Submission No 26

INQUIRY INTO THE DEFENCE INDUSTRY IN NEW SOUTH WALES

Name: Charles Sturt University

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1. Recommendations

Charles Sturt University provides a range of recommendations relating to the policy outcomes and program objectives contained in the *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017* that details the Government's defence industry strategy for the State as part of the New South Wales Parliament's Standing Committee on State Development as part of the Committee's inquiry into the defence industry in the New South Wales:

1.1 Maximise opportunities for NSW-based companies from Defence's growing exports and investment in defence capability – in both acquisition and sustainment

Charles Sturt University recommends that the New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017 defence industry strategy be implemented in its current form and that the Government consider further increasing its financial investment in the sector to ensure that its industry policy outcomes are achieved.

1.2 Encourage defence industry innovation, research and education including developing the future workforce

Charles Sturt University recommends that the defence industry innovation, research, education and future workforce elements of the New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017 be strengthened by direct Government investment, including:

i. a defence industries technical skills development fund of up to $25m per annum;

ii. a professional development fund of up to $10m per annum; and,

iii. implementation of a "development-intensive" research fund of at least $25m per annum modelled on the highly successful Small Business Innovation Research Program (SBIRP) in the United States.

1.3 Identify targets, programs and projects for defence spending in New South Wales

Charles Sturt University recommends establishment of a Ministerial Council for Defence Industry Development that would comprise members drawn from Defence, industry, scientific and community sectors.

1.4 Maximise the economic benefits of locating defence force bases and defence industry in the regions

Charles Sturt University recommends strengthening the regional development element of the New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017 by establishing a committee of the Ministerial Council for Defence Industry Development that we propose above, that would focus exclusively on maximising the regional economic benefit attained from colocation of Defence bases and defence industries in the

State's regional centres, with membership of this committee comprising members drawn from regionally-based Defence, industry, scientific and community sectors.

1.5 How to establish and sustain defence supportive communities

Charles Sturt University recommends that the Government establish a $5m per annum community development fund to support **establishing and sustaining defensive supportive communities*.***

1.6 Further enhance collaboration between the NSW Government and Commonwealth agencies

Charles Sturt University makes no recommendations with regards enhancing collaboration between the New South Wales Government and Commonwealth agencies.

1.7 Any other related matters

Charles Sturt University makes no further recommendations regarding the policy outcomes to be achieved and the program objectives to be implemented as part of the New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017.

2. Introduction

The Legislative Council of the New South Wales Parliament's Standing Committee on State Development has commenced an inquiry into the defence industry in the State. The Committee will report to Parliament by June 2018 and has called for submissions from the public due by 18 June 2017.

The Committee is inquiring into and reporting on the opportunities to incentivise and grow the defence industry in New South Wales to generate economic development. The inquiry is focusing on the *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017* (Appendix I).

2.1 Defence Industry in New South Wales

New South Wales has received a significant proportion of national Defence funding, with Defence-related operations in New South Wales generating in excess of $5.4 billion annually.

The NSW Government recognises the significant contributions made by Defence and defence-related industries to the State in terms of attracting investment, economic growth and job creation. Significant Defence acquisition decisions are being made now and over the next decade and New South Wales industry is well placed to respond to capability and capacity requirements, either within New South Wales or in partnership with other States and Territories. A strategic and coordinated approach to developing New South Wales industry has potential to substantially increase direct Defence expenditure in the State with significant flow-on benefits.

For every $1 billion non-capital recurrent Defence operational spending that comes into New South Wales, the estimated economic impact is approximately $1.4 billion in Gross State Product (GSP) and 10,000 jobs supported.

2.2 Standing Committee on State Development Inquiry – New South Wales Defence Industry

The Legislative Council of the New South Wales Parliament's Standing Committee on State Development has commenced an inquiry into the defence industry in the State. The Committee will report to Parliament by June 2018 and has called for submissions from the public due by 18 June 2017.

The Committee is inquiring into and reporting on the opportunities to incentivise and grow the defence industry in New South Wales to generate economic development. The inquiry is focusing on the *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017* (Appendix I). In particular, the Committee is investigating:

- Maximise opportunities for NSW-based companies from Defence's growing exports and investment in defence capability – in both acquisition and sustainment.

- Encourage defence industry innovation, research and education including developing the future workforce.

- Identify targets, programs and projects for defence spending in New South Wales.
- Maximise the economic benefits of locating defence force basis and defence industry in the regions.
- How to establish and sustain defence supportive communities.
- Further enhance collaboration between the New South Wales Government and Commonwealth agencies.
- Any other related matter.

2.3 *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017*

The objectives of *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017* are to

- support Defence in its objectives;
- assist Defence in the delivery of its ambitious acquisition targets; and,
- maximise the economic opportunities for NSW businesses and communities.

To achieve these objectives, *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017* comprises five statewide strategies supported by a number of targeted state and regional initiatives. The strategy recognises the importance of Defence to regional economies and communities by putting forward a hub and spoke delivery approach. This involves central coordination of state priority initiatives delivered through dedicated resources and specialised expertise in each region.

New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017 sets out strategies for developing and growing the defence industries in the State:

- foster stronger relationships with Defence and across the New South Wales defence industry at a state and regional level;
- leverage New South Wales's strengths in critical capability areas to grow existing work and create new Defence and defence industry activity;
- provide Defence and defence industry with their future workforce;
- sustain and grow existing and new Defence and defence industry activity across regional New South Wales; and,
- increase opportunities for innovation, commercialisation and research within Defence and the defence industry

3. Charles Sturt University

Charles Sturt University is Australia's largest regional university, with more than 39,000 students and approximately 2,100 FTE staff. Established in 1989, the University traces its origins to the formation of the Bathurst Experimental Farm and Wagga Wagga Experimental Farm in the 1890s. In one form or another, research, innovation and education has been integral to the University's character and mission for more than a century.

Charles Sturt University is a unique multi-campus institution with campuses at Albury-Wodonga, Bathurst, Canberra, Dubbo, Goulburn, Manly, Orange, Parramatta, Port Macquarie and Wagga Wagga, as well as various study centres located throughout regional and rural south-eastern Australia.

The University's commitment to the development and sustainability of rural and regional Australia is informed by the unique research focus undertaken, and the partnerships it has formed with each of its campus' local communities, local industry, and with the broader regions it serves.

