

Institution: University of West London

Unit of Assessment: 11 Computer Science and Informatics

1. Unit context and structure, research and impact strategy

1.1 Context

Since 2014, the University has invested in research and has provided an infrastructure to expand and support strategic areas, of which this UoA is one. The plan for growth and improvement is articulated through our two last strategic plans (*Ambition 2013-2018*; *Achievement 2019-2023*), and the related research strategies which require Schools to plan research in ways that reflect the main objectives of the institutional strategies (see institutional statement, section 2). This UoA was submitted in REF 2014, and it is strongly embedded in the School of Computing and Engineering, where research in Computer Science was first submitted in RAE 2008. Over the present REF period, the direction of research for the UoA has been refined - three clear clusters have been nurtured - and the main strategic aim has been to increase quality and reach, particularly by engaging with industry partners. The University has invested in this UoA; we have acquired new facilities, created an interdisciplinary research centre, and invested in staff and funding opportunities for doctoral students (see institutional statement, section 2.1.2). This unit has therefore significantly matured and focused its research.

1.2 Structure and Description of the UoA

Currently, 10 (9.8FTE) academics and 20 research students comprise the computer science and the associated fields. The composition of the unit has changed significantly since December 2013; 75% of academics have joined this UoA since 2014. The academics who left were replaced by leading/promising world-class researchers, allowing us to bring maturity to the research areas identified for growth whilst ensuring sustainability for the years ahead. Of the 10 current members, six hold Associate/Full Professor positions. Four are more junior members. We have also identified six members starting their career who have been identified as 'next generation' researchers (see section 2).

| Academic | Position & Research Area/Expertise | Year Appointed/Left |
|-----------------------|---|----------------------------|
| Jose Abdelnour-Nocera | Associate Professor, HCI | 2003 |
| Junaid Arshad | Associate Professor, Cybersecurity | 2015- 2020 |
| Waqar Asif | Lecturer, Cybersecurity | 2020 |
| Wei Jie | Associate Professor, Cybersecurity | 2009 |
| Elahe Kani-Zabihi | Senior Lecturer, HCI | 2015 |
| Jonathan Loo | Professor, Cybersecurity & AI | 2017 |
| Christian Sauer | Lecturer, AI | 2011- 2019 |
| Shanyu Tang | Professor, Cybersecurity | 2017 |
| Ikram Ur Rehman | Lecturer, AI | 2019 |
| Hui Wang | Professor, AI | 2020 |
| Xinheng (Henry) Wang | Professor, Cybersecurity & AI | 2017- 2019 |
| Scott Yang | Lecturer, AI & Cybersecurity | 2020 |
| Massoud Zolgharni | Associate Professor, AI | 2018 |

The principal focuses of research are reflected in three multi-disciplinary themes. Each theme links to a research centre/group that provides the coordination and infrastructure/expertise for targeted

research. Academics involved are not limited to just one theme, and many work collaboratively across a number of these thematic areas.

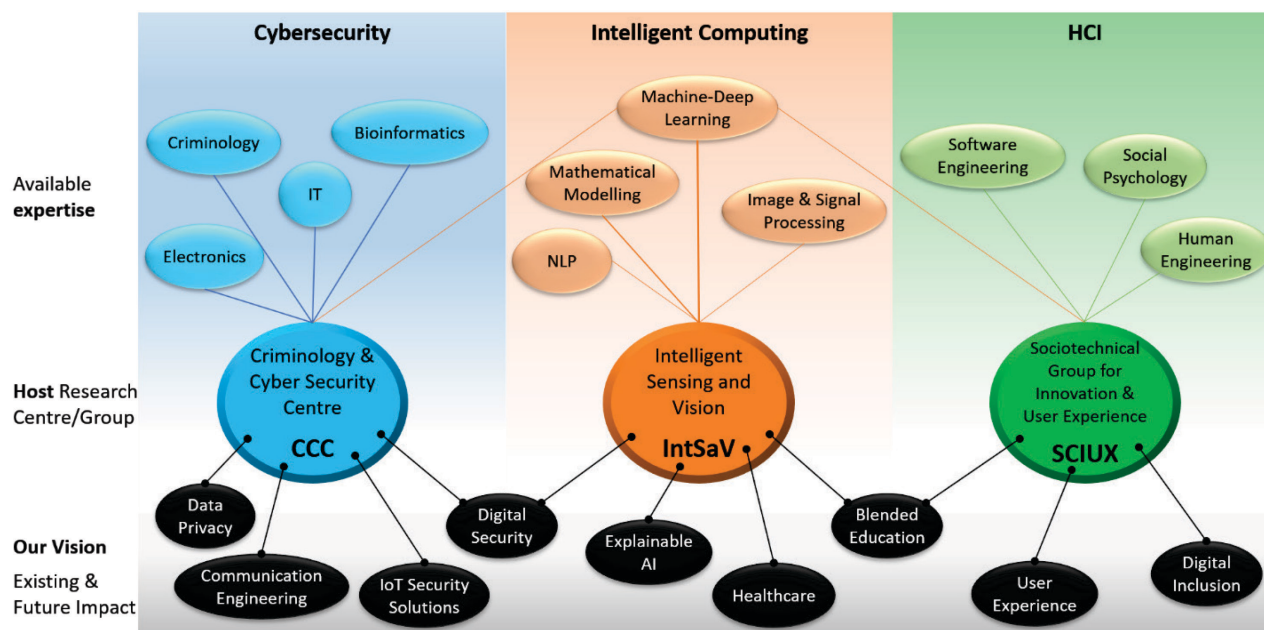


Figure 1. Our main research themes: Cybersecurity, Intelligent Computing, and Human-Computer Interaction.

