Impact case study (REF3b)

Institution: University of Kent

Unit of Assessment: 15 General Engineering

Title of case study: Biometrics: Supporting technology, policy and professional developments

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

Our impact on the theory and practice of biometrics (identification of individuals through measurement/analysis of their physiological/behavioural characteristics) embraces contributions to technological development, to general systems-level principles and to public policy and professionalisation issues. Our research and consequent engagement across the stakeholder community has impacted on the technological development of practical biometrics through take-up by industry (e.g. InMezzo, one of the UK's leading secure information specialists, has enhanced identity authentication procedures), company spinout (the EFIT-V facial recognition suite from VisionMetric Ltd fundamentally changed the means by which facial composites are created and is now used by more than 85% of Britain's Police Forces), leadership of the development of standards for the expanding commercial marketplace (e.g. establishment of standards for image acquisition for e-passports and other access control applications) and policy-level input to Government and International Professional Bodies, providing long-term support for practical deployment and end-user engagement (the Biometrics Assurance Group with Fairhurst as an independent member reported the security risk and problems identifying fingerprints within the UK government's £5.6bn ID card scheme proposal).

2. Underpinning research (indicative maximum 500 words)

Our long-standing and widely recognised biometrics research has made a significant impact on the development of the field through the work of a group comprising M. Fairhurst (1972-, Professor), F. Deravi (1998-, Reader), R. Guest (2000-, Senior Lecturer), G. Howells (1996-, Reader), K. Sirlantzis (2003-, Lecturer) and C. Solomon (1994-, Reader). Our work reflects the multi-faceted nature of biometrics, integrating specific research with aspects of outreach into practice, policy and supporting activities, the individual elements combining to contribute to overall impact.

The breadth and interdisciplinarity of biometrics has meant that contributions to our research have encompassed not only explicitly identifiable work central to the field (for example, work on face, signature/handwriting and iris modalities) but also related supporting work (in handwriting analysis for medical diagnostics, forensics, handwritten document analysis, etc). We have investigated the functionality and applicability of some of the principal biometric modalities (both physiological and behavioural). In face recognition we have examined facial image capture under challenging environmental conditions, explored the relationship between 2-D and 3-D facial imaging and the fundamental implications for practical access control and have developed techniques for facial composite construction and identification based on the cognitive processes of human observers [2]. In iris recognition we have investigated the implications of ageing on performance and how to manage template construction, developed strategies for measuring iris image quality and for iris capture under unconstrained conditions (including mobile platforms) and carried out some underpinning work on evidential synthesis. In handwriting biometrics we have developed improved identification structures using multisource combination, shown how signature biometrics can be transformed from a "weak" to a "strong" biometric using appropriate supplementary input and carried out fundamental work to show how feature selection can both individualise optimisation strategies and minimise inter-database effects on performance metrics and system evaluation [6]. We have shown how forensic inspection techniques and automatic signature verification can be mutually supportive in relation to feature extraction processes and provision of support tools. At a systems-oriented level we have developed classifier structures based on intelligent agent methodologies which are generically applicable but especially well-suited to biometric data processing and which can very effectively integrate soft biometrics and other evidence sources to enhance performance [5]. We have pioneered (now patented, 8165289, 8401184) research linking encryption to personal biometric data, removing the need for key storage, increasing usability and

enhancing privacy options and have extended this work to the identification and protection of hardware devices and software processes [3]. We have contributed extensively to the development of biometric standards, building on our mainstream technology-oriented research and the breadth of our research to understand how to specify standards which are acceptable, workable and optimal [1,4]. Fairhurst is the founding Editor of *IET Biometrics Journal*, encompassing both the industrial context of biometrics and promotion of standards in biometrics, bridging the research-industry interface internationally.

This work has been funded by the EPSRC, EU programmes, TSB, Centre for Defence Enterprise (CDE), industry including InMezzo, Smart Sensors, BAE Systems and agencies, such as DSTL, National Policing Improvement Agency (NPIA), Her Majesty's Government Communications Centre (HMGCC) and the Home Office (The Identity and Passport Service). Some examples, illustrative of the range and type our research outputs, are referenced below. The total value of funding received for the underpining research since 2004 exceeded £3.3m.

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

References to the key outputs (references [1]*, [2]* and [6]* best indicate the quality of the underpinning research):

[1]* R. Veldhuis and **F. Deravi**, Q. Tao, "Multibiometrics for face recognition", IT-Sicherheit & Datenschutz (now Datenschutz und Datensicherheit), vol.32, no.3, pp.204-214, 2008. DOI: 10.1007/s11623-008-0033-8. *This paper underpins seminal and continuing contributions to standards on multibiometrics.*

[2]* S.J. Gibson, **C.J. Solomon**, A. Pallares-Bejarano, "Synthesis of photographic quality facial composites using evolutionary algorithms", British Machine Vision Conference 2003 (Eds. Harvey, Bangham), vol.1, pp.221-230, 2003. DOI: 10.5244/C.17.23. *The original paper (others also contributed) which led to the ultimate development of the commercial EFIT/EFIT-V system. This output was returned by **Solomon** in RAE2008.*