CSU offers a comprehensive suite of research and academic training programs that focus on addressing rural and regional labour market needs, growing regional economies, and preparing students for the jobs of the new economy through rural and regional Australia.

Particularly in health and medical related disciplines, Charles Sturt University seeks to address key training and equality of access issues across our rural and regional footprint, ensuring the critical supply of health professionals into local markets.

As one of Australia's largest online and distance education providers Charles Sturt University has been able to leverage its course profile and specialist expertise in education provision for the delivery of nationally available study programs. These programs support labour market skills development regardless of student location.

Our rural and regional focuses, as well as strength in online and distance education, position's Charles Sturt University as a leading institution in providing higher education opportunities to first-in-family applicants, mature-aged students, as well as those from disadvantaged backgrounds.

Increasing participation of Indigenous Australians in higher education has been a key focus area of the University's mission and ethos. Charles Sturt University consistently works in collaboration with Indigenous communities across our footprint to ensure access and develop links into the University. Our position as one of the top Australian universities for Indigenous participation is proof of our strong background in this regard.

The success of the University is demonstrated by its sector-leading performance in work-integrated learning, graduate employment and graduate incomes. Underpinning this success is the close links that the University has forged with industry, both regionally and nationally.

For example, the University is internationally recognised as a leader in work-integrated learning with students spending extended periods in employment with our industry partners as part of their degree learning and applying their knowledge in practice.

Research excellence, with a strong commitment to addressing the complex regional needs through innovation, has long been at the centre of Charles Sturt University's mission.

As evidenced by the recent Excellence in Research for Australia results (ERA 2015), Charles Sturt University is recognised internationally for competitive research strengths in agricultural science, horticultural production, food and wine sciences, crop and pasture production, veterinary science, animal production, education, curriculum and pedagogy, environmental science, applied ethics, philosophy, religious studies, criminology, nursing and marketing.

Charles Sturt University has a proud tradition of delivering high-quality research that creates new knowledge, benefits people's lives, enhances the profitability of regional industries and helps communities grow and flourish. Through its Higher Degree by Research programs, Charles Sturt University is training the next generation of researchers and professionals who use critical thinking and seek to influence the world for the better.

The recently announced AgriSciences Research and Business Park, to be located on the Wagga Wagga campus exemplifies our industry focus. The AgriSciences Research and Business Park will facilitate industry engagement and collaboration, economic growth, wealth creation, employment and skills development. Success will be evidenced by the recognition of Wagga Wagga as a world-standard centre for agricultural innovation, research and development, extension, education and training.

Today, Charles Sturt University continues a 100-year tradition of engagement and leadership with our local communities, of research and innovation in collaboration with industry, expansion in the educational opportunities offered to our diverse student body, and preparing students for employment markets emerging with the evolution of regional and the national economy.

4. Submission to Inquiry

Charles Sturt University is pleased to provide a submission to the Standing Committee on State Development as part of the Committee's inquiry into the defence industry in New South Wales. We have prepared a comprehensive and detailed submission containing commentary of our view and position of the Government's *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017*.

Building on our commentary, view and position, Charles Sturt University also proposes a range of recommendations, that we believe would strengthen the *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017*. Adopting our recommendations would further catalyse the development and growth on the defence industry in New South Wales by:

- fostering stronger relationships with Defence and across the New South Wales defence industry at a state and regional level;
- leveraging New South Wales's strengths in critical capability areas to grow existing work and create new Defence and defence industry activity;
- providing Defence and defence industry with their future workforce;
- sustaining and growing existing and new Defence and defence industry activity across regional New South Wales; and,
- increasing opportunities for innovation, commercialisation and research within Defence and the defence industry

Charles Sturt University's submission has been prepared based on the Committee's Terms of Reference for its inquiry into the defence industry in New South Wales which was obtained from the Parliamentary website at https://www.parliament.nsw.gov.au/committees/inquiries/Pages/inquiry-details.aspx?pk=2440#tab-termsofreference.

4.1 Maximise opportunities for NSW-based companies from Defence's growing exports and investment in defence capability – in both acquisition and sustainment

(a) Position of Charles Sturt University

As a university institution with a long and proud history in defence teaching, learning and research, as well as supporting regional development in regions of New South Wales that are defence industry-intensive, we commend the Government's interest and focus on the defence sector.

Charles Sturt University supports the policy outcomes sort by the New South Wales Government through implementation of the strategies detailed in *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017.* We believe that the strategies in the Government's defence industry policy will aid in

maximising the opportunities for New South Wales-based companies from defence exports and Defence's investment in defence capability.

(b) **Charles Sturt University's Recommendations**

Charles Sturt University recommends that the New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017 defence industry strategy be implemented in its current form and that the Government consider further increasing its financial investment in the sector to ensure that its industry policy outcomes are achieved.

4.2 Encourage defence industry innovation, research and education including developing the future workforce

(a) **Position of Charles Sturt University**

Charles Sturt University supports the policy outcomes sort by the New South Wales Government through implementation of the strategies detailed in *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017.* We believe that the strategies in the Government's defence industry policy will aid in encouraging defence industry innovation, research and education including developing the future workforce.

However, the Government will need to invest heavily in defence industry innovation, research and education to ensure development of an internationally competitive future defence industries workforce in New South Wales.

Charles Sturt University is one of Australia's leading defence and security teaching, learning and research universities, which together with our regional footprint and colocation with several defence facilities, for example in Wagga Wagga, positions us uniquely to play a pivotal role in enabling the Government's attainment of the policy outcomes and program objectives in this sphere. A comprehensive overview of our teaching, learning and research capability is provided in Appendix II and III for reference.

Charles Sturt University believes that effecting defence industry innovation, research and education to ensure development of an internationally competitive future defence industries workforce will require direct investment by the State Government in a number of areas, by way of specific programs, such as:

i. a defence industries technical skills development fund of up to $25m per annum, which would provide full and part scholarships to defence force personnel and future students looking to develop careers in the defence industries to off-set HELP debt;

ii. a similar, but smaller professional development fund of up to $10m per annum, which would provide for skills transition training which would enable employees of existing defence industries to upgrade their skills and ensure international competitiveness of the State's defence industry workforce; and,

iii. implementation of a "development-intensive" research fund of at least $25m per annum aimed unashamedly at developing solutions to defence challenges, with the fund design mirroring that of the highly successful Small Business Innovation Research Program (SBIRP) in the United States, see https://www.sbir.gov/about/about-sbir. This fund would align defence needs with the joint capability of a research institution and a private company, with the fund providing resources to undertake projects like those detailed at Appendix III. The Committee should note that the SBIRP in the US has played a significant role in the development of the economically successful US military-industrial complex.