Cybersecurity research, supported by the *Cybersecurity and Criminology Centre (CCC)*, addresses research and public engagement in cybersecurity, crime and their intersections. This Centre became fully operational in 2017 to focus on cybersecurity research and research in other forms of criminality and security issues, with a view to be an interdisciplinary resource for internal and external collaborators. It has a wide research scope: in **computer system and network security**, Loo has recently been supported by the Innovate UK and the Department for Digital Culture, Media and Sports (DCMS): i) to develop Cyber monitoring and Defence for IoT (04/2018-02/2019), and ii) to investigate an intelligent threat hunting system based on Linux security hardening and mandatory access control policies (04/2020-07/2020). In **communication security**, Tang secured an Innovate UK grant (1026790, 12284 GOL) in May 2020 to develop a secure mobile apps universal converter using cybersecurity and automation technology (10/2020-03/2023). Asif, a more recent addition to the CCC, has been involved in multiple EU projects focusing on **data privacy**. Currently, 7 PhD students are attached to the Centre. Key researchers in this stream are:

- Loo, Tang, Jie, Arshad, Asif, Yang
- Also from UoA20: Brooks, Harding, Henry, Murji and Wakefield

Intelligent Computing research is supported by the **Intelligent Sensing and Vision Research Group (IntSaV)**, which is a specialised group coordinating advanced research in all aspects of Artificial Intelligence and Big Data. It covers a range of topics in machine learning and computer vision/sensing, encompassing various applications in industry and healthcare. IntSaV has fostered interdisciplinary research by providing a framework for cross-faculty collaborative working beyond the School. The group has pursued a successful strategy of growth in several key areas: in **biomedical image processing**, Zolgharni was awarded a British Heart Foundation (BHF) grant to develop computer-aided diagnostic technologies (01/2020-12/2022). The area of **signal processing** has been revitalised with the recruitment of Yang whose novel methodologies for biometric recognition has attracted attention. IntSaV has recruited 8 PhD students. In 2020, this group introduced a new MSc in AI as a one-year bridge between undergraduate and PhD degrees. Key researchers in this stream are:

- Zolgharni, Loo, Rehman, Yang, Wang and Sauer
- Contributory members: 2 'next generation' colleagues, and Chousidis from UoA12; and Brew from UoA3

Human-Computer Interaction research, supported by the *Sociotechnical Group for Innovation and User Experience* (SCIUX), addresses the design and development of systems that meet the needs of end-users globally. It investigates the sociotechnical and cultural differences inherent in the process and product of design, and development, of interactive systems. SCIUX has developed strong relationships with industry, national and international partners, and has been supported by several funding bodies. In **HCI**, Abdelnour-Nocera is funded and working closely with Heathrow Airport on improved decision-making in the deployment of automation in terminal airside operations. In exploring various dimensions of **quality of experience**, Kani-Zabihi has focused on human factors in multimedia systems. Currently, 5 PhD students are attached to the group. Research at SCIUX also feeds into our postgraduate courses in Information Systems, Health Informatics, and Software Engineering. Key researchers in this stream are:

- Abdelnour-Nocera, Kani-Zabihi
- Contributory members: 4 'next generation' colleagues.

1.3 Research and Impact Strategy

With the appointment of an Executive Dean in late 2014 (Professor Amir Alani), and under his direction, the UoA has grown strategically to occupy a strong position in a number of niche research fields. Four **major goals** were set in 2015:

- 1) Focus on strategic research areas to increase quality and impact.
- 2) Strengthen the environment to generate a long-term and stable research community and culture within the UoA, including through the establishment of Research Centre/Groups.
- 3) Increase bid activity and secured funding, improving our national and international reach and recognition.
- 4) Develop industry-related links, and identify and develop impact communities, and impact monitoring mechanisms for long-term impact engagement.

These goals were achieved as follows:

1. **Developing strategic areas of research**

It was agreed that we would reduce our focus from five to three main research areas; AI, Cybersecurity, and HCI. Early in the cycle, the School set out its strategy to support staff in the UoA, to be able to produce high quality research and strong impact in the field. We recruited staff with cybersecurity expertise that brought additional STEM weight to our UoA. This provided us with an opportunity to impact directly on sector-wide technological developments in the areas related to cybersecurity, as our third major research theme.

2. **Strengthening the environment**

The CCC was established in 2017 to address current and future security threats in a cross-disciplinary approach, contributing to the areas of cybersecurity and information security. The Centre has recruited and promoted world-class researchers (six professors from this UoA and other schools within the University). IntSaV, opened in 2018 to provide the expertise and support for our AI research, and includes seven members. HCI research, supported by the SCIUX group, has six members.

3. **Improving our reach**

Over the period, the UoA has established collaborative links with many industrial and clinical partners, including the following partnerships with:

- Secure Technologies UK Ltd and Imediavan, funded by the Innovate UK (Loo, to develop cyber monitoring and Defence for IoT (CYMOND)).
- AB5 Consulting Ltd, through a KTP fund (Tang, to develop a secure mobile apps universal converter predicting apps security strength with a new fractal algorithm against security metrics).
- SALMAC: 'Security Assessment tool for Linux Mandatory Access Control', project funded by Innovate UK/DCMS, led by Middlesex University with Loo as a CI, (April 2020 to July 2020) investigating an intelligent threat hunting system based on Linux security hardening and mandatory access control policies
- The National Heart and Lung Institute (Zolgharni, funded by BHF Project to develop cardiovascular diagnostic tools).

4. Impact

The University holds an Impact Group which has supported academics with their ICSs, and is presently focusing on upcoming impact opportunities beyond REF2021. Group members meet monthly to identify promising early-stage research projects which could potentially be impactful. From this UoA, Zolgharni serves as a group member.

The two impact case studies submitted illustrate the UOAs approach to impact. One shows how we have developed an innovative approach to protecting internet-connected consumer devices from cybersecurity threats, winning financial development support from Innovate UK / DCMS and then taking this forward towards commercialisation. The second shows how our Sociotechnical Research Group for Innovation and User Experience has contributed to the effective adoption of Human-Centered Systems Design in Asia and Africa, as well as in the UK. This builds on well-established research at the University and extended it to benefit new partners, particularly in South Africa.

1.4 Strategic plan for the next 5 years

Based on the University Research Strategy for 2025 (see institutional statement, section 2.1) the principal aim for this unit is to further develop the quality and reach of its established areas of research, to continue focusing on applied interdisciplinary projects, and to pursue quality research spanning from underlying theoretical studies to transformative applications in the scientific, commercial, and social domains. We will develop and pursue collaborative research, engaging across the institution, and with regional and international partners, based on existing partners and impact communities – with a view to expand. This is the basis on which will continue to develop and grow this UoA towards the next REF, as we intend to produce research that impacts social (in HCI research), medical (see collaborations with hospitals in Section 4.1), environmental and scientific (see AI and Cybersecurity) aspects of our field. Our main objectives are:

1. Expansion of existing research capacity

The recent pandemic has accelerated digital transformation as people work remotely. This paradigm shift will not be completely reversed in post-COVID era. CCC will be addressing the profound questions posed by these changes to enhance cyber resilience and improve data security distributed across private and corporate systems.

