Institution: University of Reading

Unit of Assessment: 13 Electronic and Electrical Engineering

Title of case study: Intelligent Systems incorporating Automatic Classification and Carbon Footprinting for Corporate E-Procurement

1. Summary of the impact

Two Knowledge Transfer Partnership projects, carried out between 2006 and 2009, between an e-commerce marketplace provider (@UK plc) and the University of Reading, led to the development of two software tools that were launched in 2010. The tools, SpendInsight and GreenInsight, are the first of their kind to use artificial intelligence techniques to handle the extremely challenging data associated with purchasing in large organisations. Since their launch, these tools have been used by @UK plc to identify procurement savings and environmental costs of procurement activities for governments, multi-national corporations, academic institutions and healthcare providers. Over the last three years @UK plc has benefitted from the launch of these products as it has provided them with a competitive advantage over the market place, increased the quality and efficiency of their spend analyses and led to multi-million pound licensing agreements. An analysis of spending in some of the NHS Trust Foundations has led to changes in procurement behaviours that have resulted in hundreds of thousands of pounds saved to date – benefitting not only the NHS, but also taxpayers.

2. Underpinning research

Background

Purchasing of goods and supplies by large organisations is a complex process, which can be streamlined through an e-procurement system. However, implementing e-procurement requires tools that can cope with vast amounts of data from multiple and disparate sources, such as supplier and product information, in order to analyse where the best value is and where efficiency can be improved. The nature of e-procurement data (large quantities, heterogeneous, sparse, unstructured, distributed and noisy) makes it challenging to apply existing state of the art management techniques.

In 2006, three linked Knowledge Transfer Partnership (KTP) projects were started to create innovative solutions to the challenges of e-procurement data; the solutions needed to be cost effective and commercially viable. Two of these were with the University of Reading, while the third took place at Goldsmith's, University of London. The company @UK plc, a leading e-commerce marketplace provider, giving support to over 1 million businesses worldwide, was the industry partner on all three KTP projects. The University of Reading was the knowledge base partner for two of the KTP projects which focused on innovative approaches to data classification and related artificial intelligence techniques; one of these projects concentrated on classification of products, while the other dealt with ranking web pages on the basis of textual search, as well as finding property structure from product descriptions based on natural language. Goldsmith's was the knowledge base partner on the third KTP project, which concentrated on systematically spidering web pages to gather relevant product information from them. These linked projects ran for three years from 2006 to 2009.

Classification of data using artificial intelligence

The University of Reading team was comprised of: Dr Richard Mitchell, Associate Professor (2013-present) previously Senior Lecturer (1994-2013); Slawomir Nasuto, Professor of Cybernetics (2012-present), previously Reader (2007-2012); Dr Virginie Ruiz, Associate Professor (2013-present), previously Senior Lecturer (2004-2013); and Victor Becerra, Professor of Automatic Control (2012-present), previously Reader (2005-2013).

The Reading team brought decades of experience in classifying challenging data to the partnership with @UK plc. When data are collected by a spider – a program that "crawls" through the web looking for relevant data in response to a query about, for example, a product – they need to be analysed to determine the category to which the product belongs; this classification can then be used to find equivalent products from different suppliers. The products also need to be ranked to determine which are most important or relevant to the search request. The Reading team have been developing and applying methods for classifying data using various artificial intelligence approaches, including neural networks [1,2,8], evolutionary computing, swarm intelligence, adaptive signal processing, and machine learning [1,2]. The team have developed and applied

these methods in response to challenges faced in a diversity of disciplines, including health [2, 7 & 8] and economics [1].

There are several challenges with real world text classification, including poor class structure, overlapping classes and blurred boundaries between categories. Moreover, training data pooled from multiple sources tend to be inconsistent and contain erroneous labelling, leading to poor performance of standard text classifiers. In 2010, the Reading team looked at how health service products were classified to specialised procurement classes in order to examine and quantify the extent of these problems [3]. They presented a novel method to analyse the labelled data by selectively merging classes where there was not enough information for the classifier to distinguish them. Additional contributions made through the research that lead to SpendInsight include: ensuring that the data pre-processing and classification methods were scalable so that they were able to process procurement data from large organisations (`big data') in reasonable time; the development of a sophisticated rule engine for de-duplication [3], which is employed to automatically detect and eliminate duplicate items from the procurement data; and finally the development of methods for automatic detection of attribute data in textual descriptions of products [6]

This research led to the development of an intelligent spend analysis system known as SpendInsight which became a key component in the @UK plc e-procurement and e-marketplace platform.

