Institution: University of Kent

Unit of Assessment: 12: Engineering

Title of case study: Improving Biometrics Best Practice, Policy, and Knowledge for End Users, Government, and Industry Internationally

Period when the underpinning research was undertaken: 2005-2020

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:**
Richard Guest	Professor of Biometric Systems Engineering	1995-current
Fazin Deravi	Professor of Information Engineering	1998-2020
Sanaul Hoque	Lecturer in Secure Systems Engineering	2004-current
Gareth Howells	Professor of Secure Electronic Systems	1990-current

Period when the claimed impact occurred: 2014-2020

Is this case study continued from a case study submitted in 2014? Yes

1. Summary of the impact (indicative maximum 100 words)

University of Kent research in biometric verification technologies has: a) enhanced algorithmic performance of biometric implementations, increasing rates of accuracy in recognition and protection against attacks, thereby ultimately enhancing the experience and convenience for users of systems such as mobile phones and legal signature systems; b) provided multiple worldwide standards since 2007 for the interchange of data, directly used by implementors of systems worldwide, with sustained usage growth over the past seven years; and c) contributed to deployment theory and practice in novel biometric implementations, in particular on mobile devices, increasing the security of devices for the general public and service providers. The research team has continued to provide direct policy advice to UK Government. Furthermore, in 2014 their device authentication work led to the spin-out of a successful company, Metrarc Ltd, for the commercialisation of their technology.

2. Underpinning research (indicative maximum 500 words)

Automated biometric systems are increasingly used to authenticate human identity across a wide range of end-use scenarios; for example, in passport systems, bank account authentication and mobile device access. Kent has a longstanding and internationally recognised reputation for its broad contributions across the multidimensional fields of biometrics, specifically in biometric system design and industrial best-practice and policy deployment – research areas that underpin the impacts identified in this case study.

Biometric Identity Linkages: Between **2011** and **2015**, Guest led the Kent team on the interdisciplinary ESPRC SuperIdentify Project, which explored facets of identity incorporating biometrics, on-ine behaviour, social networking, and anthropology. In particular, the team examined the implications of biometric inteference, identifying if you have information about one biometric modality, what statistical inferences can be made about other biometric modalities from additional identity items. From the project, the Kent team: (i) established models that can be used either for intelligence-led investigation or to discover weaknesses in security systems; (ii) contributed to both identity performance linkage strength across a common dataset and a numerical model of identity assessment; and (iii) discovered novel

intra-modality relationships (such as recognition performance attributes of facets of the hand), which have fed into theoretical models for use within the forensics community **[R1]**.

Standardisation: International biometric standardisation enables developers, integrators, and end users to implement systems with the knowledge that data storage and transmission formats will be open, understandable, and usable between devices and platforms. Since **2004**, Deravi and Guest have both been UK Principal Experts to the International Standards Organisation committee ISO/IEC SC37 for data interchange formats and application programming interfaces. In **2010**, they developed a novel compression data format for storing biometric signature data based on extracted features used worldwide within ISO/IEC 19794-7, proving a solution for storing signature data in a memory-efficient manner, minimising performance deterioration **[R2]**.

Mobile biometrics usage: Over recent years, biometric implementations have expanded from predominately large-scale 'fixed' systems such as those found at border controls and other governmental systems, to mobile consumer devices, including phones, tablets, and laptops. Although biometric modalities such as face and fingerprint perform well under controlled conditions, the nature of the mobile devices means that they can be used in many different environmental conditions, which can affect underlying recognition performance, particularly with image-based modalities such as face. At the same time, mobile devices represent the largest use of biometrics, thus requiring the need for accuracy and user trust. Supported by the EU (2014-23), GCHQ/NCSC (2016-23), and industry (2018-22), Deravi and Guest established how facial biometrics on mobile device are affected by environment and user movement; how individuals can use the natural swipe interaction with a device as a form of verification; and the definition of a formal framework for mobile biometric testing and evaluation **[R3]**.

At the same time, Dervari and Hoque have undertaken pioneering work on gaze-based biometrics recognition and presentation attack detention that has developed a cooperative, challenge-response approach to increased accuracy and security for biometric systems in mobile devices **[R4]**.

Interaction/cooperation between humans and machines: The performance of automated biometric systems is typically very good under constrained capture conditions, but may significantly deteriorate with changes in pose, occlusions, or short-term subject sample modifications (for example, glasses, masks, illness, etc.). This can be overcome by involving humans (who are adaptive to such changes) within the decision-making process. It is also the case that in some situations a human decision is the only admissible outcome, for example in legal and forensic work.