Similarly the rapid development of new online teaching and learning approaches in schools and universities will engage HCI in the design of online learning platforms, and study wider socio-political and economic implications on learning.

The Government's Industrial Strategy identifies AI as one of its four Grand Challenges. This will be a key focus area for us. It is envisaged that an AI Research Centre will emerge from the IntSaV research group, spanning the breadth of its interdisciplinary research areas.

2. Transformative multidisciplinary research

We will sustain and expand our problem-driven and interdisciplinary research in the relevant areas of AI, Healthcare, Security, and Ageing Society. We will do this by building on the strengths of different disciplines at UWL already engaged interdisciplinary research, and grow externally to tackle complex computer science problems.

3. Emerging research challenges in the discipline

We will focus on fast emerging challenges and shifting paradigms - including AI ethics, explainable AI, cloud computing, and human-centred systems design - to meet the evolving needs of industry, healthcare, and society.

4. Growth and diversification of research income

We will grow and diversify our research income portfolio, from commercial and non-commercial sources, ensuring high-quality submissions and effective management of awards. We aim to double our present research income by focusing on large and longer-term projects.

5. Training the next generation of researchers

We will continue to include the 'next generation' of researchers, and ensure they are targeted for UoA and University funding and support opportunities. We will continue to attract high-calibre PhD students, including securing further industry-based PhDs.

6. Pathways to impact

We will further engage with existing identified impact communities and end-users, as well as identifying new ones, deploying systematic mechanisms to monitor and collect evidence. We will further establish and generate new highly effective collaborations (including KTPs), through consultancy work to industry.

1.5 Support for Standards and Ethics**1.5.1 Academic research infrastructure to support standards**

The University Research, Scholarship and Enterprise Committee (URSEC) chaired by the Deputy Vice-Chancellor, receives reports on matters of University-wide interest, including regular updates and annual reports from schools on research, scholarship, and knowledge transfer activities. URSEC also advises on research governance within the individual Schools. It oversees key performance indicators and their fitness for purpose in the context of the University's Strategic Plan. A University Research Degrees Sub-Committee oversees progression by postgraduate research students to registration to MPhil status, and onward to doctoral (PhD) completion.

1.5.2 Ethics

The University Research Ethics Committee (UREC) – also a subcommittee of the University Research, Scholarship and Enterprise Committee (URSEC) - has overall responsibility for ethics approval of all staff and students' applications. This UoA's staff and student approvals are scrutinised by the School's Research Ethics Panel (SCREP), chaired by Abdelnour-Nocera. SCREP reports regularly to UREC. UREC subgroups are convened where 'high risk' applications are identified by any School/College SCREP.

In UoA11, all research activities are also assessed rigorously for the health and safety under the University's established directives and protocols. The equipment being used for research purposes are regularly inspected and tested to ensure it meets the technical and safety requirements.

1.6 Open and Interdisciplinary Research

All researchers in this UoA are ORCID registered, and 386 publications are associated with this UoA and openly accessible through repository, out of which 304 (80%) publications have full text associated with the record. At UoA level, we do the following to support open research:

- In the wake of open science, the priority in this UoA has been the full publication of details of all methods developed in research, so that they can be reproduced, criticized, and improved upon.
- Crucial to the field of computer science, where not only publications but also other research materials can be usefully shared, industry-standard code-sharing utilities, such as GitHub, is used to make the datasets, code of experiments, and analyses freely available.
- To stimulate faster impact, when possible, the scholarly research outputs are also openly available by publishing in open access journals and arXiv repository.

As indicated earlier, this UoA has a strong **interdisciplinary** make-up. This is sustained through regular meetings and seminars, and through expansive engagement with a range of industry partners (see section 4).

2. People**2.1 Staffing Strategy**

In 2015, UWL introduced an Academic Employment Framework (AEF) which addresses the recruitment, management, development and support of all academic staff. In this framework all academic staff can focus (in addition to teaching) on research, scholarship and/ or knowledge exchange activities (see institutional statement, section 3.1). Academic staff agree targets for these activities which form part of their annual appraisals. Through this framework, SCE has benefitted (as explained in section 1) from the addition of new research-active staff. Over the REF period, seven key appointments were made to strengthen the areas of AI and Cybersecurity.

The unit's current diverse level of seniority (Professors, Associate Professors, and more junior SRR) is supported through different mechanisms, and ensure we have succession plans within the unit. Research expectations and publications in peer-reviewed reputable journals, and participation in bids applications, are at the core of this UoA's activities. All new members of staff are allocated mentors to enable them to adapt well to the School culture. This process ensures that talent is spotted early to allocate research responsibilities that will contribute to the future shape of the UoA. Where relevant, new members of staff join a supervisory team as 'observers', and later - after training (which is mandatory at UWL) - as second or third supervisors. Our UoA is diverse, in terms of gender, race, religion, and age. Our academics originate from over nine different countries on three continents, with 80% being of BAME background.

2.2 Staff Development

There is a broad-ranging staff development provision, both at University and at School level (as described in the institutional statement section 3.2). Several services contribute to research-based staff development, which has involved staff in this UoA. The AEF framework provides a 5-day annual allowance for CPD and development.

