Natural Solutions to Practical Problems

an Overview of Marketing, Scheduling and Information Filtering Problems Solved by Neural and Evolutionary Techniques

M.C. van Wezel & A.E. Eiben & C.M.H. van Kemenade & J.N. Kok & W. Kosters & I.G. Sprinkhuizen-Kuyper

Department of Computer Science, Leiden University, The Netherlands

Introduction: We present a number of projects of the ALP group at Leiden University, within marketing, scheduling and information filtering. The projects use neural and evolutionary techniques.

1 Marketing Applications

Market Response Modelling: In market response modelling one seeks to model the market share of a brand as a function of a number of marketing variables. Since many relationships between marketing variables and market share are thought to be non-linear, neural networks are ideal for market response modelling. In our case, we modelled the market shares of five competing beverage-brands on a European market. The variables we used as inputs to a multi-layer perceptron neural network were price, distribution, out-of stock, and share of voice (advertising share). Since only a very limited amount of data was available, a regularization technique called weight elimination was used to prevent overfitting. Several neural network models were compared to traditional market response models (i.e. a linear model and a multiplicative model). In all cases, the neural network models outperformed the traditional models when absolute variables were used. The average performance-gain was 51 %. When relative values of the variables were used, the differences were smaller, but still significant (16 % on average). For more details, see [5] or contact Michiel van Wezel (`michiel@cs.leidenuniv.nl`).

The Dimensions in Customer Behaviour: In this project we tried to determine which factors (dimensions) influence the behaviour of customers of a wholesale company, using only the sales lists of the wholesale retail company. This means that we use a huge amount of very limited, though easily accessible information.

In our model, customers and products are represented as points in a k dimensional Euclidean space. The coordinates of the customer express the customers 'needs' or 'wishes' on k underlying dimensions. The coordinates of the product determine what a product 'offers' on the k underlying dimensions. In the model we use, it is assumed that customers buy products, if the coordinates of the products are sufficiently close to the coordinates of the customer. The aim is now to find low-dimensional coordinates for products and customers such that

the sales lists generated by the above model match real or artificially generated sales-lists as closely as possible. After a solution has been found, domain experts interpret the revealed dimensions.

We used a competitive neural network to solve this problem. Results were good on artificially generated sales-lists, less convincing but still reasonable on real sales-lists. For more details, see [2, 6] or contact `kosters@cs.leidenuniv.nl`.

Data mining applications of EA and NN: Data mining application studies have been done by the 'Stichting Marketing Intelligence and Technology (MIT)', a foundation which promotes the use of computational intelligence techniques in marketing applications, and in which UvA, VU and RUL collaborate. Projects have been carried out for Hewlett-Packard, PTT Telecom, Robeco en Videtex Nederland. In all studies, the aim was to train and to compare computational intelligence techniques with historical data in order to optimize future marketing activities. The techniques used were NN, GA, decision trees and (linear) statistics. For more details, see [1]. or contact Gusz Eiben (`gusz@cs.leidenuniv.nl`).

2 Data Visualisation

Neural Vision - A Neural Network Based Data Projection and Visualisation Tool: Data visualisation by means of data projection is useful in exploratory data analysis. We developed a software package called 'Neural Vision', in cooperation with Nijenrode University for the Dutch Ministry of Transport, Public Works and Water Management. This software package is able to visualise high dimensional data by means of a linear projection (based on a Sanger Neural network) and a non-linear projection (based on an Samann neural network). The data points in the projection can be coloured to visualise the distribution of the classes or indicator values in the projection. The data can be clustered by a frequency sensitive competitive neural network.

An illustration of the program is given in figure (1), where a linear projection is shown of the thirteen dimensional Boston dataset. For more information, contact Michiel van Wezel (`michiel@cs.leidenuniv.nl`).

3 Evolutionary 3D-Air Traffic Flow Management

Air Traffic Flow Management (ATFM) is involved in planning the movements of aircraft. A complete plan describes the trajectories of all involved aircraft. A trajectory defines the exact position of an aircraft as a function of time, so it corresponds to a path with additional temporal information. Two trajectories are conflicting when at a certain time the separation between these trajectories is too small. The minimal required separation between trajectories is approximately 30 kilometers in the horizontal plane or 600 metres in vertical direction. The primary target is to find a conflict-free planning where all aircraft move from their entry to their exit location. As a secondary target, one can minimise the number of maneuvers, the additional distance traveled, and try to satisfy the

