

Institution: Middlesex University London		
Unit of Assessment: 11		
Title of case study: Intelligence-led Policing using VALCRI Visual Analytics Technology		
Period when the underpinning research was undertaken: 2008 - 2018		
Name(s):	Role(s)(e.g. job title):	Period(s) employed by submitting HEI:
B.L. William Wong	Professor of Human-Computer Interaction	2003 - present
Neesha Kodagoda	Senior Researcher	2010-2018
Chris Rooney	Senior Researcher	2010-2018
Patrick Seidler	Researcher	2016-2018
Stefan Lozovanu	Researcher	2016-2018
Period when the claimed impact occurred: 2019 - present		
Is this case study continued from a case study submitted in 2014? Y/N - No		

1. Summary of the impact.

Prof. B.L.W. Wong led the 17-organisation, €16.6 mil, EU-funded VALCRI project, Visual Analytics for Sense-making in Criminal Intelligence Analysis, from 2014-18. The output was a visual analysis system using tactile reasoning which enhances criminal and intelligence investigations.

Direct impacts claimed are:

- Economic – through commercialisation. The VALCRI IP was acquired by Canadian global security systems company, Genetec Inc, with paying customers from Sep 2019
- Improved performance, practices and policies for police investigations and subsequent societal benefits. VALCRI has already raised skills and technology awareness across a number of police and intelligence communities
- Informed public debate - through active dissemination on best practice in intelligence-led policing.

2. Underpinning research

The VALCRI project, Visual Analytics for sense-making in Criminal Intelligence Analysis, (FP7-IP-608142, see valcri.org), is a €16.6 mil EU FP7 Integrating Project, that was driven by Wong's research into the representation design of information and the interaction design of user interfaces to support human decision making in complex dynamic environments. He uses concepts and techniques from human-computer interaction, human factors, and cognitive engineering to understand and model the nature of expertise and cognitive work in these domains, and then develops appropriate technologies to support such work. In VALCRI, he continues research into the problems associated with making sense of big data using visual analytics, a recently established field that focuses on creating human-information discourse by coupling interactive visualisations with automated data analysis.

In prior research, Wong led other visual analytics research projects including the UKVAC (UK Visual Analytics Consortium) jointly funded by the US DHS and UK Home Office (2010-13; PNNL Contract No. 116077, DHS funded through NVAC at PNNL; Agreement No. 4112-46065, Sub-Agreement under the US DHS Cooperative Agreement No. 2009-ST-061-CI0001; Agreement with Home Office, dated 21 March 2012); and the EPSRC MakingSense project (2010-13; EP/H023135/1). In VALCRI, he combined this work with earlier research in which he invented the interaction design INVISQUE (2009; JISC RI Ref. No. IEDEV19), the interactive visual search and query environment, that makes information grasp-able, enabling 'tactile reasoning', an epistemic action that facilitates sense-making and decision making. These ideas and principles drove the design of

VALCRI.

Wong led the VALCRI consortium that comprised 9 universities and research organisations, 5 SMEs, and 3 Law Enforcement Agencies (LEAs) from across Europe. The Consortium's 103 scientists and engineers, brought together a diverse set of expertise including ethics, privacy and law, human bias, sense-making and insight, argumentation and logic, knowledge management, ontology engineering, complex events processing, video analysis, data mining and semantic extraction, algorithm design, software security and access control, training design and development, and user interface design, to research and develop technology alongside an international team of police end-users. In this section we describe the research that underpinned the IP developed and owned by Middlesex University which was acquired by Genetec Inc.

Police intelligence analysts only ever have fragmented data from which to investigate cases and pre-empt terrorist attacks. They also operate in data-overload situations where they trawl through large volumes of forensic, operational, structured and unstructured data in multiple databases to discover the required data from which to construct the chains of evidence needed to investigate or prosecute cases. Police therefore need a combination of tools to discover relevant data across vast data sets e.g. other police reports that might be related to a case, while trying to make sense of fragmentary pieces of data.

We developed a model of sense-making for police intelligence analysis which we used to guide the design of the VALCRI system. The model was based on a number of different cognitive task analysis studies with intelligence analysts, some pre-dating the VALCRI project e.g. [Ref1] and a series of studies on 'how analysts think' conducted during the project e.g. [Ref2]. We discovered that analysts regularly use their expertise and intuition to make abductive inferences to create early, tentative explanations. Analysts also use inductive and deductive inference-making strategies, depending on what data is available, what rules are applied, and what goals are desired. Intuition plays an important role to create leaps of faith that produce insight and new lines of inquiry, laddering to elaborate, find or make associations. Critically, they also test the hypotheses.