At University level, Research and Enterprise Operations (REOps) offer lunchtime seminar sessions on research issues including knowledge exchange; impact; collaborative projects; commercialisation; managing research budgets; funding opportunities, industry and user engagement. REOps also support applications for research funding. This UoA has greatly benefited from this training and support, and been supported by REOps with funding applications. HR provide training on equality and diversity, managing stress, appraisals, preparing for promotion, working with external collaborators, and leadership. They hold a budget for conferences, sabbaticals, and other staff development programmes. For instance, Abdelnour-

Nocera spent one year at the IT University of Copenhagen as part of a University's sabbatical. Staff on this UoA staff have also been supported for attending international conferences. The University also pays for internal and external courses, and for staff to study additional qualifications, including MAs and PhDs. For example, staff who take up studying for a PhD are supported financially (no fees are paid) and through a 100-hour reduction in their teaching load. Five members of staff have benefitted from this over the period; and another is presently completing their PhD. The Library has provided training and one-to-one support on Open Access; and has trained members of the UoA on understanding open access and compliance rules. They encourage staff and research students to sign up to and use ORCID ID. The Communications department offers advice on media; public engagement; engaging with diverse audiences; social media. The University also runs impact workshops, with access to impact advice (described in section 1). It has provided training on impact; outputs planning; REF guidance; REF Code of Practice. The annual University Research Conference led by the PVC (Academic) provides opportunities to disseminate research findings, and network with potential new research partners. This UoA has played a strong role in the conference, with regular attendance and presentations (e.g., Abdelnour-Nocera in 2018, and Zolgharni in 2019 and 2020). Members of the UoA have attended sessions on impact, public engagement, interdisciplinary research, mentoring, new career researchers, at the annual conference.

At School level, the School of Computing and Engineering organises its own monthly research seminars. Each session includes up to three internal (staff and doctoral students) or external (visiting researchers) speakers presenting their latest research plans/findings. The seminars are well-attended (>50 attendees each month) and attract audience from beyond SCE. It provides the opportunity for junior researchers to benefit from detailed discussions and feedback on their work with senior researchers. The UoA has been very active, accounting for ~70% of the speakers.

Other School-based support includes:

- Junior academics are encouraged to meet with their link/mentors at least twice a year. This may be on a one-to-one basis, and many discussions also occurred informally or during the monthly research surgeries. Some junior staff have submitted joint bids with their mentors.
- Staff are supported with research and scholarly activities through regular developmental workshops: e.g., introductory sessions to 'Research Professional'; Research Data Management and Data Management Plans.
- All staff including junior staff are supported for attending internal and external conferences and contribute to the research centre/groups.

Regular events include:

- Peer review groups where colleagues review each other's research outputs and doctoral students' proposals, prior to submission.
- Monthly School's Research Meetings during which research ideas, projects, and research-related concerns are discussed.
- Twice-yearly Research Showcases, an all-day event which showcases the research work of all students and selected academics within the School.

All these initiatives are well embedded in the activities of the UoA, and have been sustained for several years.

2.3 Research Students and Supervisors

Community

All our doctoral students benefit from a formal centrally-run research training programme (see institutional statement, section 3.2) based on the *VITAE Researcher Development Framework* and delivered by the Graduate School, with contributions from senior academics from across the institution. On this programme, PGRs complete a series of Research Development Units (RDU) throughout the entire period of their registration, with embedded Epigeum interactive online activities. At School level, our current 20 registered research students are an integral part of the UoA, and we engage them in seminars and meetings where we discuss their research and that of staff. We run **monthly** research seminars where attendance is mandatory for doctoral students. They are also required to present their research at least twice throughout their PhD journey: once in first year of their studies when are forming their research ideas and plan, and can benefit from feedback/comments provided by Schools' academics and from practicing their presentation skills; and closer to completion they present their final research findings, to get feedback from colleagues as part of good preparation for their Viva. These activities are considered as required milestones for progression, and are monitored via regular updates and annual progress reports. We also run **twice-yearly** School Research Showcase full-day events within the School to enable doctoral students to showcase their research work to the wider University and to the invited guests from industry/media/charities (e.g., speakers/guests from Royal Academy of Engineering in January 2020). Showcase exhibits include research posters and oral presentations. Ten prizes are awarded (through visitors and staff vote) each year for the best exhibit in different categories. Prizes are in the region of £100 (in the form of Amazon vouchers or Students' Union goods such as quality clothing items).

Expansion has been a key priority. Fifteen of our students have gained Vice-Chancellor's PhD Scholarships (on a competitive basis) to study towards a PhD over the period; seven are current students. During the period of assessment, there have had 20 successful PhD completions. This compares favourably when contrasted with the previous REF period with just three awards. In parallel, supervisory capacity has also increased from 10 to 14.

Training

The Graduate School also runs a mandatory training course for all supervisors on topics including good supervision management, regulations, equality and diversity issues, student support, using the VITAE framework, and helping students through the various progression stages and milestones. We also discuss in these sessions the University's *Code of Practice for Research Students and Supervisors*. This policy sets-out the main principles for successful supervisory arrangements, and the University's main priorities for doctoral research (see institutional statement, section 3.2). Quite a few senior colleagues contribute to this training from across the University, including Zolgharni from this UoA. It also has also run a comprehensive SEDA-accredited programme on Supervising Postgraduate Research for training new and experienced PhD supervisors to enhance their practice of supervision (e.g., one member of the UoA successfully completed the course in 2020, a school colleague also completed in 2019). The Graduate School runs an annual doctoral conference across all subjects. The annual doctoral conference is always very well attended by academics and PhD students in this UoA. We play a significant role in supporting the event, and students presenting their latest research findings; at least 15 PhD students from this UoA have presented in the last 5 years (2015-2020).

PhD students are each supported by a sizeable group of people. Each student is assigned a principal supervisor who is a subject specialist, and a second supervisor. In case of multidisciplinary research projects, a third supervisor from a different discipline may also be assigned, when needed. Ensuring the next generation of researchers are confident in

disseminating their knowledge we provide teaching opportunities with a limit of 6 hrs/week (including preparation). Students engage with groups according to their evolving degree of expertise. Supervisors act as mentors to support them in delivering those teaching duties. Pastoral support is provided through the University's central student support services.

Our students present regularly, and we support them in preparing for their presentations. They have access to a central conference fund; e.g. a PhD student from IntSaV, was funded to attend and present his research at ICRMIRO2020, for which he was awarded the 'Best Presentation Award'. The doctoral students are also encouraged, and supported, to publish in discipline-specific journals and the UWL University Press publication, *New Vistas* (see institutional statement, section 3.2).

2.4 Equality and Diversity

Training

The HR department delivers a mandatory programme of face-to-face and online training on all aspects of equality and diversity which has been attended by all members of the UoA. Supervisors have been trained on these issues through the compulsory programme of training run by the Graduate School.