[3] (i) A method and apparatus for the generation of code from pattern features, UK Patent Application GB 06 13482.9, filed July 2006, PCT application PCT/GB2007/002471 filed July 2007 (**Howells, Fairhurst. Deravi**), Pat. No. 8165289 and (ii) A device to generate a machine specific identification key, UK Patent Application GB 0615392.8, filed August 2006 (**Howells**), PCT application PCT/GB2007/002916, filed August 2007, Pat. No. 8401184. *These patents (i) underpin our work on biometrics-mediated encryption and (ii) the corresponding patent relating to hardware-based identification.*

[4] **R.M. Guest** (Co-editor)**,** ISO/IEC 19794-7: 2007 Information technology - Biometric data interchange formats - Part 7 - Signature/sign time series data http://www.iso.org/iso/catalogue_detail.htm?csnumber=38751. *The standard which has seen take-up in a wide range of public and private organisations.*

[5] **M.C. Fairhurst**, M. Abreu, "Enhancing identity prediction using a novel approach to combining hard- and soft-biometric information", IEEE Transactions on Systems, Man and Cybernetics, Part C, vol.41, no.5, pp.599-607, 2011. DOI: 10.1109/TSMCC.2010.2056920. *A paper illustrative of the power of our generic intelligent-agent approach to classifier design in biometrics applications. This paper is submitted by **Fairhurst** to REF 2014.*

[6]* **M.C. Fairhurst**, M. Erbilek, "Analysis of physical ageing effects in iris biometrics", IET Computer Vision, vol.5, no.6, pp.358-366, 2011. DOI: 10.1049/iet-cvi.2010.0165. *A paper, returned by **Fairhurst** in REF 2014, provides some fundamental new insights into how ageing impacts on the long-term use of iris biometrics. This was a key publication which led to the production of the first reference book (Edited by Fairhurst) to address a wider understanding of the crucial issue of ageing in biometric systems, now widely recognised as essential for future success of practical systems, bringing together contributions from major international researchers from academia and industry.*

Key supporting grants:
Fairhurst, *Novel image analysis techniques for enhanced automatic signature verification*, EPSRC, GR/K76931, £155,412, 1997-1999.
Fairhurst, *Novel multiple expert classifiers for handwritten data analysis*, EPSRC, GR/M95882, £179,265, 2000-2003.

Fairhurst, Deravi, Howells, *Enhancing trust and reliability in distributed documents*, EPSRC,
 GR/N37803, £174,439, 2000-2003.
Deravi, Fairhurst, Intelligent agents for multimodal biometric identification and control, EPSRC/DTI
 LINK Grant, GR/N09732/01, £206,661, 2000 - 2003.
Deravi, Fairhurst: *FINGER_CARD*, EU_IST_Programme, Ref: 25168, 183,618 Euros, 2001-2003.
Howells: *Evolvable Networks of Intelligent and Secure Integrated and Distributed Reconfigurable*
 System-On-Chip Sensor Nodes for Aerospace Based Monitoring and Diagnostics, EPSRC
 (Joint award Kent/Essex), EP/C54630X, £132,009 to Kent, 2005-2008.
Deravi: *3DFACE,* EU_ICT_Programme, Ref: 026845, £303,234, 2006-2009.
Howells, Fairhurst: SmartCare Caller ID, Technology Strategy Board, 130340, £49,947, 2010-
 2011, collaboration with InMezzo Ltd.

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

The demonstrable impact of our research falls into three interrelated strands:

(A) Direct technology impact: In face biometrics, via company spinout (VisionMetric) our face modelling has spawned a highly successful commercial product (EFIT-V), enabling victims of crime to create near-photographic quality facial likenesses from memory, assisting hundreds of serious crime investigations. EFIT-V is used by more than 85% of Britain's Police Forces [S1] and is deployed in over 30 countries, with a client base of around 200 organisations. Since its release in early 2008, licensees have seen increases of more than 100% in useful intelligence (as reported in the Investigative Practice Journal of Police Professionals, the largest circulation police weekly). An extended study of its performance in the field involving more than 1000 interviews resulted in an exceptional 40% naming rate (Driver and Rowbotham, E-FIT user conference 2009). Construction is also up to 100% quicker than for traditional, feature-based systems. The system has not only been pivotal in fundamentally changing the means by which facial composites are created but has proven to be of major social value. Our work on biometric access monitoring supports the integration of dual biometrics into the SmartCare telehealth platform marketed by InMezzo Ltd [S2], establishing the engineering parameters required for implementing/managing biometric security on generalised hardware platforms and providing additional customer features. Kent's iris biometrics research has had impact in two areas. First, in collaboration with Smart Sensors Ltd, we have developed a flexible imaging system which allows easy iris image capture at multiple gaze angles and differing illumination conditions. This coupled with the training strategy optimisation process for unconstrained image capture which has thereby been facilitated, is helping the company develop its next generation iris recognition systems [S3]. Second, we have researched the way in which physiological ageing influences iris image processing, and how this affects template management. This and parallel work using the handwritten signature modality has made an important contribution to the growing body of work urgently needed on understanding ageing effects in biometrics, leading to the commissioning of the first reference book (appearing in 2013) on this subject [S4], edited by Fairhurst, representing a state-of-the-art benchmark essential to promoting longevity for practical biometrics solutions. Work on pressure profile dynamics in signature biometrics (Fairhurst) has been taken up by Wacom, an international market leader in digitising graphics tablet manufacture, in a redesign of products (notably their current Intuos and STU-signature tablets; in excess of 100,000 signature pads are sold per year) extending their reach into biometrics/forensic applications [S5]. Our work on novel classifier structures has informed fundamental biometric landscape reports for DSTL, HMGCC and BAE Systems and is at the heart of work with Accenture (Fairhurst, Guest) to develop new client-facing technologies [S6]. In implementing privacy enhancing technologies, work on biometrics-mediated encryption (Howells, Fairhurst, Deravi) has impacted directly on the InMezzo Ltd development (above), and has extended to system development for DSTL. It is protected by patent PCT/GB2007/002471 and has driven the spinout of a new company (Metrarc).

