ACTIVITY BASED COSTING FOR MARITIME ENTERPRISES

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Abstract. This paper is concerned with the development of an Activity Based Costing (ABC) system for use by SMEs in the shipping industry in Turkey. It reports on the application on an Artificial Neural Network in ABC/ABM with the intention of determining costs more accurately.

Currently many companies are using costing software and some project management or scheduling software to define activities and timing and in the majority of the case companies leave the costing to a parallel exercise where each activity is 'costed' using historical or empirical data. The analysis of costing systems in the ship building companies has shown that the historical data has not been effectively used for future ship building projects costing. A review of neural network applications indicated that such networks could provide a means of accumulating historical data and also a decision making tool in costing activities and determining time taken for each of these activities. To this end, a neural network which had been used successfully elsewhere was adapted in the development of an ABC system.

This paper reports how data used in constructing five ships was applied to configure a neural network with the intention of establishing, on the one hand, a relationship between the cost of the activities in building a ship and the ship's identity parameters (length, width, tonnage, etc.) and on the other hand, to establish a relationship between the hours of the activities for a ship applying the same identity parameters.

Keywords: Activity Based Costing, ship building and neural networks.

1. Introduction

The research presented in this paper has shown that the existing costing systems used in shipping industry are not dissimilar to those used in design and manufacture of other engineering products and services. However, the costing systems employed in the sector, investigated to-date, do not provide tools that can be used to either identify or to accurately determine and/or allocate overhead costs (Cokins, 2001). This is of particular interest in the shipbuilding industry where overheads are often estimated using past practices and account for a large % of the overall costs. The second weakness and probably more serious is that in conventional costing systems indirect costs are not distributed to each and every activity.

Introduction of Activity Based Costing (ABC) techniques in recent years has shown ABC can provide an appropriate means of identifying and determining overhead costs, and allocating these to each and every activity in the design and manufacturing processes as well as associated pre design and management activities (Ziarati, 1989). As yet, no cases have been noted to apply ABC in the shipbuilding sector. There are also no published reports or papers on the application of ABC techniques in the shipbuilding companies.

Increase in the application of ABC led to the realisation that some of the limitations of traditional cost accounting systems could be overcome by ABC costing practices. There are many papers reporting on how ABC could form the basis for an overall costing practice (Beajon and Singhal, 1990; Turney, 1992).

ABC has primarily two problems viz., it does not have general criteria to select relevant cost drivers, and secondly ABC provides a linear system and hence unsuited in situations when cost behaviour shows non-linear characteristics (Ziarati, 1989). The intention in this report is to establish general criteria for cost drivers and apply non-linear mechanisms such as neural networks to cases where the costing is non-linear.

The analysis of costing systems in the shipbuilding industry has shown that the historical data has not been effectively used for costing the future shipbuilding projects. This is because generally there are almost 400 activities in the manufacture of a ship.

A review of Artificial Neural Network (ANN) applications indicated that such networks could provide a mechanism for accumulating historical data and be used to aid decision making process (Ziarati and Stockton, 2003). However, of equal importance, if not more, is the ANN capability of allowing cost relationships for the intended ABC to be determined. ANN therefore overcomes both limitation of ABC and provides a means of using past data in an effective manner.

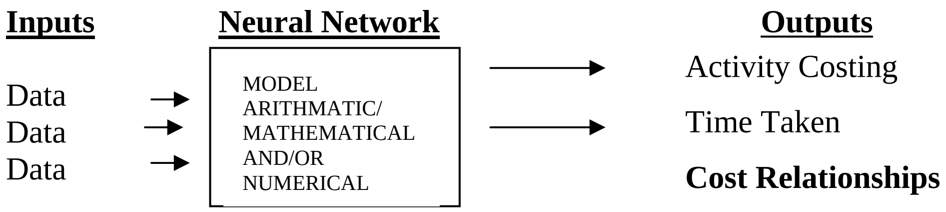

Figure 1. The Basic System for Estimating Activity Costing/Time Taken (Source: Ziarati, 2003) – Cost Relationships for the Intended ABC

The first task was either to identify an existing ANN or to develop one for knowledge acquisition and presentation. The literature search led to an existing neural network (Ziarati, 2003, Bilgili, 2004) which had been used successfully elsewhere. This network was adapted in the development of the ABC system.