Research development opportunities

The research development opportunities available to staff – e.g. research funding, sabbaticals, conference funding - always state the conditions and criteria that are applied. There is a transparent process for these applications. Academic staff are actively encouraged to attend briefing sessions on research funding opportunities, such as our regular lunch seminars and our triannual research events. Access to other research support, such as conference attendance support, sabbaticals and "seed grants" follow established procedures and are open to all staff meeting the relevant criteria.

Recruitment and progression of research students

The recruitment of doctoral students is based on regulations that specify entry requirements, and their application is supported by a written statement and an interview by a panel including supervisors and a Graduate School Director of Studies to ensure fairness and consistency across the institution. Progression is monitored by the Graduate School through a set of staggered milestones, and final registration to PhD status (transfer) is overseen by the University Research Degrees Sub-Committee. We aim to support completion within 3 to 3.5 years and have mechanisms (e.g. regular supervision meetings, milestone presentations; regular reports) to support all students in achieving this (see institutional statement). We subscribe to the Postgraduate Research Experience Survey (PRES) and this shows that students are satisfied with this support; UWL is ranked 7th out of 103 institutions on progression in PRES 2020.

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As a UoA, we have received training on recruitment, promotion, appraisal; and the UoA leads and reviewers have received specific training on equality and diversity, and unconscious bias to support them in their role. They have been advised to access to practical advice and support from HR if needed.

3. Income, infrastructure and facilities

3.1 Income

The strategy in the unit is to support applications to both external income (Research Councils, industry, government agencies, consultancy) and internal investments. The internal funding is used to support active researchers with travel and equipment, and to provide funding for bursaries

for PhD students. The University has a responsive structure - the Research and Enterprise Operations (REOps) – to identify relevant funding opportunities and support bids.

This UoA has used REOps to identify funding opportunities and been supported to produce strong applications. The UoA has its own panel of expert reviewers, composed of academics from various research themes, to support each other with peer-review of the bids under development, to ensure high quality research proposals are submitted to the funding bodies. This model, established during the census period, has seen annual income generation of c£650k for the REF2021 period.

We have been successful at attracting research income in all main themes in this UoA, and the diversity of funders reflects the multidisciplinary nature of our research. The main sources of research income for Cybersecurity include Innovate UK and industry (e.g., Amazon), realised via our close collaboration with the industrial partners. The AI research has benefited from support provided by Innovate UK, whilst we also target specialist funders and medical funding bodies (e.g., BHF). The HCI research theme has been supported by the national academies (e.g., British Academy) and industry (e.g., Heathrow Airport). This has allowed the expansion of our research capacity in our three strategic areas of research.

Below is a brief account of funded projects started during the REF2021 period:

Cybersecurity (£381,140):

- A Self-organizing Community Detection Algorithm for Large-scale Social Networks (in AWS credits) \$10,000 (£7,400)
Funded by Amazon Research Grant (Jie), 2016
- A Provenance Framework to Minimize Malleability Risk in Blockchain, approx. £23,000
Funded by Ministry of Science and Technology, Pakistan (Arshad), 2017
- CyMonD: Cyber Monitoring and Defence System for Internet of Things, £9,446
Funded by DCMS & Innovate UK's Cyber Security Academic Startup programme. Phase 1 (Loo and Arshad), 2018
- CyMonD: Cyber Monitoring and Defence System for Internet of Things, £16,000
Funded DCMS & Innovate UK's Cyber Security Academic Startup programme. Phase 2 (Loo and Arshad), 2018
- CyMonD: Cyber Monitoring and Defence System for Internet of Things, £100,000
Funded by DCMS & Innovate UK's Cyber Security Academic Startup programme. Phase 3 (Loo and Arshad), 2018
- A Scalable Framework for Trustworthy Marketplaces, £50,000 (PhD Scholarship)
Funded by MyPocketSkill (Loo and Arshad), 2018
- Representation Learning of Large-Scale Complex Information Networks by Integrating Community Structure, RMB100, 000 (£11,300)
Funded by Shaanxi Provincial Department of Science and Technology, China (Jie), 2019
- SELMAK: An Intelligent Threat Hunting System Based on Linux Security Hardening and Mandatory Access Control Policies, £16,000
Funded by DCMS & Innovate UK's Cyber Security Academic Startup programme. Phase 1 & 2 (Loo), 2020
- Secure mobile apps universal converter, £147,974
Funded by Innovative UK – KTP (Tang), 2020

Intelligent Computing (£201,472):

- Personalised Service Assistant for Journey Planner, £48,472
Funded by the Innovate UK - Newton Fund: UK-Malaysia urban challenge (Wang) 2018

- Tensor-mapping to resolve the Achilles heel of echocardiographic imaging, £143,000
Funded by the British Heart Foundation (Zolgharni), 2020
- Digital Innovation in Flood Early Warning and Water-related Disease Prevention for Community Capacity Building and Resilience, approx. £10,000
Funded by the EPSRC (Zhang), 2020

HCI (£70,000):

- Digital Inclusion, £20,000
Funded by British Academy (Abdelnour-Nocera), 2017-2019
- Industrial PhD on Sociotechnical Innovation and User Experience £50,000
Funded by Heathrow Airport Innovation Unit (Abdelnour-Nocera), 2018-2021

3.2 Infrastructure and facilities**3.2.1 Digital research infrastructure**

The University actively supports research data management and the use open data repositories to archive research data. It offers a suite of tools to assist researchers in managing their research data. Our online tools enable simple and secure collaboration, and are aligned with requirements our Data Management Policy and General Data Protection Regulation (GDPR).

1. Support for Research Data Management and Storage

The University has a workflow to support for research data management of funded research, and a package of Microsoft programs, both desktop and web-based, for collaborative document editing and data management. OneDrive is used for data storage, which has a desktop syncing application.

2. Research Software

The UoA is equipped with a set of free and specialised commercial software packages (e.g., Matlab Mathworks, Microsoft Visual Studio, Deep Learning Frameworks), necessary for model developments and data analysis in research. The unit benefits from access to a Research Programming Platform which is a browser-based service providing access to Python, R and Julia through Jupyter Notebooks, Jupyter Lab, for general purpose code development.