(b) **Charles Sturt University's Recommendations**

Charles Sturt University recommends that the defence industry innovation, research, education and future workforce elements of the New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017 be strengthened by direct Government investment, including:

iv. a defence industries technical skills development fund of up to $25m per annum;

v. a professional development fund of up to $10m per annum; and,

vi. implementation of a "development-intensive" research fund of at least $25m per annum modelled on the highly successful Small Business Innovation Research Program (SBIRP) in the United States.

4.3 Identify targets, programs and projects for defence spending in New South Wales

(a) **Position of Charles Sturt University**

Charles Sturt University believes that the policy intent of the *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017* would provide an effective framework for identifying targets, programs and projects for defence spending in New South Wales.

We believe that, with targeted investment, the strategies in the Government's defence industry policy will aid in maximising the

opportunities developing Defence's footprint in New South Wales and concomitantly the development of the State's export-focused defence industries.

Through a combination of Charles Sturt University's regional campus footprint and the expertise of our School of Computing and Mathematics, we are in a unique position to offer the Government expertise to assist with determining investment targets, programs and projects for defence spending in New South Wales. This element of the Government's defence industries strategy would need to build on existing Defence base and industry locations. With regards the capability Charles Sturt University could bring to this elements of the Government's strategy, please refer to Appendices II and III.

We would encourage the Government to establish a Ministerial Council to oversee investment targets, programs and projects for defence spending in New South Wales. The Council's remit would be to maximise the economic benefits from colocation of such facilities and capabilities. The Council would comprise Defence, industry, scientific and community leaders.

(b) **Charles Sturt University's Recommendations**

Charles Sturt University recommends establishment of a Ministerial Council for Defence Industry Development that would comprise members drawn from Defence, industry, scientific and community sectors.

4.4 Maximise the economic benefits of locating defence force bases and defence industry in the regions

(a) **Position of Charles Sturt University**

Charles Sturt University supports the regional economic development policy outcomes and program objectives sort through locating defence force bases and defence industries in the regions element of the *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017.* We believe that the strategies in the Government's defence industry policy will aid in maximising the opportunities for regionally-based companies from defence exports and Defence's own investment in defence capability.

Through a combination of Charles Sturt University's regional campus footprint and the expertise of our School of Computing and Mathematics, we are in a unique position to offer the Government expertise to assist with determining investments that would be made in regional locations with regards collocating defence force bases and defence industries in regional centres. We do believe that this element of the Government's defence industries strategy should build on existing Defence base and industry locations, for example the Wagga Wagga area and the Central West.

With regards the capability Charles Sturt University could bring to this elements of the Government's strategy, please refer to Appendices II and III.

We would encourage the Government to establish a committee of the Ministerial Council for Defence Industry Development that we propose above, that would focus exclusively on maximising the regional economic benefit attained from colocation of Defence bases and defence industries in the State's regional centres, with membership of this committee comprising members drawn from regionally-based Defence, industry, scientific and community sectors. The committee would oversee defence force base and defence industry location in the regions. The committee's remit would be to maximise the economic benefits from colocation of such facilities and capabilities in regional centres. The committee would comprise regional representatives from the Defence, industry, scientific and community sectors.

(b) **Charles Sturt University's Recommendations**

Charles Sturt University recommends strengthening the regional development element of the New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017 by establishing a committee of the Ministerial Council for Defence Industry Development that we propose above, that would focus exclusively on maximising the regional economic benefit attained from colocation of Defence bases and defence industries in the State's regional centres, with membership of this committee comprising members drawn from regionally-based Defence, industry, scientific and community sectors.

4.5 How to establish and sustain defence supportive communities

(a) **Position of Charles Sturt University**

Charles Sturt University supports the policy outcomes sort by the New South Wales Government through implementation of the strategies detailed in *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017.* We believe that the strategies in the Government's defence industry policy will help to establish and sustain defence supportive communities.

Charles Sturt University has a long and proud tradition of supporting communities across its footprint. The University works collaborately with our communities to optimise their economic and social strengths to further drive regional development outcomes.

Charles Sturt University's network across New South Wales allows for the Government to tap into a unique ecosystem that would assist in boosting engagement with communities to boost awareness about the opportunities that are on offer from the defence industry.

We believe the Government should invest in a defence community development fund which would have the purpose of establishing and sustaining defensive supportive communities. This fund, of say $5m per annum would be allocated to community organisations, including regional teaching, learning and research institutions on a merit based selection processes.

(b) **Charles Sturt University's Recommendations**

***Charles Sturt University recommends that the Government establish a $5m per annum community development fund to support* establishing and sustaining defensive supportive communities.**

4.6 Further enhance collaboration between the NSW Government and Commonwealth agencies

(a) **Position of Charles Sturt University**

Charles Sturt University supports the Government's policy outcomes and program objectives with regards further enhancing collaboration between the New South Wales Government and Commonwealth agencies as set out in the *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017*.

(b) **Charles Sturt University's Recommendations**

Charles Sturt University makes no recommendations with regards enhancing collaboration between the New South Wales Government and Commonwealth agencies.

4.7 Any other related matters

(a) **Position of Charles Sturt University**

Charles Sturt University makes no further commentary regarding the policy outcomes and program to be implemented as part of the *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017*.

(b) **Charles Sturt University's Recommendations**

Charles Sturt University makes no further recommendations regarding the policy outcomes to be achieved and the program objectives to be implemented as part of the *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017.*

5. Conclusion

Charles Sturt University welcomes the Government's focus on the defence industries in New South Wales, as set out in *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017.* Including the Government's policy outcomes and program objectives to:

- fostering stronger relationships with Defence and across the New South Wales defence industry at a state and regional level;
- leveraging New South Wales's strengths in critical capability areas to grow existing work and create new Defence and defence industry activity;
- providing Defence and defence industry with their future workforce;
- sustaining and growing existing and new Defence and defence industry activity across regional New South Wales; and,
- increasing opportunities for innovation, commercialisation and research within Defence and the defence industry

We have prepared a comprehensive and detailed submission for the New South Wales Parliament's Standing Committee on State Development's inquiry into the defence industry in the State. Building on our commentary, view and position, Charles Sturt University we proposes a range of recommendations, that we believe would strengthen the *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017*. Our recommendations include:

- *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017* defence industry strategy be implemented in its current form and that the Government consider further increasing its financial investment in the sector to ensure that its industry policy outcomes are achieved.
- The defence industry innovation, research, education and future workforce elements of the *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017* be strengthened by direct Government investment, including:
    i. a defence industries technical skills development fund of up to $25m per annum;
    ii. a professional development fund of up to $10m per annum; and,
    iii. implementation of a "development-intensive" research fund of at least $25m per annum modelled on the highly successful Small Business Innovation Research Program (SBIRP) in the United States.
    - Establishment of a Ministerial Council for Defence Industry Development that would comprise members drawn from Defence, industry, scientific and community sectors.
    - Strengthening the regional development element of the *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017* by establishing a committee of the Ministerial Council for Defence Industry

Development that we propose above, that would focus exclusively on maximising the regional economic benefit attained from colocation of Defence bases and defence industries in the State's regional centres, with membership of this committee comprising members drawn from regionally-based Defence, industry, scientific and community sectors.

- The Government establish a $5m per annum community development fund to support establishing and sustaining defensive supportive communities.

Appendix I – *New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017*

Please refer Attachment 2.

Appendix II – Charles Sturt University – Defence Teaching and Learning Capability

Charles Sturt University is the largest provider of postgraduate IT coursework programs in Australia, in addition to having strong undergraduate enrolments. From a postgraduate perspective, our Master of Information Systems Security, proposed Master of Cyber Security and Master of Cyber Studies and Investigations aim for cohesive and cyber-oriented programs which will be of benefit to the future workforce in Defence.

These programs cover security topics across technical, legal, and procedural areas. Further, our Master of Information Technology has a specialisation in Network Security as well as security subject electives, which are available to all students in the course. Within the Master of Information Systems Security, industry professionals deliver up to 50% of the subjects within the degree. Further, a number of subjects within the course have their content based on world-class industry certifications, such as the Certified Information Systems Security Professional (CISSP).

Charles Sturt University's postgraduate security courses link strongly with market needs through the integration of current, popular security certifications, and by responding to areas that are on the Australian Government's Skilled Occupations List. We have a joint partnership with IT-Masters who supply MOOCs on cybersecurity for interested security professionals. This relationship has enabled the University to become the largest provider of postgraduate IT coursework programs in Australia.

For all IT courses, Charles Sturt University has assembled an industry advisory panel to review and make recommendations to further ensure a strong link between our programs and industry requirements. Our Master of Information Systems Security offers strong integration between academic and workplace components, via industry certification linkages and the use of industry professionals as lecturers and tutors. Moreover, the Doctor of Information Technology program uses industry professionals as adjunct supervisors. Also, we hold an annual cybersecurity symposium (CSS), in which participants are drawn from other universities and industry professionals.

Charles Sturt University's cybersecurity courses and subjects can be specifically designed to formulate tailored and customised cybersecurity short courses to cater the unique needs of Defence trainees and personnel. Our cybersecurity courses attract students from law enforcement agencies such as AFP, NSW Police and Victoria Police. Through interaction with students from these employers we understand that our subject content delivers training to very relevant hands-on cybersecurity and digital forensics cases which are helpful to our forces.

If Defence personnel hold Australian Qualification Framework (AQF) qualifications achieved at the level they are seeking admission to, Charles Sturt University provides options for transfer of their previous credit towards our qualifications. Reciprocally, our qualifications are accredited through the AQF and recognised throughout Australia and worldwide.

Appendix III – Charles Sturt University – Defence Research Capability

The School of Computing and Mathematics at Charles Sturt University has the capacity to provide research into defence applications of computer vision, image processing, data analytics, machine learning, sensor network, and simulation and modelling. Research in the area of Artificial Intelligence and Image Processing at CSU received a rating of world class in the ERA 2015 evaluation. The School also has strong expertise in cybersecurity and digital forensics, which find their applications in network security, intrusion detection, malware identification and detection, content integrity verification and authentication, inference of media provenance, information assurance, trust management, steganography (covert communications) and steganalysis (for detecting covert communications). We can also offer our strengths in cybersecurity both in consultancy to sustain and grow the defence industry across regional New South Wales as well as to tailor a short term cybersecurity training program exclusively for defence personnel.

Research Leadership

In addition to a wide spectrum research expertise of the School's research team, we also have strong defence-relevant research leadership provided by Professor Chang-Tsun Li, with over 22 years military experience in Taiwanese army and US navy, and Professor Terry Bossomaier, with four decades of research experience in the UK and Australia.

Professor Chang-Tsun Li

Professor Chang-Tsun Li was trained at ROC Military Academy, Taiwan with a specialty in artillery and an Associate Degree in Electrical Engineering. He then served as Fire Control Officer and later as Executive Officer of an artillery battery. After two years' service in the field unit Chang-Tsun Li enrolled on the BEng Course in Electrical Engineering in the Chung Cheng Institute of Technology (CCIT) at ROC National Defence University (NDU). During the BEng course, he took three 2-month-long summer placements in the Weapon System Department at a Taiwanese naval base, National Chung-Shan Institute of Science and Technology of the Taiwanese Ministry of National Defence, and Industrial Technology Research Institute of the Taiwanese Ministry of Economic Affairs.

He then served as Commanding Officer of a cadet company at CCIT. He attended the Weapon System Engineering Curriculum at U.S. Naval Postgraduate School, USA and graduated with a MSc in Computer Science in1992, and the PhD degree in computer science from the University of Warwick, UK, in 1998. He was an associate professor of the Department of Electrical Engineering at NDU during 1998-2002 and a visiting professor of the Department of Computer Science at U.S. Naval Postgraduate School in the second half of 2001. He was a professor of the Department of Computer Science at the University of Warwick, UK, until he joined Charles Sturt University in January 2017.

His research interests include multimedia forensics and security, biometrics, data mining, machine learning, data analytics, computer vision, image processing, pattern recognition, bioinformatics, and content-based image retrieval. The outcomes of his research have been translated into award-winning commercial products protected by a series of international patents and have been used by many police forces and courts of law around the world, including INTERPOL, Metropolitan Police Services (UK), Sussex Police Services (UK) and Guilford Crown Court (UK). He was the Lead and Principle Investigator of the Integration of Information Warfare Technologies project (July 2000 – December 2001), which involved NDU and six other Taiwanese universities funded by the MND.