Supported by an EPSRC grant (2018-20), Guest established a framework to identify when to trust a human or machine-based biometric system in high-value, low-throughput situations across voice and face modalities. More specifically, the framework applied the Dempster-Shafer method of combining separate evidence scores from humans and machines when both are presented with the same evidence. Selection is made based on given individual levels of performance of each contributing expert. The framework defined a method for implementation of particular modalities, evidence types, and confidence levels that are directly applicable to end users in the legal, forensics, and police/border force professions **[R5]**.

Device authentication: The undelying technology for biometric systems developed in **[R6]** has been adapted to operate the identification of electronic devices in a technology termed Integrated Circuit Metrics (ICMetrics). The advance of ICMetrics authentication represents a novel concept of regulating access to devices, and is explicitly aimed at providing protection at the especially vulnerable points where data access is initiated. ICMetrics is a revolutionary new Trusted Computing approach that avoids storage of root-of-trust encryption keys by creating them on demand, based on measurable properties and features of the desired device or system.

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

[R1] Guest, R., Miguel-Hurtado, O., Stevenage, S. V., Neil, G., and Black, S. (**2014**). 'Biometrics within the SuperIdentity project: a new approach to spanning multiple identity domains'. *Proceedings of the 2014 International Carnahan Conference on Security Technology* (ICCST), Italy, 13-16 October 2014. pp. 1-6. https://doi.org/10.1109/CCST.2014.6986992

[R2] Miguel-Hurtado, Mengibar-Pozo, O. L., Lorenz, M., **Guest,. R.** (**2010**). 'Compressed data format for handwritten signature biometrics'. *Proceedings of ICCST 2010*, San Jose, California, USA, October 2010. https://doi.org/10.1109/CCST.2010.5678722

[R3] Boakes, M., **Guest, R.**, **Deravi, R.**, and Corsetti, B. (**2019**). 'Exploring mobile biometric performance through identification of core factors and relationships'. *IEEE Transactions on Biometrics, Behavior, and Identity Science* 1(4): 278-291. https://doi.org/10.1109/TBIOM.2019.2941728

[R4] Ali, A., **Hoque, S., Deravi, F.** (**2018**). **'**Gaze stability for liveness detection.' *Pattern Analysis and Applications* 21(2): 437–449. https://doi.org/10.1007/s10044-016-0587-2

[R5] Stevenage, Sarah V., and **Guest, R. (2016**). 'Combining forces: data fusion across man and machine for biometric analysis'. *Image and Vision Computing* 55(1). https://doi.org/10.1016/j.imavis.2016.03.012

[R6] Zhai, X., Appiah, K., Ehsen, S., **Howells, G.**, Hu, H., Gu, D., and McDonald-Maier, K. (**2015**). 'A method for detecting abnormal program behaviour on embedded devices'. *IEEE Transactions on Information Forensics and Security* 10(8): 1692. https://doi.org/10.1109/TIFS.2015.2422674

Grants

Between **2005** and **2020**, the underpinning research has been supported by 18 externally funded grants and industrial contracts with a total value of £5 million from the EPSRC, Innovate UK, European Union, and a range of industrial partners. These include two grants from the European Union (AMBER and PriMa) and five from EPSRC, SPIRIT, and ESPACENET.

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

Since **2014**, the key areas of impact that have evolved from the Kent team's research are: establishing and developing standardisation of biometric use to industry internationally **[a]**; delivering expert advice to Government and end users on the use of biometric technologies **[b-e]**; and advancing Government agencies' knowledge of the best-practice use of mobile systems and human/machine interaction **[f]**.

Advancing biometric standardisation worldwide: The International Standards Organisation (ISO) is an independent, non-governmental international organisation with a membership of 165 national standard bodies. Through its members, ISO bring together experts to share knowledge and develop international standards. The British Standard Institute (BSI) is the UK national standards body feeding into the work of ISO and defining UK-wide standards, addressing the needs of UK industry, Government, and academia. As the Chair for the British Standards Institute (BSI) IST/44 Committee on Biometric Standardisation, Dr Peter Waggett, confirms: 'Since 2007, the biometrics research of both Professors Richard Guest and Farzin Deravi have been incorporated into seven international standards for biometric systems. These standards have widespread worldwide deployment across the biometric community [... and] since **2014**, Dervari's work on ISO 19794-5 Face Image Data format is in widespread use

in international travel documents standards and a revision to 19794-7 continue to incorporate Kent research having been informed directly by Kent reserarch' **[a]**. The continued implications of the standards initially informed before 2014, paired with the new standards effected thereafter, is, as Waggett confirms, 'continuing to inform the practices of thousands of biometric systems globally', specifically in banking, legal, and border control applications **[a]**. Waggett considers Guest and Dervai to be 'experts in the area of biometric technologies' and is 'grateful for their knowledgeable insights and contributions to the BSI and ISO processes' **[a]**.