3. Research Data Resources

Due to the long-standing relationships with several NHS Trusts and hospitals, IntSaV has access to the clinical data, in accordance with the ethical regulations. Complementary to information access, the group holds strong relationship with leading clinicians and medical scientists – important for guiding research directions and providing ‘ground truth’ interpretations for AI developments. IntSaV also has participated in the development of, and therefore has access to the UK’s largest biobank of echo expertise (<http://unityimaging.net>), under the aegis of the British Society of Echocardiography.

3.2.2 Research facilities and equipment

In addition to a significant investment programme on campus that has created social and open learning spaces; advanced simulation spaces for research; a library without boundaries; and a large flexible performance auditorium, the University has built a Sports Centre and a postgraduate building for doctoral students. It has also built a number of laboratories and specialist facilities.

This UoA enjoys fully equipped computer labs and studios available to support ongoing research with assistance of two full-time computing officers. We also have a dedicated Cybersecurity lab to support research in the CCC. Researchers including permanent academics, postdoctoral researchers, and research students have access to these resources. The CCC is also equipped with Titax RTX GPU servers for high performance computations. These considerable in-house computing and communication systems are enhanced by the extensive network infrastructure

provided by the University IT Service. The SCIUX lab has several servers, cameras, and software licences for usability testing in HCI research. It also benefits from an eye tracking specialised room to conduct research on human cognition and perception.

IntSaV's laboratory equipment and infrastructure includes several ultrasound imaging machines (General Electric, Philips, Ultrasonix) for data collection, deep learning servers equipped with NVIDIA GPUs for model training and developments, RAID servers for data management, 3D motion tracking systems (Polhemus), medical imaging test equipment (Blue Tissue Mimicking Phantoms, and GAMMEX Precision Resolution Phantoms), and 3D printers.

The facilities and infrastructure strategies are based on a mix of institutional investment, philanthropic donations, and capital investment through bid income (where applicable). Our next research strategy has factored in the acquisition of HPC facilities and state-of-the-art GPU-equipped servers, reflecting our view of emergence of an AI Research Centre from the IntSaV research group, and expansion objectives for Cybersecurity and HCI research themes.

4. Collaboration and contribution to the research base, economy and society

4.1 Nature and scope of research collaborations

Much of the UoA's success in research has been realised via collaborative research. We collaborate with other disciplines and divisions of UWL (e.g., Biomedical Sciences, Hospitality and Tourism, Law and Criminology, Nursing, Midwifery and Healthcare). Externally, we engage and collaborate with academia, industry and government, both at national and international levels.

The research grants we participate in are multi-institutional and involve industrial/clinical collaborations. We are partners on these grants with other HEIs (e.g., Imperial College and UCL). Strong industry links ensure that our research remains at the forefront of the computing fields, allowing us to contribute meaningfully to national and international challenges in cybersecurity and HCI areas, where we are partners with many companies (e.g., Amazon, Imediavan Ltd, AB5 Consulting Ltd, Heathrow Airport). A considerable body of the work being carried out in this unit has also focused on healthcare applications and clinical research, where we have strong ties with researchers in many NHS sites (e.g., St Mary's Hospital, ULCH, Kings College, London) and industry (e.g., KYMIRA Ltd). Examples of research collaborations which were initiated - or matured - during the REF2021 period, and have been identified as promising and potentially impactful projects by the Impact Group (see section 1), are provided below.

Collaborations with other HEIs

We collaborate with >15 **UK academic institutions**, including KCL, UCL, Imperial College, University of Lincoln, University of Swansea, Brunel University, University of Salford, Ulster University, University of Leicester, Queen Mary University of London, University of Birmingham, London Metropolitan University, University of Derby, University of Huddersfield, and University of Manchester. Examples of collaborative work include Zolgharni's joint efforts with the Laboratory of Vision Engineering at Lincoln to develop AI-driven solutions for oesophageal cancer detection from endoscopic images/videos, and the work with the School of Medicine at Imperial on myocardial deformation imaging from echocardiograms. In the area of Internet of Things, Asif has been working closely with City, University of London, to develop prediction and control models for energy management in sensor networks. In HCI, and in collaboration with Brunel University, Kani-Zabihi has been conducting a large experimental study to establish the impact of the fundamental dimensions of scent intensity and valence on user experience in multimedia environments.

The academics in this UoA have also developed close working relationships with a number of **Non-UK academic institutions**, including Aalto University in Finland, University of Oulu, Copenhagen Business School, IIT Bombay in India, IT University of Copenhagen, KU Leuven in Belgium, Instituto Superior Tecnico Lisbon, University of Madeira, ITI / Larsys in Portugal, Dalian Maritime University in China, Columbia University in the USA, University of Verona and University

of Florence in Italy. For instance, in collaboration with KU Leuven, Zolgharni is developing innovative ultrasound strain imaging applications. A joint research proposal is being drafted. Another example is the collaboration between Sauer and Aalto University, Finland, which focused on the use of AI in selection of cyanide-free hydrometallurgical gold ore processing. More recently, Zolgharni has been working with the Heart and Vessels Department within the University of Florence to develop machine learning algorithms for automated clinical measurements. Abdelnour-Nocera has been working closely with Cape Peninsula University of Technology and University of Fort Hare, supporting them in service design and student retention. Loo has been working closely with a number of universities in cutting edge technology; for instance, i) Beijing University of Post and Telecommunications (BUPT) funded by Ministry of Education China in AI and Machine learning in telecommunication technology (5G and beyond), and deep learning technology for natural language processing and image processing, ii) University of Engineering and Technology (UET Taxila) in wireless communication and antenna design, and iii) University Tunku Abdul Rahman (UTAR) in advance wireless resource management with AI.