He was the Coordinator and PI of the EU international project entitled Digital Image and Video Forensics from 2010 to 2014. As part of this EU project he spent two years on secondment at the participating companies Forensic Pathways Ltd in the UK and XLAB in Slovenia. He is currently the Coordinator and PI of the EU Horizon 2020 project, entitled Computer Vision Enabled Multimedia Forensics and People Identification (acronym: IDENTITY). The IDENTITY project has a consortium consisting of 16 institutions from 12 countries (January 2016 to December 2019). Professor Li has secured over AUD 10 million of scientific and industrial research grants in collaboration with partners, of which AUD 3.4 million is his share.

He has published 5 edited books and over 160 refereed papers. He also involved in the organisation of many international conferences and workshops, and is actively contributing keynote speeches and talks at various international events.

Professor Terry Bossomaier

Professor Terry Bossomaier is a leading expert in complex systems, graduated from the University of Cambridge with a BA in the Natural Science Tripos and continued with a PhD at the University of East Anglia in the UK. He then went on to work for five years as an image physicist in the photographic industry, studying the perception of images and the measurement of image quality. He then returned to academic life at the Australian National University in Canberra Australia to apply his knowledge of image physics to visual neuroscience, information characteristics of colour vision and aspects of perception such as size constancy.

His interest in sensory information processing continues with a new book published by Cambridge University Press in 2012. At the ANU he began an ongoing interest in simulation to model neural systems, leading to an abiding involvement in parallel and high performance computing, leading in turn to study the nature and applications of complex systems, He, with colleague David Green, ran the inaugural Australian Complex Systems conference, in 1992, a series which continues to the present day, and led to the first graduate level text in complex systems, published by Cambridge University Press in 2000. He organised the first Australasian conference in complex systems in1992.

After moving to Charles Sturt University in 1996, he set up CRiCS, the Centre for Research in Complex Systems and started the biennial complex systems research summer school in 1998. He was a founder CI in COSNET, the ARC Network in Complex and Open Systems. He was Technical Chair of the Asia-Pacific World Wide Web conference in 1996 and CSU onsite coordinator for the UN Bathurst Declaration and convener of the subsequent conference on spatial metadata and online GIS, leading to a book for Taylor and Francis, and a subsequent expanded 2nd edition in 2015. An ongoing underpinning of much of his research has been information theory, culminating in a Springer book on information flow in complex systems in 2016.

He has delivered keynote addresses in Japan, South Africa and Hong Kong and invited research summer school presentations in Italy, run by the universities of Genoa and Milan.

Other notable members of the research team

Other notable members of the research team at Charles Sturt University include Dr. Li-Minn Ang, Prof. Terry Bossomaier, Dr MD Rafiqul Islam, A/Prof. MD Zahidul Islam, Prof. Chang-Tsun Li, Dr. Xufeng Lin, A/Prof. Manoranjan Paul and A/Prof Tanveer Zia.

Research areas and projects that could contribute to the Government's roll-out of New South Wales: Strong, Smart and Connected Defence and Industry Strategy 2017

The School will contribute its expertise and leadership to the following two broad areas of defence applications:

- Enhancing Situation Awareness through Computer Vision and Data Analytics, and,
- Cybersecurity and Digital Forensics.

These projects are supported by a range of hardware facilities, including GPU cluster computers for deep learning and simulation; hyperspectral and high speed robotic video cameras; sandbox systems for studying malware; a Wi-Fi sensor lab; a mining lab with ground penetrating radar and wheeled robots; EEG and eye-tracking equipment.

I. Enhancing Situation Awareness through Computer Vision and Data Analytics

Project 1. Fusion of information from heterogeneous sensors and sources

This area of research is intended to enable military commanders to gain accurate and real-time situation awareness as well as to predict the likely intentions of the engaging forces. Sensor based reconnaissance information [1], news, social media and complex non-military information [2] are crucial factors in the military intelligence operations. By collaboratively identifying the key issues affecting data and information fusion problems with the stakeholders and end users, we can develop automated information and data fusion technologies to facilitate effective military intelligence analysis and operations.

Project 2. Multimodal biometrics for people (re-)identification and verification at a distance

This project will involve the fusion of multiple physiological and behavioural traits, such as facial features [3], gait [4], iris, etc. to facilitate identification and verification in uncontrolled imaging environments without the subjects cooperating with the vision system. By fusing "soft biometrics" (e.g. colour of clothes or hair, scars, and particular objects carried by the subjects, etc) with the afore-mentioned biometric traits, this project can be extended to cover people re-identification for surveillance by tracking individuals in question across different CCTVs [5]. The re-identification technique can enable post-event situation reconstruction and real-time surveillance.

Project 3. Automatic abnormal events and activities detection

This project is intended to equip the armed forces and military institutions with early warning systems to automatically monitor the vicinity of military facilities or locations by detecting abnormal events and activities [6, 7]. This project involves context identification and abnormality definition in collaboration with end users, characterisation of abnormalities, scene analysis and abnormality detection, feature extraction and representation, scene interpretation, and machine learning.

Project 4. Multicamera networks and multimodal sensing for enhanced situation awareness in cluttered environments

This area of research is intended to recognise patterns and develop a world model of newly encountered spaces in military environments. The project develops approaches for recognition and classification of activity, understanding and perception of complicated dynamic scenes in cluttered environments by incorporating multi-modal and situational contextual information. Some of our previous works in multicamera networks and multimodal sensing can be found in [8 - 10].

Project 5. Custom computing machine (CCM) visual acceleration for mobile situation awareness and rapid decision-making

This research is intended to develop a portable imaging device to be carried by the dismounted soldier for real-time situation awareness capabilities by exploiting mobile high performance computing (HPC) FPGA technology. The project involves the development of CCMs for recognition and classification of activity in non-cluttered environments, robust object detection using contextual and semantic cues, determining visual saliency in large scale imagery. Some of our previous works in FPGA CCMs can be found in [11, 12].

Project 6. Data pre-processing and cleansing for making sense and future prediction

Armed forces use various sensors to collect valuable data which can often have missing or corrupt values due to different reasons such as flat batteries and adverse weather. This missing or corrupt data can have a fatal impact on some critical situations. This area of research intends to develop and apply algorithms for automatic corrupt data detection and missing value estimation [13 -17]. The clean data will be useful for better knowledge discovery, making sense of the data and future prediction. We will also develop domain specific algorithms optimised for military conditions to maximise the knowledge discovery from such clean data. In addition to sensor data, these algorithms can also be applied on images and videos collected through cameras in order to improve the quality of images and videos. Thus, accuracy of various image/video processing, segmentation and compression can also be improved.