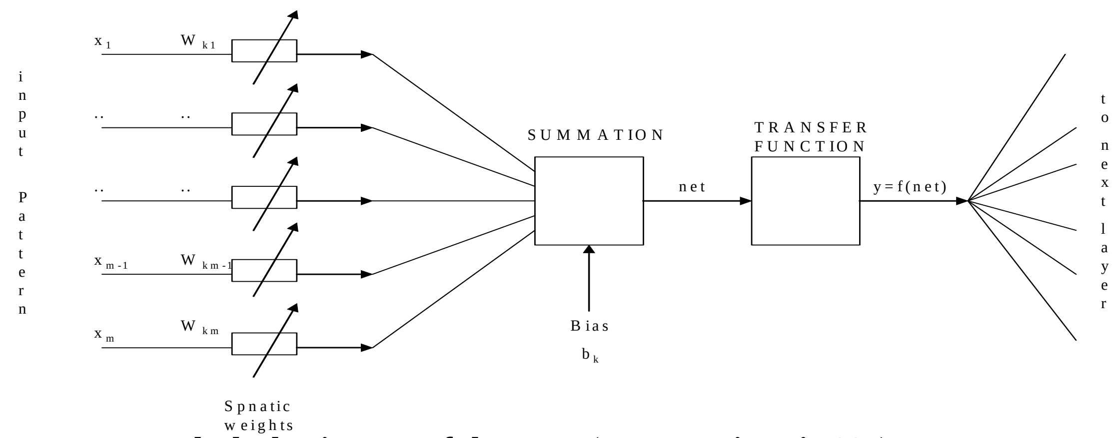

Figure 2 General Block Diagram of the ANN (Source: Ziarati 2003)

The above ANN is designed to carry out two basic tasks. The first task establishes a relationship between the cost of the activities for a ship and ship's identity parameters such as length, width etc. The second task establishes a relationship between the activity periods for constructing a ship and again identity parameters as before.

The research overall is concerned with the development of an Activity Based Costing (ABC) system for use by Small and Medium size Enterprises (SMEs) in the shipping industry in Turkey. It represents a review of Artificial Intelligence (AI) techniques and practices and its application in ABC particularly in determining costs more accurately. The ultimate aim of this work is to design and develop a more reliable costing model.

2. Research Work

The initial work involved a review of costing techniques, current practices and processes applied in the maritime SMEs in Turkey. Several companies were included in a preliminary phase which led to the development of a questionnaire. The questionnaire was used in follow-up interviews with managers within the sector. ANN can only produce acceptable output (knowledge presentation) if the inputs (knowledge elicitation) are admissible. After all an ANN is a system and like all systems it requires admissible inputs and stable state to produce acceptable outputs (Ziarati, 2003).

The review of the outcomes of the survey clearly indicates that the companies no longer use laborious manual calculations reported by Ziarati (1989). The emergence of inexpensive computerised accounting systems has provided opportunities for many companies to update their previous spreadsheet based practices.

The business of the companies involved in this phase of the investigation is in ship management and shipbuilding. It was interesting to note that none of the companies were aware that indirect overheads (management costs) may have been considered when allocating costs to specific projects and/or activities.

The companies involved in ship management in the shipping industry in Turkey were found to use similar costing software and a given methodology (Urkmez, 2007) which is in line with the international practice. This international practice does not allocate indirect costs to projects/activities.

The companies involved with shipbuilding were found (Urkmez, 2007) to have their own method of costing and make use of a variety of software product with varying degree of complexity. However, no company of those contacted/investigated currently uses ABC/M or has a systematic method of distributing indirect costs to each activity within a given project. Typical costing systems used by companies, for different cost headings are reported in Urkmez, (2007)**.** Although these companies have similar conventional cost systems, there are two essential differences. In one approach more attention is paid to detailing direct costs and in the other more effort is exerted in detailing indirect costs. It is easier to adapt ABC for latter than the former.

Analysis of the data collected so far shows that the method often used in costing ship building is relatively simple; the shipyard simply lists direct equipment costs by use of spreadsheet based software e.g. MS Excel. The labour costs are accepted as the average cost for building such a ship based on per unit kg in shipyards in Turkey. To follow the work flow and estimate the delivery time of the ship, activities are listed and an approximate period is attributed to each activity, leading to an estimation of cost.