Collaborations with Industry

Collaboration with the local and global industries involves joint formulation of challenging and relevant research agendas of our research strategy, they include:

- A partnership with the Heathrow Airport that aims to address improved decision making in the deployment of automation in terminal airside operations (Abdelnour-Nocera).
- In collaboration with Secure Technologies Ltd and Imediavan Ltd, research has been carried out to exploit Cyber monitoring and defence for IoT which was developed under the Innovate UK and DCMS funding (Loo).
- Partnership to develop a novel framework for online marketplaces to facilitate safe, secure and dynamic multi-party interactions, in collaboration with MyPocketSkill which funded a PhD student (Loo).
- Joint venture in IntSaV developing deep learning models for monitoring and detecting atrial fibrillation using wearable ECG recordings, in collaboration with KYMIRA Ltd. Mobile apps are being developed to deploy the developed models for clinical pilot studies (Zolgharni).

The UoA also meets quarterly with SCE **Industrial Consultative Board**, comprised of several major companies, including SEGA, Amazon, Oracle, Fujitsu, Huawei, Heathrow Airport, PE.fiberoptics Ltd, Ratcliffe Groves Partnership, EMEA at Birst, Acumin Consulting Ltd, Digital Service, Enterprise Services PLC, Masagi Ltd, SAS UK, Ketchup, and Lombard Street Research. The Board provides opportunities for both academics and industry practitioners to discuss and receive feedback about current industry best practice, current changes and needs, and inform the unit's research agenda.

Collaborations with Hospitals/NHS

The IntSaV's research profile, in many respects, is aligned with the government research agenda on global societal impact and healthcare aspects. Most of the research carried out is focussed on issues that have direct practical implications on quality of life. For instance, involvement in healthcare relates to the advancement and exploitation of medical imaging from understanding clinical needs to assisting in medical diagnosis. IntSaV has established strong research relationship with several clinical partners, such as St Mary's Hospital, Hammersmith Hospital, and West Hertfordshire Hospitals NHS Trust. A recent example of collaborative research with the clinical partners is the development of "Echognition" (<http://unityimaging.net>), a user-friendly image annotation platform for collecting and building a large biobank of cardiac expertise, working closely with cardiologist and physiologists from many NHS sites across the UK, including Glasgow, Birmingham, Manchester, Sheffield, Oxford, Cambridge, Luton, Watford, Ealing and London (Imperial, Kings College, London, UCLH, Bart's Heart Centre, St Thomas's Hospital).

4.2 Academic leadership and wider contributions to the research base

We publicise our research strengths regionally, nationally, and internationally to ensure that the valuable work of individual academics is recognised by the local community, and on the world stage. The research academics within the Computing subject and the associated fields have produced 386 peer-reviewed journal and international conference papers since 2014. The majority of these publications are journal papers. Our staff also provide academic leadership nationally and internationally, influencing research agendas and strategy.

Editorships and membership of editorial boards

Academics in this unit hold editorial roles on the major journals:

- **Editor-in-Chief.** *International Journal of Sociotechnology and Knowledge Development*. 2014-2019 (Abdelnour-Nocera)
- **Editorial Board Member.** *International Journal of Biomedical Science and Engineering*. 2019-present (Zolgharni)
- **Associate Editor.** *Wiley International Journal of Communication Systems*. 2011-present (Loo)
- **Editor.** *KSII Transactions on Internet and Information Systems*. 2017-present (Tang)
- **Editor.** *International Journal of Computer Science & Information Technology Applications*. 2011-2017 (Tang)

Convenors of conferences; Programme Chairs

Our academics serve as Program or General Chair for many national and international Conferences and Workshops.

- 15th EAI International Conference on Collaborative Computing: Networking, Applications and Worksharing, 2019, London, UK, Publicity Chair, Zolgharni
- 30th International Joint Conference on Artificial Intelligence (IJCAI-21), 2021, Montreal, Canada, Zolgharni, Program Committee member
- 7th International Conference on Vehicle Technology and Intelligent Transport Systems, 2021, Prague, Czechia, Loo, Technical Programme Committee
- 29th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications, 2018, Bologna, Italy, Loo, Technical Programme Committee
- 4th Symposium on Engineering Energy Efficient InternetWorked Smart seNsor (E3WSN-2018), in conjunction with the 32nd IEEE International Conference on Advanced Information Networking and Applications (IEEE AINA 2018), 2018, Pedagogical University of Cracow, Poland, Loo, Workshop Chair/Organiser
- Human Work Interaction Design: Analysis and Interaction Design Methods for Pervasive and Smart Workplaces. The International Federation for Information Processing (IFIP) 13.6 Working Conference in Human Work Interaction Design, 2015, London (UWL), Abdelnour-Nocera, Chair
- Culture, Technology, Communication. Common World, Different Futures. 10th IFIP WG 13.8 International Conference, CaTaC 2016, London, UK (UWL), Abdelnour-Nocera, Chair.
- *Symposium on Digital Inclusion in the Global South*. British Academy, 2018, London (UWL), Abdelnour-Nocera, Chair.
- Participatory Design Conference 2020, Manizales, Colombia, Abdelnour-Nocera, Full Papers Chair (Spanish).
- IFIP Interact Conference, 2019, Paphos, Cyprus, Abdelnour-Nocera, Workshops Chair
- IFIP Interact Conference 2019, Mumbai, India, Abdelnour-Nocera, Field Trips Chair.

- Workshop on Cognitive Computing and Analytics (WCCA 2019), collocated to COLLABORATECOM 2019 – 15th EAI International Conference on Collaborative Computing: Networking, Applications and Worksharing, London, 2019, Zhang, Workshop Chair/Organiser
- 27th European Conference on Information System, Stockholm University, Stockholm, Sweden. 8-14th June 2019, Zhang, Associate Chair, HCI Track of ECIS2019
- 11th International Workshop on Security in e-Science and e-Research (ISSR 2019), in conjunction with the 12th International Conference on Security, Privacy and Anonymity in Computation, Communication and Storage (SpaCCS 2019) Jie, Workshop chair
- 14th International Symposium on Pervasive Systems, Algorithms, and Networks (I-SPAN 2017), 2017, Exeter, UK, Jie, Workshop Chair
- 8th International Workshop on Security in e-Science and e-Research (ISSR 2016), Zhangjiajie, China, 2016, Jie, General Chair
- 9th International Workshop on Security in e-Science and e-Research (ISSR 2017), Guangzhou, China, 2017, Jie, General Chair
- 10th International Workshop on Security in e-Science and e-Research (ISSR 2018), Melbourne, Australia, 2018, Jie, General Chair
- 11th International Workshop on Security in e-Science and e-Research (ISSR 2019), Atlanta, USA, 2019, Jie, General Chair
- IEEE Workshop on Internet Privacy Information Protection, Tsinghua University, Beijing, 2020, Tang, Chair
- IEEE Workshop on Cloud Data Security Auditing (ICCCS2018), Haikou, China, 2018, Tang, Chair