Project 7. 3D video interaction and compression

Video compression, coding and communication are crucial to interactive video, surveillance, object tracking, and abnormal event detection in military applications together with general applications in recent years. 3D video communication enhances the accuracy and provides more realistic applications. This project involves big video data compression, transmission, and extraction of important information through innovative machine learning and computer vision technologies. We are capable to encode and decode data based on the requirement of the compression, quality, computational time and secured communication. We have conducted preliminary study on *Multiview Video Coding using Cuboid Data Compression*. We have developed a number of strategies to overcome existing interactive 3D video call with better image quality and compression.

Project 8. Imaging beyond human visual territory

Hyperspectral camera systems enable greatly enhanced spectral resolution of image data, with hundreds of channels, compared to the three channels, red, green and blue of mainstream camera systems. They extend also into the infrared and ultraviolet. This imaging technique is applicable to the area of the detection of chemical weapons, identification of different materials, measurement of surface gas emissions, mapping hydrological formations, tracking pollution levels, and more. We are able to extract different features [26] from hyperspectral image for different applications.

Project 9. Video summarising

In our daily life we capture video for various purposes such as security, entertainment, monitoring, investigating and so on. It requires huge memory space to store as well as enormous time to retrieve or replay important information manually from this high volume of videos. In this project, we are able to extract important information based on the user's requirement in a concise form.

Project 10. 3D scene generation

For generating a 3D scene, we need to create a number of virtual views from the available views using depth image based rendering (DIBR) techniques. We are capable to create virtual view from an angle which is not originally available. Virtual battle environment is an important visible platform for military simulation. This project directly contributes to the 3D military models.

Project 11. Cardiopulmonary measurement using the smartphone

The aim of the project is to develop a non-contact cardiopulmonary detection method in natural disaster rescue relief, based on the use of frequencies and antennas that are similar to current smartphone-like devices. This approach could be used as an alternative to the commercially designed, devices currently used for heartbeat and respiration detection during rescue relief with the aim of reducing device transit time and cost. This project further evaluates a new type of multi-directional antenna that could be used to detect the human physiology pulsatile from 360 degree view. The application of the project is suitable for the military battle field in rescue relief.

Project 12. Augmented reality in medical surgeries

Augmented reality provides the 3-D view by combining the virtual images to the real-time environment. Soldiers are set to get a Google Glass-like augmented reality system designed for the battlefield. This allows commanders to send maps and other information directly to the soldier's field of vison. The gadget attaches to a military helmet, and can even be integrated with weapons control system. We have developed a number of systems especially for the medical applications in surgeries.

Project 13. Virtual reality in building construction

Most companies apply virtual reality in a specific area for building a virtual object as a first look of the whole project. The specific area in this research is about construction. The performance of a 3D model as a prototype needs to be built correctly to minimise defects and problems of on-site construction. The project aims to evaluate and enhance the accuracy and processing time of image processing methods through the solution of Laser Scanning and its limitation of all aspect of 3D object scanning and rendering. This is particularly useful for training soldiers for combat situations or other dangerous settings where they have to learn how to react in an appropriate manner.

II. Cybersecurity and Digital Forensics

Project 1. Detection and Prevention of spoofing attacks on biometric systems

This project is intended to automatically detect and prevent the spoofing attacks on biometric systems. Biometric information, such as human face, fingerprints, iris, hand prints, and other measures of biological traits, has enormous potential and capability in military access control and ordnance equipment management. The Australian Department of Defense has stepped up the pace in deploying biometric system for military purposes. However, the advance in digital photography and computer graphics allows unauthorised people to easily deceive the biometric system by, for example, recapturing the face image of the authorised person or generating a computer generated image (CGI) of the fingerprint unconsciously left by the authorised person. By collaboratively applying digital forensics, signal processing, computer vision and machine learning techniques, we can develop an automated spoofing detection and prevention system to enhance the reliability of biometric systems.

Project 2. Detecting covert communications through steganalysis

There is evidence that data hiding / steganography is often used by terrorists for covertly communicating plots (e.g. the 2012 arrest of the Austrian terrorist in Berlin revealed the use of steganography in covert communications). This line of research into steganalysis aims at detecting covert communications. The approaches include the characterisation of steganography techniques [30 - 33], analysis of abnormal features in multimedia content based on the understanding of the steganography characteristics through signal processing, statistical inference and machine learning.

Project 3. Content integrity verification and authentication for information assurance

Depending on the application requirements to be identified in collaboration with stakeholders and end users, this project may involve the use of cryptographic techniques for authentication purposes [34] or use digital watermarking [35 - 37] and device fingerprint for integrity verification and authentication [38, 39]. Digital watermarking embeds secret message (extrinsic data) in the content to facilitate verification. Device fingerprints, such as sensor pattern noise (SPN), are intrinsic data deposited by the source devices in the content, hence can be extracted for forgery detection by matching the extracted device fingerprint from the media in question to the reference fingerprint of the device that is claimed to be the source. Device fingerprint can also be used for source device verification [38], source device identification [40], common source inference [41], and source oriented clustering [42].

Project 4: Pattern discovery for cyber-attacks and malicious activities

Although there are numerous types of cyber-attacks each with a different signature from others, malicious cyber activities may share some common patterns. This research area aims to collect previous data on regular and malicious cyber activities. It will then develop domain specific data mining algorithms and apply them to discover generic patterns [43 - 45] for cyber-attacks and malicious activities which are independent of a specific attack signature. These patterns will be used for automatic detection of future cyber-attacks and malicious activities which are otherwise very difficult to detect due to changing signatures.

Project 5: Knowledge discovery from sensitive military data

Armed forces collect huge amount of sensitive data. If they could collaborate with researchers including university academics and share these data then the chance of extracting useful knowledge from these data would be even higher. The discovered knowledge could be used for various purposes including counter terrorism and strategic actions. However, due to privacy and national security concerns it can often be difficult to share these data outside the defense force. This project aims to develop techniques for sharing sensitive data for effective knowledge discovery without releasing any sensitive information [46]. Sometimes data can be protected by the addition of noise and a differential privacy model while allowing researchers to discover generic patterns from it [45, 47 - 49].