Methods to estimate environmental cost

With individual products classified through SpendInsight, the Reading researchers then developed methods to estimate the environmental cost of the product by mapping it to the ethical and environmental information held for millions of products by the Centre for Sustainability Accounting. The resultant system, GreenInsight, was launched in 2010 and is used by procurers to assess the carbon footprint of their purchases; they can now compare the cheapest price economically and environmentally, and thus quantify the cost of 'being green'.

3. References to the research

These outputs have been internally assessed as of at least 2* quality. Those suggested for quality assessment are indicated with *.

[1] *Becerra, V. M., Galvao, R. K. H. and Abou-Seada, M. (2005) Neural and wavelet network models for financial distress classification. *Data Mining and Knowledge Discovery*, 11 (1): 35-55. doi: 10.1007/s10618-005-1360-0 Citations=19

[2] *Froese, T., Hadjiloucas, S., Galvao, R. K. H., Becerra, V. M. and Coelho, C. J. (2006) Comparison of extrasystolic ECG signal classifiers using discrete wavelet transforms. *Pattern Recognition Letters*, 27 (5): 393-407. doi: 10.1016/j.patrec.2005.09.002 Citations=16

[3] *Roberts, P., Howroyd, J., Mitchell, R. and Ruiz, V. (2010) Identifying problematic classes in text classification, in *2010 IEEE 9th International Conference on Cybernetic Intelligent Systems*, Sept 1-2, 2010, Reading, UK: Institute of Electrical and Electronics Engineers.

[4] Roberts, P., Mitchell, R. and Ruiz, V. (2009) Using triangulation to identify word senses, in: *8th IEEE International Conference on Cybernetic Intelligent Systems – IEEE Systems, Man & Cybernetics Society*, September 9-10, 2009, Birmingham, UK: Institute of Electrical and Electronics Engineers.

[5] Roberts, P. J. (2011). *Automatic Product Classification*. PhD Thesis. University of Reading: UK.

[6] Brown, M.(2011) *Automatic production of property structure from natural language*. PhD Thesis. University of Reading: UK.

[7] Guo, Q., Shao, J. and Ruiz, V. F. (2009) Characterization and classification of tumor lesions using computerized fractal-based texture analysis and support vector machines in digital mammograms, *International Journal of Computer Assisted Radiology and Surgery*, 4(1): 11-25. doi. 10.1007/s11548-008-0276-8. Citations=18

[8] Bakstein, E., Burgess, J., Warwick, K., Ruiz, V., Aziz, T. and Stein, J. (2012) Parkinsonian tremor identification with multiple local field potential feature classification. *Journal of Neuroscience Methods*, 209 (2): 320-330. http://dx.doi.org/10.1016/j.jneumeth.2012.06.027

All citation values are from Scopus as of 3rd October, 2013.

4. Details of the impact

The classification techniques developed at Reading [5-8] became essential components of the Eprocurement system, SpendInsight, which was launched in February 2010 by @UK plc. The system uses artificial intelligence techniques to enable e-procurers to analyse their purchases and identify potentially significant savings. @UK plc subsequently launched the GreenInsight system, which again incorporated the artificial intelligence techniques developed by Reading. GreenInsight estimates the carbon footprint of products and procurement activities in order to help businesses develop environmentally friendly procurement policies.

@UK PLC benefits from the launch of SpendInsight and GreenInsight

SpendInsight immediately increased @UK plc's analysing capacity; within the first two months of launching the SpendInsight website, @UK plc had analysed over £35 billion in spend, which was an increase from the £16 billion it had analysed the previous year [a].

SpendInsight also significantly improved @UK plc's efficiency, producing results faster, at less cost and with better results than previous systems. @UK plc was working with the NHS London Procurement Partnership (LPP) and using the leading spend analysis system at the time, they had taken 2 years to analyse less than 25% of all of London's spend, costing around £500,000 [a]. In 2010, they implemented SpendInsight and in 6 months had analysed London's entire spend, with better results, for significantly less cost [a].

On September 4th, 2013, @UK plc announced that they had agreed a £3.4 million conditional licensing agreement with Tungsten Corporation plc for SpendInsight [b].Tungsten will market the software to its 122 global clients as TungstenAnalytics and @UK will receive up front establishment fees and installation costs of around half a million pounds [b].

The @UK Chairman has stated that; "SpendInsight and GreenInsight have revolutionised our business. SpendInsight is recognised as still being globally unique 3 years after development, and we just won a £ 3.4m contract where the customer is licencing SpendInsight. This is 1.5x our current turnover. Additionally the SpendInsight capablity has been a major factor in our relationship with Visa and the global roll out of our marketplace technology where SpendInsight delivers an instant business case for buying organisations." [c]

Taxpayers and NHS benefit from savings identified through SpendInsight

SpendInsight was used to identify considerable savings for the NHS London Procurement Partnership (LPP) - both soft process savings and hard cashable savings - and provided impetus to standardise and centralise their e-procurement across the Trusts' back office. SpendInsight also identified which were the key suppliers and key commodities, a process that had the effect of driving both user and supplier acceptance of the change to e-procurement.

