Institution:	University of Northumbria at Newcastle
Unit of Assessment:	10 - Mathematical Sciences
Title of case study:	Improving Social Care Call Centre Operational Effectiveness

1. Summary of the impact

Targeted Projection Pursuit (TPP) – developed at Northumbria University – is a novel method for interactive exploration of high-dimension data sets without loss of information. The TPP method performs better than current dimension-reduction methods since it finds projections that best approximate a target view enhanced by certain prior knowledge about the data. "Valley Care" provides a Telecare service to over 5,000 customers as part of Northumbria Healthcare NHS Foundation Trust, and delivers a core service for vulnerable and elderly people (receiving an estimated 129,000 calls per annum) that allows them to live independently and remain in their homes longer. The service informs a wider UK ageing community as part of the NHS Foundation Trust.

Applying our research enabled the managers of Valley Care to establish the volume, type and frequency of calls, identify users at high risk, and to inform the manufacturers of the equipment how to update the database software. This enabled Valley Care managers and staff to analyse the information quickly in order to plan efficiently the work of call operators and social care workers. Our study also provided knowledge about usage patterns of the technology and valuably identified clients at high risk of falls. This is the first time that mathematical and statistical analysis of data sets of this type has been done in the UK and Europe.

As a result of applying the TPP method to its Call Centre multivariate data, Valley Care has been able to transform the quality and efficiency of its service, while operating within the same budget.

2. Underpinning research

Targeted Projection Pursuit (TPP) is a novel data-mining method for interactive exploration of high-dimension data sets without loss of information. The method was developed by Dr Joe Faith, Dr Robert Mintram (both Senior Lecturers at the time of the research) and Professor Maia Angelova at Northumbria University [1] and was first published in September 2006. Mintram subsequently moved to Bournemouth University in 2007 and Faith moved to Google Inc. in July 2011. The method proceeds by finding projections of the data that best approximate a target view. Two versions of the TPP method were introduced based on: (i) Procrustes analysis and (ii) a single layer perceptron. These are capable of finding orthogonal or non-orthogonal projections, respectively. The method was quantitatively and qualitatively compared with other dimension reduction techniques. It was shown to find two-dimensional views that display the classification of cancers from gene expression data with a visual separation equal to, or better than, existing dimension reduction techniques developed for this purpose.

TPP allows classification and visualisation of large data sets and, if required, the implementation of certain prior knowledge about the data (known as supervised data mining) to enhance learning from data by finding patterns and visualising high-dimensional data without loss of information. The method was originally applied to gene expression data for classification of leukemic cancers based on microarray data for several types of leukemic cancers [1]. TPP was further implemented into a web-based tool [2], which can be used with any type of multivariate clustered data, and detailed in a book chapter [3]. In 2008, the method was used for classification and visualisation of gene expression to investigate the effect of knock-out of the *metJ* gene in the *E.coli* genome [4]. In 2011, post-graduate research student Helen Gibson (Northumbria University) applied the TPP method to Companies House data as part of an Industrial Mathematics KTP Programme entitled "*Modelling propensity to buy for UK business*" (in partnership with Level Business Limited). This revealed a number of key insights into the data, including visualising relationships between companies and Local Authority departments, and implementing an algorithm to 'rate' company directors. In 2012, the TPP method was used in the development of an artificial intelligence system applied to the study of ovarian cancer [5].

In 2009-2010, Angelova was co-investigator in a Northumbria-led, multi-disciplinary research grant, "*Enabling environment: modelling wellbeing in ageing*", funded by the Lifelong Health and Wellbeing Cross-Council Programme led by MRC (Ref: G0900012, Grant ID 90535, £50,000) in collaboration with Newcastle, Manchester and Sheffield Universities. As part of this project, Angelova became aware of the Telecare service provided by Valley Care, and during these discussions realised that TPP could be used to better understand Valley Care's multivariate data, and so potentially improve the operational efficiency of the Telecare service. These discussions led to the application of TPP research to Valley Care data as part of Work Packages 1, 2 and 5 in a European Framework 7 Project entitled "MATSIQEL: *Models for ageing and technological solutions for improving and enhancing the quality of life*" (FP7-PEOPLE-2009-IRSES 247541, 2011-2014) for which Angelova was PI and international coordinator.