Leadership of advisory boards, industry, commerce, research councils, learned societies or professional bodies

- **Representative** appointed by the British Computer Society (BCS) to represent the UK in the Technical Committee 13 in Human-Computer Interaction in International Federation for Information Processing (IFIP), under the auspice of UNESCO. September 2017-present, Abdelnour-Nocera
- **Advisor** to the UK government through the BCS on the development of the Internet Safety Strategy green paper. January 2018-present, Abdelnour Nocera
- **Advisor** to South African universities (University of Cape Town, Cape Peninsula University of Technology, and University of Fort Hare) in designing digital services for student retention in higher education in Cape Town and Eastern Cape. September 2016 – April 2019, Abdelnour Nocera
- **Steering Committee Member** of AITECHTalents, a global forum exploring the future of artificial intelligence and its impact on the future of work, global corporations and society as a whole. 2019-present. Zolgharni
- **Lead** for Team UK, 45th WorldSkills International Competition on Cloud Computing, Kazan, Russia, 2019, Jie
- **Scientific Advisory Board** of Ministry of Education of China, 2012-2017, Tang

Invited/keynotes speakers

Our academics gave about >15 keynotes or invited speeches in recent years. Main keynotes are:

- Abdelnour-Nocera, BCS Software Quality Management Conference, 2016
(<http://sqminspire2016.weebly.com/keynote-speakers.html>)

- Zolgharni, Mechanical Engineering Department, Fresno State Directory, USA Novel Automated Methods for Cardiac Imaging, 2018
- Zolgharni, IBM (Querétaro, Mexico), Data Science and Machine Learning in Healthcare, virtual event, 2020
- Loo, BCS West London, Blockchain for the real world, “Blockchain for Businesses”, November 2017
- Loo, London Tech Week, Cyber and Blockchain in One Breath, “The 51% attack on Blockchain”, Westmont Enterprise Hub, June 2018
- Loo, 2nd China-ASEAN Computer Technology Development and Cooperation Forum, China Computer Federation (CCF), “Proactive Edge Caching in Content-Centric Networks with Dynamic User Requests”, December 2020.

Reviewer for research funding bids

Academics in this unit review research proposal for research councils and other funding bodies including:

- Reviewer for EPSRC, Zolgharni, since 2020
- Reviewer for British Council (Newton Fund & Researcher Links), Zolgharni, since 2018
- Reviewer for NIHR, Abdelnour-Nocera, since 2020
- Reviewer for EPSRC, Abdelnour-Nocera, since 2019
- Reviewer for Academy of Finland’s Centre of Excellence Programme, Loo, since 2020
- Reviewer for EPSRC, Loo, since 2012
- Reviewer for National Natural Science Foundation of China, Tang, since 2015

Peer-review for journals

Currently, we provide peer-review services to >35 journals, including:

- *Physiological Measurement*, IOP, Zolgharni
- *Physics in Medicine and Biology*, IOP, Zolgharni
- *Measurement Science and Technology*, IOP, Zolgharni
- *Biomedical Physics & Engineering Express*, IOP, Zolgharni
- *International Journal of Imaging Systems and Technology*, WILEY, Zolgharni
- *International Journal of Cardiovascular Imaging*, Springer, Zolgharni
- *Medical and Biological Engineering & Computing*, Springer, Zolgharni
- *Microfluidics and Nanofluidics*, Springer, Zolgharni
- *International Journal of High Performance Computing*, SAGE, Zolgharni
- *Sensors*, MDPI, Zolgharni
- *Micromachines*, MDPI, Zolgharni
- *Journal of Medical Imaging and Health Informatics*, ASP, Zolgharni
- *PLOS ONE*, Zolgharni
- *Transactions on Medical Imaging*, IEEE, Zolgharni
- *Transactions on Instrumentation and Measurement*, IEEE, Zolgharni
- *Journal of Medical Imaging and Health Informatics*, ASPBS, Zolgharni
- *Transactions on Wireless Communication*, IEEE, Loo
- *Transactions on Communications*, IEEE, Loo
- *Transactions on Vehicular Technology*, IEEE, Loo
- *Internet of Things*, IEEE, Loo
- *Transactions on Computational Social Systems*, IEEE, Loo
- *Transactions on Network and Service Management*, IEEE, Loo
- *Transactions Industrial Informatics*, IEEE, Loo

- *International Journal of HCI*, Taylor & Francis Online, Abdelnour-Nocera
- *Information Systems Journal*, WILEY, Abdelnour-Nocera
- *Information Technology and People*, Emerald, Abdelnour-Nocera
- *Co-Design*, Taylor & Francis Online, Abdelnour-Nocera
- *Journal of Computer Mediated Communication*, WILEY, Abdelnour-Nocera
- *Interacting with Computers*, Oxford University Press, Abdelnour-Nocera
- *Journal of Design Research*, Inderscience, Abdelnour-Nocera
- *Human Technology*, Open Science Center (University of Jyväskylä), Abdelnour-Nocera
- *Transactions on Dependable and Secure Computing*, IEEE, Tang
- *Transactions on Information Forensics and Security*, IEEE, Tang
- *Transactions on Multimedia*, IEEE, Tang
- *Transactions on Industrial Informatics*, IEEE, Tang
- *Transactions on Computers*, IEEE, Tang
- *Transactions on Networking*, IEEE/ACM, Tang

Visiting professorships and fellowships

We also engage with the wider community through our visiting research positions which include:

- **Visiting Associate Professor**, IT University of Copenhagen, Denmark, 2016-2017, Abdelnour-Nocera
- **Honorary Research Fellow**, School of Medicine, Imperial College London, 2015-present, Zolgharni
- **Foreign Expert**, Ministry of Education China Foreign Expert Programme (equivalent to Royal Society International Fellowship), Beijing University of Posts and Telecommunications, 2017-present, Loo.