Project 6. Automatic Detection and Removal of Online Video Malvertising

Recently cyber attackers are focusing on the usage of non-executable files such as video to initiate advanced and multistage attacks. Research conducted by PandalLab shows that video/multimedia is the most popular “bait” used to lure unsuspecting users into malware-laden traps. Its contribution is more than 25% of the enticements leading to malware infected sites. The research also reveals that the hackers use video which has sensational subject matter or hot topics or personal favourite things. The hacker uses it as video requires minimum investment and attracts a large number of victims. Therefore, a good security solution capable of identifying, blocking and removing them is extremely helpful for users who, in most cases, cannot distinguish between ‘good’ and malicious’ online video malicious advertisement (video malvertising). We are working on different aspects to prevent cyberattack through online video malvertising [16, 27, 28] and will conduct further research to create deployable systems for defence applications.

References

1. T.R.J. Bossomaier. *Introduction to the Senses*. Cambridge University Press, 2012
2. T.R.J. Bossomaier and D.G. Green, editors. *Complex Systems*. Cambridge University Press, 2000
3. X. Wei, C.-T. Li, Z. Lei, D. Yi and S. Z. Li, "Dynamic Image-to-Class Warping for Occluded Face Recognition," *IEEE Transactions on Information Forensics and Security*, vol. 9, no. 12, pp. 2035-2050, Dec 2014.
4. Y. Guan, C.-T. Li and F. Roli, "On Reducing the Effect of Covariate Factors in Gait Recognition: a Classifier Ensemble Method," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 37, no. 7, pp 1521 - 1528, Jul 2015.
5. Y. Guan, X. Wei, C.-T. Li, G. L. Marcialis, F. Roli and M. Tistarelli, "Combining Gait and Face for Tackling the Elapsed Time Challenges" in *Proc. the 6th International Conference on Biometrics: Theory, Applications and Systems* (*BTAS'13*), Washington DC, USA, 29 Sep - 2 Oct 2013.
6. R. Leyva, V. Sanchez and C.-T. Li, "Anomaly Detection with Compact Feature Sets for Online Performance," *IEEE Transactions on Image Processing* (Accepted and to appear in 2017).
7. F. Ahzar and C.-T. Li, "Hierarchical Relaxed Partitioning System for Activity Recognition," *IEEE Transactions on Cybernetics*, vol. 47, no. 3, pp. 784 - 795, Mar 2017.
    a. Cat, L.M. Ang, K.P. Seng, G. Qiu, “Multi-scale discriminant saliency with wavelet-based hidden markov tree modelling”, *Computers & Electrical Engineering*, vol. 40, no. 4, 2014.
8. K.P. Seng, L.M. Ang, C.S. Ooi “A combined rule-based and machine learning audio-visual emotion recognition approach”, *IEEE Transactions on Affective Computing*, 2016.

9. L.M. Ang, K.P. Seng (Eds.), *Visual Information Processing in Wireless Sensor Networks: Technology, Trends and Applications*, IGI Global, 2011.
10. L.M. Ang, K.P. Seng, L.W. Chew, L.S. Yeong, W.C. Chia, *Wireless Multimedia Sensor Networks on Reconfigurable Hardware: Information Reduction Techniques*, Springer, 2013.
11. C.W.H. Ngau, L.M. Ang, K.P. Seng, "Low memory visual saliency architecture for data reduction in wireless sensor networks", *IET Wireless Sensor Systems*, vol. 2, no. 2, pp. 115-127, 2012.
12. M. G. Rahman and M. Z. Islam: Missing Value Imputation using a Fuzzy Clustering Based EM Approach, *Knowledge and Information Systems*, Vol. 46, Issue 2, pp. 389-422, Springer, 2015.
13. M. G. Rahman and M. Z. Islam: FIMUS: A Framework for Imputing Missing Values Using Co-appearance, Correlation and Similarity Analysis, *Knowledge-Based Systems*, vol. 56, pp. 311-327, Jan 2014.
14. M. G. Rahman and M. Z. Islam: Missing Value Imputation Using Decision Trees and Decision Forests by Splitting and Merging Records: Two Novel Techniques, *Knowledge-Based Systems*, vol. 53, pp. 51 - 65, 2013.
15. M. Paul, W., Lin, C.T. Lau, and B. –S. Lee, "Direct Inter-Mode Selection for H.264 Video Coding using Phase Correlation," *IEEE Transactions on Image Processing*, vol. 20, no. 2, pp. 461-471, 2011.
16. M. Paul and M. Murshed, "Video coding focusing on moving regions and occlusion," *IEEE Transaction on Image Processing*, vol. 19, no. 3, pp. 691-701, 2010.
17. M. Paul, W. Lin, C.T. Lau, and B.-S. Lee, "A Long Term Reference Frame for Hierarchical B-Picture based Video Coding," *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 24, no. 10, pp. 1729–1742, 2014.
18. K.K. Halder, M. Paul, M. Tahtali, S. G. Anavati, and M. Murshed, "Correction of geometrically distorted underwater images using shift map analysis," *Journal of the Optical Society of America. A, Optics and Image Science and Vision*, vol. 34, no. 4, pp. 666-673, 2017.
19. S. Chakraborty, M. Paul, M. Murshed, and M. Ali, "Adaptive weighted non-parametric background model for efficient video coding," *Neurocomputing*, vol. 226, pp. 35-45, 2017.
20. P. Podder, M. Paul, DM M. Rahaman, and M. Murshed, "Improved Depth Coding for HEVC Focusing on Depth Edge Approximation," *Signal Processing: Image Communication*, vol. 55, pp. 80-92, 2017.
21. P. Podder, M. Paul, and M. Murshed, "Fast Mode Decision in HEVC by Exploiting Dominated Motion and Saliency Features," *PLoS ONE*, 2016.
22. P. Podder, M. Paul, and M. Murshed, "A Novel Motion Classification Based Intermode Selection Strategy for HEVC Performance Improvement," *Neurocomputing*, vol. 173, pp. 1211-1220, 2016.
23. M. Paul, "Efficient Multi-view Video Coding using 3D Motion Estimation and Virtual Frame," *Neurocomputing*, vol. 175, pp. 544-554, 2016.
24. M. Ali, M. Murshed, S. Shahriyar, and M. Paul, Lossless image coding using hierarchical decomposition and recursive partitioning," *APSIPA Transactions on Signal and Information Processing*, 2016.
25. M. Paul, R. Xiao, J. Gao, and T. Bossomaier, "Reflectance prediction modelling for residual-based hyperspectral image coding," *PLoS ONE*, 2016.
26. MD. Salehin and M. Paul, "Video Summarization using Line Segments, Angles and Conic Parts," *PLoS One*, 2017.
27. DM M. Rahaman and M. Paul, "Virtual View Synthesize for Free Viewpoint Video and Multiview Video Compression using Gaussian Mixture Modelling," *IEEE Transactions on Image Processing*, 2017.