Police face significant difficulties in discovering relevant data, partly due to the lack of adequate tools to discover relevant data in the large volumes of data in their systems. Criminals rarely provide enough data for police to prosecute them. When analysts discover relevant data, they assemble it into evidential chains and create narratives to explain what they concluded. These chains also need to be compliant with the laws of argument and logic so that such arguments can withstand interrogation, especially in a court of law. VALCRI technology aims to enable and support this model [Ref3].

The uniqueness and appeal of the VALCRI technology lies in the radically different user-interface based on the concept of tactile reasoning [Ref4]. Information is presented in 'tiles' which can be touched and moved around freely, as in the game of Scrabble. Initial ideas were researched as part of the INVISQUE project to develop a more tangible, epistemic action-based method for interacting with electronic library resources.

Each tile contains data or analysis functions such as a statistical process control chart to analyse crime patterns. These tiles can be assembled into arguments or explanatory sequences to re-construct crime events. Our studies suggest that user creativity and analytic reasoning performance can double when a user can rapidly re-arrange the tile sequences. We also found that users were better at maintaining provenance, or tracing their analytic reasoning pathways with the tactile reasoning approach.

Underlying the tile interaction are machine learning [Ref5] and database, e.g. ElasticSearch, algorithms that perform semi-automated semantic searches of both structured and unstructured text fields to discover similar reports in other databases and possibly associated information such as gang networks, using Formal Concept Analysis [Ref6].

We applied principles of representation design by mapping the analytic reasoning process on to key elements of the user interface. The VALCRI technology was designed

around the concept of fluidity and rigour, where the interaction and transition between steps in a task is fluid, while ensuring that analytic processes retain the necessary analytic rigour.

The key outcome from this aspect of the VALCRI research has been a visual analytics technology where users can interact fluidly while ensuring analytic rigour, where hypotheses can be formulated and tested quickly, enabling investigators to discard or modify their hypotheses within minutes and hours, rather than days and weeks.

3. References to the research

- [Ref1] Rooney, C., Attfield, S., Wong, B. L. W., & Choudhury, S. T. (2014). INVISQUE as a tool for intelligence analysis: the construction of explanatory narratives. *International Journal of Human Computer Interaction*, 30(9), 703-717.
- [Ref2] Wong, B. L. W., & Kodagoda, N. (2015). How analysts think: Inference making strategies. In *Proceedings of the Human Factors and Ergonomics Society 59th Annual Meeting, 26-30 October 2015, Los Angeles, USA* (pp. 269-273): SAGE Publications.
- [Ref3] Wong, B. L. W., Seidler, P., Kodagoda, N., & Rooney, C. (2018). Supporting variability in criminal intelligence analysis: From expert intuition to critical and rigorous analysis. In G. Leventakis & M. R. Haberfeld (Eds.), *Societal Implications of Community-Oriented Policing Technology* (pp. 1-11). Cham, Switzerland: Springer Open, Springer International Publishing AG.
- [Ref4] Takken, S., & Wong, B. L. W. (2015). Tactile reasoning: Hands-on vs. Hands-off - what's the difference? *Cognition, Technology & Work*, 17(3), 381-390. doi:10.1007/s10111-015-0331-5.
- [Ref5] Jentner, W., Sacha, D., Stoffel, F., Ellis, G. P., Zhang, L., & Keim, D. A. (2018). Making machine intelligence less scary for criminal analysts: reflections on designing a visual comparative case analysis tool. *The Visual Computer* 34 (9), 1225-1241
- [Ref6] Qazi, N., Wong, B. L. W., Kodagoda, N., & Adderley, R. (2016). Associative Search through Formal Concept Analysis in Criminal Intelligence Analysis. In *Proceedings of 2016 IEEE International Conference on Systems, Man, and Cybernetics • SMC 2016 October 9-12, 2016, Budapest, Hungary*: IEEE Press.

4. Details of the impact

We claim 3 forms of direct impact from our work:

1) Economic impact from commercialisation

- (a) Twenty-four pieces of VALCRI IP produced by the Middlesex University team were acquired by **Genetec, Inc.**, a Montreal-based, global security systems company, in April 2019 [Source A]. Genetec created a new business unit to market the new Valcri™ product, creating 14 new jobs to commercialise VALCRI. To enable the knowledge transfer, Wong and 4 key researchers from his lab were employed by Genetec in the new Valcri™ Product Group. The VALCRI acquisition catalysed Genetec to invest in a new Genetec UK head office in London in November 2019 to showcase Valcri™ and other Genetec products. Genetec is also combining VALCRI with its other security systems to create new products to open new markets. Genetec Valcri™ secured its first paying customer in September 2019 with expected annual sales thereafter. Potential Market Value: The US alone has 17,985 law enforcement agencies, although pricing information is competitor-sensitive, we estimate potential US market value at USD \$3,579,000,000.
- (b) **i-Intelligence GmbH** is a Zurich-based SME which specializes in teaching intelligence analysis globally. They translated VALCRI research in analytic reasoning and sense-making into curricula for training police analysts. Following trials during the VALCRI project with 214 law enforcement officers from 50 agencies in 16 countries, i-Intelligence completely overhauled their original training programs, and

developed new executive level training that focused on managing complexity, ambiguity and uncertainty; issues central to VALCRI. [Source B]