3. References to the research (* references which best indicate quality of underpinning research)

[1*] Faith J., Mintram R. & Angelova M. (2006)
Targeted Projection Pursuit for Gene Expression Data Classification and Visualisation
Bioinformatics, vol. (22), no. (21), pp. 2667-2673
http://dx.doi.org/10.1093/bioinformatics/btl463

[2] Faith J. & Brockway M. (2006)
Targeted Projection Pursuit Tool for Gene Expression Visualisation
Journal of Integrative Bioinformatics, vol. (3), no. (2)
http://dx.doi.org/10.2390/biecoll-jib-2006-43
For a further demonstration of how the tool works see http://vimeo.com/17527997

[3*] Faith J. (2007)
Targeted Projection Pursuit for Interactive Exploration of High-dimensional Data Sets
Book Series: IEEE International Conference on Information Visualization
Book Editor(s): Banissi E., Burkhard RA., Grinstein G.; et al., pp. 286-292
http://dx.doi.org/10.1109/IV.2007.107

[4*] Angelova M., Myers C. & Faith J. (2008)
Classification of Genes Based on Gene Expression Analysis
Physics of Atomic Nuclei, vol. (71), no. (5), pp. 780-787,
http://dx.doi.org/10.1134/S1063778808050025

[5] Enshaei Amir (2012)
Development of Artificial Intelligence systems as a prediction tool in ovarian cancer
PhD Thesis (Newcastle University)
http://hdl.handle.net/10443/1552

Relevant Grants

- Clarke C. *et al.* (2009-2010), Ref: G0900012, £50,000
  "*Enabling Environment: Modelling Wellbeing in Ageing*"
  Funded by the Lifelong Health and Wellbeing Cross-Council Programme led by MRC
- Angelova M., *et al.* (2011-2014), FP7-PEOPLE-2009-IRSES 247541, €189,000
  "*MATSIQEL: Models of Ageing and Technological Solutions for Improving and Enhancing the Quality of Life*"
  FP7 Marie Curie Actions: International Research Staff Exchange Scheme
- Angelova *et al.* (2012), London Mathematical Society, £7,500
  "*Mathematics of Human Biology*": LMS Regional Meeting and Workshop
  (results of work on the Valley Care Call Centre data were reported at this meeting)
- Gibson H., Faith J., Dobree J. & MacManus L. (2011), £15,000
  "*Modelling Propensity to Buy for UK Business*"
  Part of the KTN's Industrial Mathematics KTP Programme, co-funded by EPSRC
  https://connect.innovateuk.org/web/partnership-programmes/articles/-/blogs/modelling-propensity-to-buy-for-uk-business and http://www.mathscareers.org.uk/_db/_documents/IP11-001-LevelBusiness_Northumbria_CaseStudy.pdf

4. Details of the impact

In December 2011, TPP was applied by Angelova and collaborators from the MATSIQEL team to high-dimension data from Valley Care. The data were subjected to substantial data cleaning and preparation between December 2011 and April 2012. Valley Care's primary aim is to assist people to live independently in their own homes. Therefore the data describes the usage of equipment and facilities required for ambient living for people (mostly ageing or in a need of assistance). The Telecare equipment mainly consists of: (i) a base unit for making and/or receiving calls from the operator, which is available to each client; and (ii) a range of mobile or fixed units, such as personal radio triggers, medication dispenser, smoke, gas and CO detectors, fall detector, temperature-extremes sensor, property exit sensor, bogus caller, bed/chair sensor, flood detector, epilepsy sensor and GPS trackers. These devices monitor the life of people with limited abilities, enabling them to look after themselves and live in their own homes, without the need of a carer or transfer to care homes. Valley Care provided data for 500 (consent given) clients aged between 45 and 90 collected from August 2007 to December 2011. The objectives of applying the TPP method were to evaluate the usage of the equipment, to identify possible risk factors and to establish usage patterns of Valley Care services. To the best of our knowledge, this is the first time that the mathematical and statistical analysis described has been carried out on a data set of this type in UK and Europe.

Our study identified a number of users at a higher risk of falls, seasonal peaks in the use of the service (predominantly in the weekends and bank holidays) and the frequency and type of calls. Our research enabled Valley Care managers to establish the volume and frequency of calls, to identify users at high risk and inform the manufacturers of the equipment how to write database software to enable Valley Care to plan efficiently the workloads of call operators and social care workers. The Team Manager of Valley Care stated that the research findings have enabled Valley Care: "*to improve the quality and efficiency of the services whilst operating in the same budget*."