28. P. Linh, "An exploration of non-contact cardiopulmonary measurement using the smartphone in rescue relief events," in *Proc. of International Conference on Advances of Electrical, Electronic and Systems Engineering (ICAEESE 2016)*, 14-16 Nov 2016.
29. C.-T. Li and Y. Li, "Progressive Exponential Clustering-Based Steganography," *EURASIP Journal of Advances in Signal Processing*. Vol. 2010, Article ID 212517, 14 pages, doi:10.1155/2010/212517
30. H. Si and C.-T. Li, "Maintaining Information Security in E-Government through Steganology," in Encyclopedia of Digital Government, ed. by A.-V. Anttiroiko and M. Mälkiä, Vol. III, pp. 1180 - 1184, Idea Group Publishing, 2006
31. Y. Wang, W. Chen, Y. Li, W. Wang and C.-T. Li, "HPS: Histogram Preserving Steganography in Spatial Domain," in *Proc. 2nd International Workshop on Biometrics and Forensics*, Valletta, Malta, 27-28 March 2014
32. Y. Li and C.-T. Li, "Steganographic Scheme for VQ Compressed Images Using Progressive Exponential Clustering," in Proc. IEEE International Conference on Advanced Video and Signal based Surveillance, Sydney, Australia, 22 - 24 November, 2006
33. D. C. Lou, J. L. Liu, and C.-T Li, "Digital Signature-Based Image Authentication," in Multimedia Security: Steganography and Digital Watermarking Techniques for Protection of Intellectual Property, ed. by C. S. Lu, pp. 207-230, Idea Group Publishing, 2004
34. Y. Yang, X. Sun, H. Yang, C.-T. Li and R. Xiao, "A Contrast-Sensitive Reversible Visible Image Watermarking Technique," *IEEE Transactions on Circuits and Systems for Video Technology,* vol. 19, no. 5, pp. 656 - 667, May 2009
35. F. Peng, R.-S. Guo, C.-T. Li and M. Long, "A Semi-Fragile Watermarking Algorithm for authenticating 2D Engineering Graphics Based on Log-Polar Transformation," *Computer-Aided Design*, vol. 42, no. 12, pp. 1207-1216, December 2010
36. C.-T. Li, "Digital Fragile Watermarking Scheme for Authentication of JPEG Images," *IEE Proceedings - Vision, Image, and Signal Processing*, vol. 151, no. 6, pp. 460 - 466, 2004
37. C.-T. Li and Y. Li, "Color-Decoupled Photo Response Non-Uniformity for Digital Image Forensics," *IEEE Transactions on Circuits and Systems for Video Technology,* vol. 22, no. 2, pp. 260-271, Feb 2012
38. X. Lin and C.-T. Li, "Refining PRNU-Based Detection of Image Forgeries," in *Proc. The 1st IEEE Digital Media & Academic Forum*, Santorini, Greece, 4 -6 July, 2016
39. C.-T Li, "Source Camera Identification Using Enhanced Sensor Pattern Noise," *IEEE Transactions on Information Forensics and Security*, vol. 5, no. 2, pp. 280 – 287, June 2010
40. X. Lin and C.-T. Li, "Preprocessing Reference Sensor Pattern Noise via Spectrum Equalization," *IEEE Transactions on Information Forensics and Security*, vol. 11, no. 1, pp. 126-140, Jan 2016
41. X. Lin and C.-T. Li, "Large-Scale Image Clustering based on Camera Fingerprint," *IEEE Transactions on Information Forensics and Security*, vol. 12, no. 4, pp. 793 – 808, April 2017
42. Siers, M., and Islam, M. Z. (2015): Software Defect Prediction Using a Cost Sensitive Decision Forest and Voting, and a Potential Solution to the Class Imbalance Problem, Information Systems, Vol. 51, pg. 62-71
43. Adnan, M. N. and Islam, M. Z. (2016): Optimizing the Number of Trees in a Decision Forest to Discover a Subforest with High Ensemble Accuracy using a Genetic Algorithm, Knowledge-Based Systems, Vol. 110, pp. 86-97, ISSN 0219-1377, Springer London. doi: http://dx.doi.org/10.1016/j.knosys.2016.07.016
44. Fletcher, S. and Islam, M. Z. (2017): Differentially Private Random Decision Forests using Smooth Sensitivity, Expert Systems with Applications (ESWA), Vol. 78, pg. 16-31, DOI: http://dx.doi.org/10.1016/j.eswa.2017.01.034.

45. Burmeister, O., Islam, M. Z., Dayhew, M., Crichton, M. (2014): Interagency Communication of Private Mental Health Data, In Proc. of the 25th Australasian Conference on Information Systems (ACIS 2014), Auckland, New Zealand, 8-10 December, 2014
46. Islam, M. Z., and Brankovic, L.(2011): Privacy Preserving Data Mining: A Noise Addition Framework Using a Novel Clustering Technique, Knowledge-Based Systems Vol. 24, Issue 8, ISBN 0950-7051,(December 2011) pg. 1214-1223, (DOI: 10.1016/j.knosys.2011.05.011)
47. Fletcher, S. and Islam, M. Z. (2015): A Differentially-Private Random Decision Forest using Reliable Signal-to-Noise Ratios, In Proc. of the 28th Australasian Joint Conference on Artificial Intelligence (AI 2015), Canberra, Australia, 30 November - 4 December, 2015, Lecture Notes in Computer Science (LNCS), pp. 192-203, Vol. 9457, ISBN 978-3-319-26350-2, DOI: 10.1007/978-3-319-26350-2_17
48. Fletcher, S. and Islam, M. Z. (2015): A Differentially Private Decision Forest, In Proc. of the 13th Australasian Data Mining Conference (AusDM 15), Sydney, Australia, 8- 9 August, 2015. CRPIT Vol. 168, pp. 99- 108, ISBN 978-1-921770-18-0.