Institution: University of Gloucestershire

Unit of Assessment: UoA 12 General Engineering

Title of case study: Applied Computing for Improving the Business Performance of SMEs' (ACES): Impact on Business Performance

Period when the underpinning research was undertaken: 2013 - 2021

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Qublai K. Ali Mirza	Senior Lecturer	2016 to present
Kamal Bechkoum	Professor	2016 to present
Hassan Chizari	Associate Professor	2017 to present
Williams Sayers	Senior Lecturer	2017 to present
Martin Wynn	Reader	2001 to present
Shujun Zhang	Professor	2002 to present

Period when the claimed impact occurred: 2015- 2021

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

1. Summary of the impact

More than 10 data analytics algorithms, 9 smart ISs and 6 engineering system performance algorithms have been developed. These algorithms have been applied by 12 SMEs from manufacturing, trading and architectural industries to effectively improve their business performances with business growth, high operative efficiency, and on-time and intelligent business decision, which leads to (1) Uni-electronics Ltd and its 9 partner companies have doubled their turnover from £10million to £20 million pa; (2) McCarthy Taylor Systems Ltd has attracted new 400 users with £91k extra income pa, (3) TMP Ltd has increased turnover from £ 874,152 to £ 2,138,782 pa.

2. Underpinning research

The research is a product of the collaboration between the School of Computing and Engineering at the University of Gloucestershire (SCE-UG) and 12 businesses, in the West Midlands and Southwest regions of the UK. The collaborations have been funded by 2 KTPs (one finished £166k and one starting from 01-12-2019 £217k), 2 industrial application projects (£69k), one Industrial sponsored PhD (£90k) and UG's annual priority research funding (£100k).

The theoretical investigation was carried out to research and develop a number of smart algorithms for achieving (i) explicit understanding of business intelligence and automation (**R1**), (ii) effective methods for point cloud processing for identifying meaningful geometry features for landscape design and planning (**R2**), (iii) nature-inspired techniques for data mining (**R3**), (iv) measurement optimisation of local networks and distributed mobile sensor deployment in wireless sensor networks (**R4**), (v) an intelligent malware-detection system cyber security (**R5**), (vi) mechanics analysis of over-constrain engineering system. The outcomes of these pure researches have been applied to 12 local businesses (**R6**).

The collaboration has been focused on business performance improvement including (1) streamlining supply-chain management, (2) dynamic product pricing, (3) efficient inventory management, (4) purchasing automation, (5) production efficiency, (6) smart data mining for business intelligence, (7) smart CRM, (8) system integration with partners, (9) system analysis and design, (10) engineering system modelling, analysis and optimisation.

As a result of the underpinning research, nine smart e-business systems listed below have been developed, demonstrating significant impact through improved/enhanced business improvement (**C1**, **C2**, **C4**):

IS1 Daily Order Fulfilment System (2014) for processing up to 5-thousand daily orders of complicated data with smart functions for automatically sorting out the customer ordered products.

IS2 Amazon Vendor Processing System (2015) for processing Amazon Vendor Shipment, automatically.

IS3 Amazon Prime Processing System (2018) for processing Prime Shipment, automatically.

IS4 Replacement Processing System (2016) for automatically creating replace orders based on customer's new requirements.

IS5 Smart Web Scraping for Competitors' Sale Data to implement the Dynamic Pricing (2017) for automatically fetch the product models, sale prices and quantities of the competitors from e-marketing places open sources.

IS6 Sales Performance Analysis and Report System (2019) for analysing the fulfilled orders for a period, identifying the products with high sale quantities and good profits.

IS7 A smart inventory management system for e-retailing (2019) for managing and performing inventory operations for optimising operation efficiency and minimising wastes.

IS8 Special offer Sales Shipment Processing System (2020) for automatically creating product labels, packing documents for special offer sales orders.

IS9 An innovative system for Geographical and Landscape Information Processing (2017). A number of algorithms have been developed for processing huge point cloud data (the number of points is up to 2 billion) to abstract meaningful geometrical and textural information for 3D modelling, analysis and evaluation of a building/landscape. These algorithms have been used by McCarthy Taylor Systems Ltd in their latest commercial software: LSS Vista Point Clouds and LSS Elite Point Clouds.

3. References to the research

The research outputs that underpin the impact case study are:

R1 Xuemei Fan, Shujun Zhang, Kevin Hapeshi, Yinsheng Yang, (2014) Biological System Methods and Natural Inspired Algorithms and Their Applications to Supply Chain Management, *Applied Mechanics and Materials,* Vol. 461, pp 942-958. https://doi.org/10.4028/www.scientific.net/AMM.461.942

R2 Xuemei Fan, Williams Sayers, Shujun Zhang, Zhiwu Han, Hassan Chizari, Luquan Ren (2020) Review of Bio-inspired Algorithms and Their Applications, *Journal of Bionics Engineering*, Vol.17, pp 611-631. https://doi.org/10.1007/s42235-020-0049-9

R3 Usman, Mohammed Joda, Ismail, Abdul Samad, Abdul-Salaam, Gaddafi, Chizari, Hassan, Kaiwartya, Omprakash, Gital, Abdulsalam Yau, Abdullahi, Muhammed, Aliyu, Ahmed and Dishing, Salihu Idi (2019) *Energy-efficient Nature-Inspired techniques in Cloud computing data centres.* Telecommunication Systems, Vol. 71 (2). pp. 275-302. https://doi.org/10.1007/s11235-019-00549-9

R4 Chizari, H., Poston, T., Razak, S. A., Abdullah, A. H., and Salleh, S. (2014). Local coverage measurement algorithm in GPS-free wireless sensor networks. *Ad Hoc Networks*, Vol.23, pp.1–17. https://doi.org/10.1016/j.adhoc.2014.05.015

R5 Qublai K. Ali Mirza, Irfan Awan and Muhammad Younas (2018) CloudIntell: An Intelligent Malware Detection System, *Future Generation Computer Systems,* Vol.86, pp. 1042-1053. https://doi.org/10.1016/j.future.2017.07.016

R6 Wynn, Martin G (2018) *University-Industry Technology Transfer in the UK: Emerging Research and Opportunities,* IGI-Global, ISBN-10: 1522574085, ISBN-13: 978-1522574088.