(B) Standards and systems. We play an influential role in the international standards development process. The International Organization for Standardization (ISO) is the world's largest developer of International Standards and the International Electrotechnical Commission (IEC) serves world markets and society through its standardization and conformity assessment work. Standards give state-of-the-art specifications for products, services and good practice,

making industry efficient and effective and facilitating globalisation. Guest is UK Principal Expert to ISO/IEC JTC1 SC37 WG2 Biometric Technical Interfaces and played a major part in developing published ISO/IEC standards (for example ISO/IEC 19794-7 and 29109-7 for dynamic signatures). These are now adopted by numerous international Banks and other organisations (for example, Barclays, Bank of America, UPS, Interpol) as the *de facto* data interchange formats for biometric signatures [S7]. This work has also developed standards for the most commonly used programming structure supporting cross-manufacturer device interfacing, the Biometric Application Programming Interface (BioAPI). Deravi is UK Principal Expert to ISO/IEC JTC1 SC37 WG3 and was instrumental to work on ISO/IEC 24722:2007 on for multibiometric fusion. His work on International Standard ISO/IEC 19794-5 (Face Data Format) has contributed to the relaxation of image capture constraints for UK Passports and influenced accepted standards for image acquisition for e-passports and other access control applications worldwide.

(C) Wider influence. We have made a significant impact on public policy, practitioners and professional services. We have provided advice to Government across all its biometrics-related activities, ranging from technology implementation to ethical and privacy issues [S8] through membership of the Biometrics Assurance Group (Fairhurst), the Home Office Biometrics Experts Group (Fairhurst) and the broader Biometrics Working Group (Deravi, Fairhurst) and we have undertaken data collection and analysis for the National Policing Improvement Agency (NPIA) to inform Police face image capture (Deravi, Fairhurst). We have represented the academic community on several Government-sponsored, industry-oriented Missions - for example to the US (Fairhurst), Japan (Fairhurst), China (Howells), providing important international market intelligence and specific information to inform UK biometrics industry development. Deravi has spearheaded the formation of the BioSecure Association, a research charity disseminating biometrics databases/tools, ensuring a legacy from the EU BioSecure Network of Excellence. Fairhurst is a member of the international committee overseeing the IEEE Certified Biometrics Professional programme, offering opportunities for practising biometrics professionals to have their skills internationally recognised [S9]. These examples demonstrate the significant impact of the Kent Group on the wider biometrics community, a major influence on policy and practice development, and extensive support of professionalisation activities.

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

S1. Police Sergeant, Crime Performance and Strategy Unit, Wiltshire Police will confirm the value and impact of the adoption of the EFIT system in the UK.

S2. Head of Business Development, InMezzo Ltd will confirm the impact value of the development of biometrics-based control for implementation on a commercial hardware platform.

S3. CEO, Smart Sensors Ltd will confirm the value of the work on new iris image capture and the development of enhanced enrolment strategies to increase the flexibility of emerging iris recognition systems.

S4. Commissioning Editor IET will confirm details of the new benchmark reference text and its importance in promoting practical implementation of biometric systems for long term use.

S5. Director Global Signature Solutions, Wacom Europe will confirm the impact of Kent's work on the on-going update of their writing capture tablet designs.

S6. Her Majesty's Government Communications Centre (HMGCC), will confirm the influence of Kent's work on development of future R&D policies.

S7. Head of Product Management, Softpro GmbH will confirm the extent and nature of the impact of Kent's work on standards in the area of handwriting and signature.

S8. Private Consultant (ex-British Technology Group) will confirm the way in which Kent's contribution has impacted on the work of the Biometrics Assurance Group in developing and monitoring Government planning of all Government programmes using biometrics.

S9. Director, Certification, IEEE will confirm details of the work relating to the IEEE CBP programme.