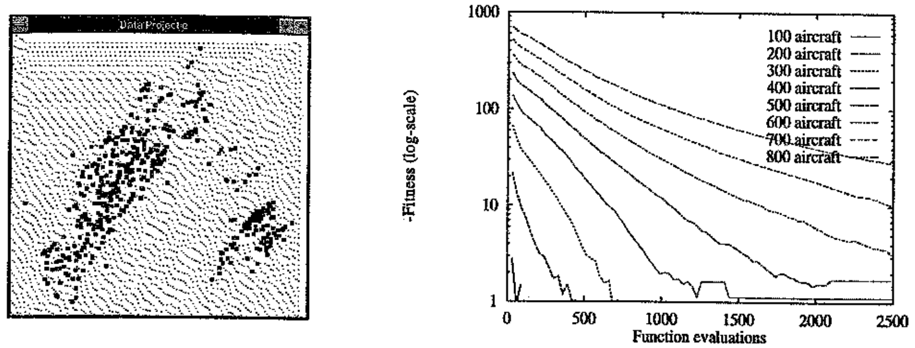

Fig. 1. Linear projection of Boston dataset (left) and error development in ATFM planning with EA

fairness requirement. Maneuvres are usually uncomfortable for the passengers, and too much additional distance may lead to a delayed arrival of the aircraft. Nowadays a network model is used to make manual planning possible. As the amount of air traffic increases rapidly more complex planning models and new (automated) planning tools are needed. One candidate is the free route model in which arbitrarily shaped trajectories are allowed. The evolutionary planner we have developed is one of the first tools that is able to handle large scale ATFM problems using the free route model. As can be seen from figure (1) an almost conflict-free planning is obtained for problem instances involving up to 800 aircraft. The maximal allowed number of function evaluations during this set of experiments was 2500. The evolutionary planner has good scaling properties and seems to be able to handle large scale problems.

Further research will be devoted to real-time re-planning. Due to weather conditions, or delays at airports it is likely that some aircraft do not fly according to their planning. Under such circumstances it is important to have rapid re-planning tools, that use the current planning as their starting point. For more information, see [4] or contact Cees van Kemenade (`kemenade@cs.leidenuniv.nl`).

4 Evolutionary Adaptive Information Filtering

Information Filtering is concerned with filtering data streams in such a way as to leave only pertinent data (information) to be perused. When the data streams are produced in a changing environment the filtering has to adapt too in order to remain effective. Adaptive Information Filtering (AIF) is concerned with filtering in changing environments. The changes may occur both on the transmission side, and on the reception side. Our goal is to build an (AIF)-system which automatically filters incoming data streams to topics a user is interested in. In a case study we took as input articles from a fixed number of different Internet newsgroups and gave them to the system. The goal of the system is to cluster

these articles in groups: that is, each article should be assigned a label which corresponds to a newsgroup. We propose an AIF system for this task based on the novel combination of weighted trigram analysis, incremental clustering, and evolutionary computation.

An incremental clustering algorithm is applied to weighted trigram representations of the documents creating a classification of the documents. In incremental clustering the number of clusters is not determined in advance, and can change over time. To find the right weights for the trigram analysis and some parameters of the cluster algorithm we designed an evolutionary algorithm. Since the clustering has to be adaptive, the fitness of a trial solution can only be statistically approximated over time and will probably change over time. It takes some time before the fitness of a new member of the population is estimated. Therefore we splitted the population in two pools, one for the new "unproven" members, and one for the "adults".

We found that a combination of weighted trigram analysis, clustering, and evolutionary computation is sufficient to separate a dynamic stream of documents. Furthermore, the experiments with a varying number of clusters indicate that increasing the number of clusters only effects the time needed to converge, not the accuracy rate, which would mean that the system is scalable. Also, the system is capable of processing untrained documents with an accuracy rate comparable to that of processing the trained documents. This means that the system successfully generalises. For more information, see [3] or contact Ida Sprinkhuizen-Kuyper (`kuyper@cs.leidenuniv.nl`).

References

1. A.E. Eiben, T.J. Euverman, W. Kowalczyk, E. Peelen, F. Slisser, and J.A.M. Wesseling. Comparing adaptive and traditional techniques for direct marketing. In H.-J. Zimmermann, editor, *Proceedings of the 4th European Congress on Intelligent Techniques and Soft Computing*, pages 434–437. Verlag Mainz, Aachen, 1996.
2. W.A. Kosters, H.A. La Poutré, and M.C. van Wezel. Understanding customer choice processes using neural networks. In H.F. Armer Jr., editor, *Proceedings of the First International Conference on the Practical Application of Knowledge Discovery and Data Mining (PADD '97)*, pages 167–178, London, 1997.
3. D.R. Tauritz, J.N. Kok, and I.G. Sprinkhuizen-Kuyper. Adaptive informationfiltering using evolutionary computation. In *Proceedings of JCIS'97*, volume 1, pages 77–80, North Carolina, U.S.A., 1997.
4. Cees H.M. van Kemenade, J.M. van den Akker, and J.N. Kok. Evolutionary air traffic flow management for large 3D-problems. In *proceedings of Parallel Problem Solving from Nature IV*, pages 910–919, 1996.
5. M.C. van Wezel and Walter R.J. Baets. Predicting market responses with a neural network: the case of fast moving consumer goods. *Marketing Intelligence and Planning*, 13(7):23–30, 1995.
6. Michiel C. van Wezel, Joost N. Kok, and Kaisa Sere. Determining the number of dimensions underlying customer-choices with a competitive neural network. In *Proceedings of the IEEE International Conference on Neural Networks (ICNN '96)*, volume 1, pages 484–490, 1996.