Over the course of the project the researchers obtained and processed NHS procurement data for 73 NHS trusts in the UK, the majority centred in London. The SpendInsight system was used to analyse the purchase orders, invoices and contracts of the different organisations, identify equivalent purchases and benchmark the best possible prices for each product, and identify savings.

The analysis found that significant savings could be made within the NHS with relatively simple changes in procurement behaviour. For example, the amalgamation of small ad-hoc orders into larger, less frequent orders could standardise product choices and facilitate lower-costs for guaranteed high-volume deals. One NHS Trust saved £320,000 in 2011 alone by switching to one supplier of examination gloves and ordering 2 choices of glove rather than 20 [d].

@UK PLC provided analysis services to the National Audit Office (NAO) to assist them in the preparation of their 2011 report on the procurement of consumables by NHS hospital trusts. The National Audit Office (NAO) included @UK plc's SpendInsight analysis in their 2011 analysis of the NHS Trust's procurement and spending on consumables [e]. The NAO concluded that if the procurement system was utilised across all NHS Trusts in England, they could "make overall savings of at least £500 million, around 10% of the total NHS consumables expenditure of £4.6 billion" [c].

After the initial analysis using SpendInsight in 2012, the Royal Berkshire NHS Foundation Trust decided to continue using the system to analyse their quarterly spend for 2013. The Principal Procurement Manager stated that "with an addressable spend of £ 60 million, to be able to save

even one percent of that is a benefit". The Trust has received data from their spending review and they "appear to have clawed back £100,000 as a result of actions taken from [their] first pass" [f].

Businesses, governments, academic institutions and others benefit from SpendInsight and GreenInsight analyses

@UK plc works with organisations all over the world and has now used SpendInsight to analyse "over £67 billion in spend, and millions of products from 100's of thousands of companies" [i].

The following is a confidential list provided by @UK of users of SpendInsight and GreenInsight, which shows that governments, health authorities, multi-national companies and academic institutions have all benefitted from the use of SpendInsight and GreenInsight.

Local Councils	Westminster City Council States of Jersey The Highland Council Tower Hamlets Council
Higher Education Purchasing Departments	University of Huddersfield University of Reading University of East Anglia Goldsmiths' College (University of London)
Multinational Companies	Steria UK Corporate Ltd
Provincial Government	New South Wales
Health Authorities / Hospitals	London Procurement Partnership Royal Berkshire Hospital Basingstoke and North Hampshire NHS Foundation

In November 2011, at an event organised by the Business Application Software Developers Association (BASDA), the Director of Solutioning for the NHS made a presentation about the SpendInsight and GreenInsight systems and claimed that they would be "saving the NHS £250 million over 10 years" and equated this to "the cost of 12,000 additional nurses".

5. Sources to corroborate the impact

[a] 'SpendInsight', *@UK plc* [website] http://bit.ly/1fgJVPW accessed 3 Oct 2013. Gives evidence of increased volume of analyses in 2010 over 2009 as a result of implementing SpendInsight.

[b] 'SpendInsight™ Agreement', *INTELLISYS*. http://bit.ly/1fgJVPW Gives value of financial gains for @UK plc for a conditional licensing agreement for the software system developed with Reading researchers.

[c] Chairman, @UK plc (testimonial letter on the impact of the software)

[d] Denwood, A. (27 Sept 2011) 'Hospital saves fortune just by swapping rubber gloves', *BBC News Health* <http://www.bbc.co.uk/news/health-14971984>. Provides figures for cost savings made by Barts and the London NHS Trust by making simple changes in procurement behaviour as a result of SpendInsight analysis.

[e] National Audit Office (2 February 2011) *The procurement of consumables by NHS acute and Foundation trusts*, Report by the Comptroller and Auditor General, HC 705, Session 2010-2011. London: The Stationery Office. http://bit.ly/187uszM

[f] 'Case Study: Spend Insight', *@UK SpendInsight Savings and Benchmarking, Royal Berkshire NHS Foundation Trust*. http://bit.ly/17odbzn

[g] Head of Purchasing and Supplies, Basingstoke and North Hampshire NHS Foundation Trust*

[h] Data Enablement Manager, NHS London Procurement Partnership*

[i] 'Process', *GreenInsight* [website] <http://www.green-insight.com/process.html> accessed 6 Oct 2013. Gives evidence of the extent and reach of SpendInsight's use.

*Contact details provided separately