- (c) **DSTL invests over £150,000 to productise VALCRI research.** During the final year of VALCRI, further work was undertaken to address algorithmic opacity, i.e. the lack of transparency of machine-learning-based black-box algorithms. Our PhD student Sam Hepenstal, who works for DSTL (UK MoD), developed a conversational agent system for investigations based on our Algorithmic Transparency Framework. This enables a user to challenge the results, while also inspecting and verifying the system processes. This work has matured such that Dstl invested over £150,000 in 2020 to create a commercial product from this research prototype. [Source C]

2. Improved performance, practices and policies for police investigations and subsequent societal benefits

VALCRI has already raised skills and technology awareness across a number of police and intelligence communities, including:

- (a) Partner **West Midlands Police (WMP)** have described the following impacts: (i) Through VALCRI's research a wider range of analytic techniques have become central to the analyst training curriculum developed by WMP for the new Intelligence Academy. (ii) VALCRI's research on ethical and privacy issues led the WMP to realize the importance of transparency for public services and the analysis of interconnected big data. New policies resulted for analysis of big data in their new Data Analytics Lab and the setting up of an Ethics Committee at WMP so that issues may be rationally debated while awaiting legislation. (iii) The WMP also re-developed one of VALCRI's modules – the Statistical Process Control (SPC) Map, into a product compatible with their newly procured platforms. [Source D]
- (b) Partner **Lokale Politie Antwerpen (LPA)** through their collaboration in VALCRI gained significant insights on how to design technology to transform traditional reactive-based policing methods to more pro-active Intelligence-Led Policing model. These insights led to an in-house developed software called 'Focus', comprising a suite of near-real-time crime analytics software for their newly formed department based on Intelligence-led policing. The VALCRI-inspired 'Focus' system is in use by all officers in the field and various analysis departments. Analysts can link data, discover associations, and present crime data in context. These are key VALCRI design concepts. [Source E]
- (c) Partner **Belgian Federal Police (BFP)** adapted the associative search and visualization methods developed in VALCRI to build their own software for identifying large, organized crime groups. The software performed auto-discovery of crime organisations by searching for patterns of related activities, objects and flows, and associations of people and places. This has been used in the "Kali Beeldvorming" joint task force to speed up the discovery of information for identifying and taking down of large, organized crime groups and their networks. [Source F]

3. Informing public debate about intelligence-led policing through active dissemination

- (a) VALCRI research sparked significant interests in the media after highlights of our research was published in the 'New Scientist' on 10 May 2017, "AI detective analyses police data to learn how to crack cases" [Source G]. A number of separate articles followed subsequently: Digital Trends, Government Technology, Legal Reader, Deccan Chronicle, ETech.com, and in the *EU Research Magazine*, 24 Jan 2018, "Plotting a path through crime data" [Source H].
- (b) After the close of the project, VALCRI was chosen to be published in the European Commission's "Success Stories" series in November 2018 as "Cyber-detective

assists police with criminal investigations” [Source I].

- (c) In 2020, VALCRI was selected as an example of best practice in UK on ‘ethics by design’. It was presented at the Roundtable on Crime Prevention, Justice and Artificial Intelligence in Latin America, 22 Oct 2020, organized by the United Nations Interregional Crime and Justice Research Institute (UNICRI), the British Embassy in Mexico, and C-Minds. Wong presented to Latin American government and police leaders, on how ethical safeguards were designed in VALCRI, and therefore how they can be incorporated into intelligence-led policing initiatives.

5. Sources to Corroborate the Impact.

Letters of Support

- A. Letter of Support from Genetec, Inc.
- B. Letter of Support from i-Intelligence GmbH
- C. Letter of Support from DSTL
- D. Letter of Support from WMP
- E. Letter of Support from LPA
- F. Letter of Support from BFP

Key References relating to Section 4 Details of the Impact: Informing Public Debate about intelligence-led policing through active dissemination

- G. “AI detective analyses police data to learn how to crack cases”, New Scientist, 10 May 2017, see <https://www.newscientist.com/article/mg23431254-000-ai-detective-analyses-police-data-to-learn-how-to-crack-cases/>
- H. “Plotting a path through crime data”, EU Research Magazine, 24 Jan 2018, see https://issuu.com/eu_research/docs/valcri_eur14_low_res
- I. “Cyber-detective assists police with criminal investigations”, in European Commission’s “Success Stories” Series, 27 November 2018, see https://ec.europa.eu/research/infocentre/article_en.cfm?id=/research/headlines/news/article_18_11_27_en.html?infocentre&item=Infocentre&artid=49801