As a direct outcome of applying our research, in 2012 Valley Care transformed its system for the Call Centre operators, specifically:

- **Providing more efficient workload planning for call centre operators**: This is due to a better understanding of the volume, type and frequency of calls.
- **Providing more efficient allocation of warden visits**: Wardens respond to alarm calls day and night. The mobile warden service visits clients in their own homes and such visits form one of the most expensive parts of the Telecare service.
- **Prioritising calls to ambulance services and relatives**: Such prioritisation could not be done quantitatively nor automatically under the old system (a key limitation), and thus our research has transformed Valley Care's Call Centre service.
- **Eliminating false alarms**: Eliminating false alarms contributes to an overall quicker response from call centre operators to real emergencies.

The research also provided knowledge about the usage patterns of the technology and valuably identified clients at high risk of falls. Monitoring and allocating special attention to clients with a high risk of falls allows them to live independently at home for longer and thus not go into residential care. Laing & Buisson's *Care of Elderly People Report 2012/13* estimates that a person can expect to pay more than £27,200 per year in residential care costs, rising to over £37,500 if nursing care is necessary. Laing & Buisson also report that the UK's elderly care market is now a £24 billion sector of the UK's service economy:

http://www.laingbuisson.co.uk/MarketReports/MarketReportsHome/tabid/570/ProductID/548/Default.aspx.

Valley Care is a preventative service, and thus allowing clients to avoid going into residential care represents a significant saving.

Valley Care provides a Telecare service to over 5,000 customers as part of the Northumbria Healthcare NHS Foundation Trust in the North East of England (we analysed a subset of 500 consenting clients). The Team Manager of Valley Care states that: "*the service informs a wider UK ageing community as part of the NHS Foundation Trust*". Valley Care's Social Care Call Centre provides a core service for vulnerable and elderly people to remain in their homes for longer periods, and receives an estimated 129,000 calls per annum (as reported in the Northumberland County Council minutes from the middle of the evaluation period - http://www3.northumberland.gov.uk/Councillor/Upload/CDocs/4380_M516.doc). As a consequence of our research, Valley Care has been able to transform the quality and efficiency of their service while operating within the same budget.

The positive benefits of this research also directly changed Valley Care's policy for recording call information, i.e. implementing categories and attributes proposed by our research. By extension, Valley Care is currently in discussion with the manufacturers of its own Call Centre's software and equipment (Tunstall Healthcare, the world's leading provider of Telehealthcare solutions) for amendments to their database software (using the categories/attributes of our research).

Building on our success of applying the TPP method to NHS data, we foresee significant future impact working with global health practitioners. Further interest was generated when we presented details of this impact case study at the LMS Regional Meeting and Workshop "*Mathematics of Human Biology*" (July 2012) and through the *MATSIQEL* FP7 project, and we have received requests for implementation of the TPP methodology to telecare data from Bulgarian and South African social care centres; namely from CITT-Global (the Center for Innovation and Technology Transfer-Global Ltd; a European-wide consultancy company based in Bulgaria) and the South African Medical Research Council.

Evidence for all the impacts described above can be found in a factual statement from the Team Manager of Valley Care, Northumbria Healthcare NHS Foundation Trust. Statements of support from the Managing Director of CITT-Global and from the South African Medical Research Council also corroborate our impact claims (see section 5).

5. Sources to corroborate the impact

- Factual statement from **Team Manager of Valley Care** (Northumbria Healthcare NHS Foundation Trust) corroborating that, as a direct result of applying the TPP method:
  - (i) a more efficient system for workload planning has been established;
  - (ii) a more efficient allocation of warden visits has been implemented;
  - (iii) calls to ambulance services and relatives have been prioritised;
  - (iv) quality and efficiency of the services improved while operating within same budget;
  - (v) customers at higher risk of falls have been identified; and
  - (vi) false alarms have been eliminated.
- Statement of Interest from **Managing Director of CITT-Global**, reporting aspiration to implement TPP method in Telecare/Telehealth practice for improving the effectiveness of social care centres in Bulgaria.
- Statement of Support from **South African Medical Research Council**, reporting desire to implement TPP model to South African Telehealth and Telecare data.

Copies of these documents are available on request.