Improving Government and end users' knowledge of biometric technologies: The Kent team's research has led to a number of activities across UK Government. Guest was an invited contributor to a Parliamentary Office of Science and Technology Briefing on Biometric Systems in **2018 [b]** This briefing provided an overview of the current state of the art in biometric technologies, and was circulated to Members of Parliament, thereby informing their decision-making processes. In **2019**, Guest was also an invited contributor to a Defence Science and Technology Laboratory/Home Office Biometrics Report on Iris Technologies that provided guidance on the usage of iris in the defence context **[c]**. This report provides information for end users on the practical issues of iris implementation and has been widely circulated to UK Government agencies.

In May **2019**, Guest was appointed by the Minister of State through a competitive process to the UK Home Office's Biometric and Forensics Ethics Group (BFEG) 'as a result of his expertise in the technical area of biometrics' **[d]**. As the Chair of the BFEG, Professor Mark Watson-Gandy, testifies: 'Over the last year, Professor Guest, as part of an independent group of 16 leading multidisciplinary experts, has provided advice and guidance to Ministers and Government on issues of biometric and forensic data use and system implementation. In particular, his casework within this group has been to advise the Home Office and Police Forces on the use of facial recognition technology and the issue of bias and operational configuration within Governmental deep learning systems – and, his expertise have proven fruitful and important in the development of knowledge and thinking for these stakeholders in issues and practices of biometrics' **[d]**.

Guest and Dervai (as a founding member in 2011) have also contributed significantly to the European Association of Biometrics (EAB), which is the leading voice for digital ID and biometrics in Europe. The Chairman of the EAB highlights that 'Thanks to the active involvement and leadership of these two colleagues from Kent, EAB has been involved in shaping and contributing to a number of EU-funded collaborative research projects and dissemination activities including the annual EAB-RPC Conference Series, and its series of workshop' **[e]**. In **September 2018**, Guest was appointed to the role of Chair of the Training and Education Committee. The Chairman of the EAB confirms that Guest's 'input and expertise has been visible in informing practice/strategy of group with respect to education and training and the initiatives it facilitates', and that the EAB 'are grateful for the knowledge he distils within the ID community' **[e]**. The Chairman highlights that 'as a result of his role as chair, we have seen Professor Guest develop a training programme for end-users on biometrics with the first delivery in September 2020 reaching over 75 European stakeholders, enabling the transfer of a broad body of knowledge to the EAB community for front line deployment in applications such as border agencies, policing and governmental system, impacting millions of European citizens' **[e]**.

Informing the understanding of biometric identity linkages: The work of the SuperIdentity project has attracted significant national and international attention, and, since **2014**, the research **[R1]** has informed Government Communication Headquarters (GCHQ) as to future identity systems, enabling them to cross-correlate sources of evidence for surveillance and

system threat assessments, and improve intelligence and evidence **[f]**.

Enhancing the National Cyber Security Centre's practice of mobile biometrics: Since **2018**, the Kent team's research on biometrics environmental performance **[R3]** has also informed best practice within the National Cyber Security Centre in the advice given on mobile systems deployment. The Kent team's work has also shown how easy it is to conduct presentation attacks on devices using consumer materials bought from Amazon.

Device authentication: Technology to identify devices from their inherent behaviour and characteristics has been commercialised since **2014** via a University of Kent spin-out company, Metrarc Ltd. Metrarc has developed a dedicated Secure Internet of Things (IoT) ICMetrics demonstrator platform to showcase and market its disruptive technology. It is apparent from discussions with the leading infrastructure suppliers and the leading telecoms operators that there is a demand to uniquely identify and authenticate IoT devices on demand without introducing a significant per device cost overhead. Thus, by overcoming a major limitation in current solutions, the resulting products are highly disruptive to the established market.

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

[a] Letter from the Chair of the British Standards Institute, describing Guest and Deravi's contributions to the British Standards Institute and the International Standards Organisation committees.

[b] Briefing: Parliamentary Office of Science and Technology – Biometric Technologies, June 2018. The Acknowledgements section provides references to Guest's contributions to the report. https://researchbriefings.parliament.uk/ResearchBriefing/Summary/POST-PN-0578.

[c] Report: Iris Recognition Technologies, Defence Science and Technology Laboratory/Home Office Biometrics Programme, 2019. (Classification: Official Sensitive.) The report describes best practice in the use of iris biometric technologies. This file is confidential.

[d] Letter from the Chair of the Home Office Biometric and Forensics Ethics Group (BFEG), describing the impact of Guest's work within the BFEG.

[e] Letter from the Chair of the European Association for Biometrics, European Association for Biometrics, describing Guest and Deravi's contributions to the European Assocation for Biometrics.

[f] Annual Report of the Government Chief Scientific Adviser 2015. *Forensic Science and Beyond: Authenticity, Provenance and Assurance*. The Government Office for Science, London. December 2015. (See p. 68 of the Report for details of the SuperIdentity Project.) https://www.gov.uk/government/publications/forensic-science-and-beyond.