4. Details of the impact

From 2013 the developed methods/algorithms/frameworks, and smart information systems have shown to have tangible and intangible impact for SMEs from manufacturing, trading and architecture sectors.

1) Impact on Uni-electronics and Its 9 Business Partners (C1, C2 and C3)
Uni-electronics Ltd (UNI), a UK E-business started as a small family business in 2003 with annual turnover of approximately £300k growing to £5m in 2008. However, challenges from poor operation efficiency, such as difficulty in rapidly processing daily orders were restricting additional operation efficiency. By 2012, annual turnover was approximately £10m, with a large increase in daily orders whilst experiencing serious issues with processing large amount of data. This created poor inventory management, poor daily order processing, unsatisfactory CRM and unsmoothed supply-chain management. In 2013, SCE-UG and UNI formed a partnership to design and develop various information systems from developed SCE-UG research. The impact of SCE-UG smart information systems had a significant improvement on UNI business growth from £10m to £20m, together with expansion of 10 business partner companies and doubling staff numbers to 70 employees by 2019 **(C1, C3).**

The four significant impact benefits are estimated at £1m pa **(C2, C3)** from operation efficiency, reduced costs and an efficient supply-chain from processing upto 5000 daily orders include:

(1) £410k/pa since 2015 from the application of an automated and efficient daily order fulfilment system developed using SCE-UG's smart daily order processing algorithm. Implementing this system has resolved the slow operation efficiency, poor data management and unsatisfactory CRM, allowing the integration of all sales orders to external e-platforms. Standardised and custom-built tools to process, trace and dispatch orders has contributed to fast and effective order fulfilment.
(2) £250k/pa from the application of the smart inventory management system derived from SCE-UG PhD project outcomes. Besides the normal functions from off-the-shelf inventory software, this dedicated system further optimises space allocation and devises better stock retrieval strategies, yielding savings from stock level optimisation, 2 fewer inventory management employees and reduced stock levels.
(3) £270k/pa from the application of the sales management system developed using SCE-UG's smart algorithms for web scraping and big data analytics to achieve dynamic pricing that gained market share and saving two salespersons.
(4) £107.5k/pa from the application of other systems developed using the data mining and big data algorithms for implementing Amazon Vendor and Prime business processing, daily replacement processing, and special offer sales and shipment processing.

2) Impact on McCarthy Taylor System Ltd (MTS) (C4)
MTS is a UK-based software vendor that supplies specialised geo-information software for users such as surveyors, landscape designers and engineers. An existing software product (LSS) was unable to fully meet the market requirements for processing large quantities of data collected using terrestrial laser scanners. Alternative software packages exist but have been shown to be costly

and without the capability of processing terrain data suitable to work in MTS's sector. In 2014 a SCE-UG and MTS KTP project developed the necessary algorithms for processing significant quantities of data with a semi-automated methodology for analysing point-clouds to generate 3D geometrical information for topographical surveys, building internals and elevations. MTS adopted these data process algorithms into their existing software LLS, and four new commercial software packages: LSS VistaPC, LSS ElitePC, LSS EducationPlus and LSS Police.

The impact of the algorithm applications supported the long-term growth of MTS, with a UK-sourced solution for their UK customers. Since 2015, MTS's annual sales increased by approximately £124k from the existing customer base and gained approximately 400 new customers including leading landscape designers and planners, Universities and Colleges, and Police collision investigation departments.

3) Impact on Total Metal Products Ltd (TMP) (C5)
TMP is a UK-based special purpose machine tool designer and manufacturer. As part of their business improvement process TMP designed and developed a new industrial robot linear track and gantry systems (IRLTGS) but lacked a live online product design and performance information service for potential customers. A SCE-UG project with TMP developed the mechanics modelling, analysis and optimisation for the over-constrained systems of IRLTGS. Various mathematical models have been established, validated and applied during the last two years. TMP's annual turnover has grown from of £874,152 in 2018 to £2,138,782 in 2020 and the net pre-tax profit from £67,127 in 2018 to £163,912 in 2020.

4) Impact on SMEs Employing E-Market Places and Wider Society (C1, C2, C5)
Our expertise of knowledge transfer from applied theoretical research in algorithm development aligned to understanding real SME business requirements will be further developed beyond this REF period for further exploitation with other SME partners.

5. Sources to corroborate the impact

C1 - Testimonial from the Managing Director, Mr David Zhuowei Gao, Unielectronics Ltd.

C2 - Testimonial from Finance Manager, Mr Muhammad Anwar, Unielectronics Ltd.

C3 - Testimonial from IT Manager, Dr Jisheng Lu, G&Z Trading Ltd.

C4 - Testimonial from Mr Nigel, General Manager, McCarthy Taylor Systems Ltd.

C5 – Testimonial from Managing Director, Mr Steve Richards, TMP Ltd.