/news/2019/01/the-world-food-program-fighting-hunger-with-blockchain/>

[E7]. “WFP Introduces Iris Scan Technology To Provide Food Assistance To Syrian Refugees In Zaatari:” <https://www1.wfp.org/news/wfp-introduces-innovative-iris-scan-technology-provide-food-assistance-syrian-refu>

[E8]. “‘These changes show that WFP loves us.’ Biometric verification in Uganda: getting the right food to the right people:” <https://insight.wfp.org/these-changes-show-that-wfp-loves-us-247f0c1ebcf>

[E9]. “OPM and UNHCR complete countrywide biometric refugee verification exercise, 2018:” <https://www1.wfp.org/news/opm-and-unhcr-complete-countrywide-biometric-refugee-verification-exercise>

[E10]. “A Decade of Aadhaar: Lessons in Implementing a Foundational ID System”, ORF Issue Brief No. 292, May 2019, Observer Research Foundation, p 5.

<https://www.orfonline.org/research/a-decade-of-aadhaar-lessons-in-implementing-a-foundational-id-system-50464/>

[E11]. "Biometrics on a mass scale:" <https://phys.org/news/2014-02-biometrics-mass-scale.html>