Some Companies also make use of commercial costing project management and scheduling software to define activities and timing and leave the costing to a parallel exercise where each activity is ‘costed’ using historical or empirical data.

One company used MS Project software rather innovatively where all activities were plotted against time schedule and then costs were estimated for each activity. Generally, there are almost 400 activities in the manufacture of a ship. Although the activities are ‘costed’, it is not an ABC system, as indirect costs have not been distributed to each activity.

The analysis of costing systems of these ship building companies has shown that the historical data has not been effectively used for future ship building project costing. A review of neural network applications indicated that such networks could provide a means of accumulating historical data and also a decision making tool. To this end, a neural network which had been used successfully elsewhere (Ziarati, 2003) was adapted to develop an ABC system.

3. Data collection and analysis

In the company selected for measuring and distributing the cost of manpower and the operational costs of machines as accurately as possible, it was necessary to design a form to gather the necessary data. A review of the arrangements in various departments necessitated two forms to be developed. One form was for some departments which calculated the cost for the whole department rather than calculating the cost of each member of staff individually. This form was given to the appropriate heads of departments who completed the form on a departmental basis.

The second form was given to the departments where the cost of each staff member could be calculated individually. Once the costs were determined these costs were then distributed to activities/projects. In addition, the data obtained using the two forms were complemented by specific reports by departments, i.e. the data from the CNC department was cross-referenced with the data included in steel cutting reports.

The accounts department of this shipyard is preparing monthly material costs for each ship building project, sub-contractor payments, salaries of shipyard personnel and other costs; this data was collected and stored using the MS-Access database project. It is planned to calculate the exact costs of each activity in any of the ship building projects.

4. Neural Network Configuration and Training

This artificial neural network undertakes two basic tasks, it establishes the relationship between the:

i) cost of the activities for a ship and the identity parameters of the ship , e.g. length, width, tonnage, etc., and
ii) hours of the activities for a ship and the identity parameters of the ship.

Architectures of both neural network configurations are identified except for the weights of the processing elements within the neural networks. The ANN has the following properties:

a) Consists of multiple neurons.
b) There are three layers termed ‘input’ layers, ‘hidden’ layers and ‘output’ layers. The number of neurons at the ‘input’ layer must be equal to number of the input parameters so that each ‘input’ is represented by a given neuron. In the work presented here there are 11 input parameters. Each input parameter represents a specific property such as ‘length of the ship’, ‘width of the ship’, etc. Since there are 11 input parameters, the number of the nodes for the input layer of the network is also 11 in order that the above rule is satisfied.
c) There are no restrictions or analytical formula for the number of nodes in a hidden layer. It has been set to 20 nodes.
d) For the output layer, the number of neurons must be equal to the number of output parameters since each node represents an output parameter. There are 395 activities for ships being tested here. Therefore, the number of the neuron in the neural network has been set to 395.
e) Neural networks process the normalised values of the input parameters and produce the normalised values of the output parameters.
f) The neural network must be trained enabling reliable relationships between input and output parameters to be established. Although there are several training methods, the most common method, i.e. back-propagation, is used for these neural networks. The main aim in the back-propagation learning algorithm is to achieve minimum Sum Square Error.

5. Discussions and Conclusions

Figure 3 demonstrate that neural network reached a steady state after some 9000 epochs, reaching a tolerance error of less that 0.001 hence providing a stable system for the intended experiments. The Figure 4 shows the regression line representing the relationship between original training data and neural networks output. As can be seen for ship 1 the two sets of data converge and have strong and positive correlation. The second figure shows relative and average % error for all the 395 activities in constructing the first ship. Similar experiments were carried out with the other four ships.

The results are promising, clearly showing that neural network can reliably be used to predict the cost of each activity in building a vessel and also forecast the time taken for each of these activities. Similar experiments were carried out for the four ships. Full activity charts identifying cost of activities and time taken for each of these activities for all seven ships are available but due to the shear size of these charts, these are not presented in this paper but given in Urkmez (2007).

The results obtained were used in the construction of the two new vessels. The research work is continuing and is expected the work would lead to improved data gathering system enhancing the quality of the data. In parallel the neural network developed as part of this research programme is being incorporated into a knowledge-based-system with a view to improve the quality and reliability of forecasted activity costs and activity time as well as ability to predict lead-times and project management of ships built in the future.

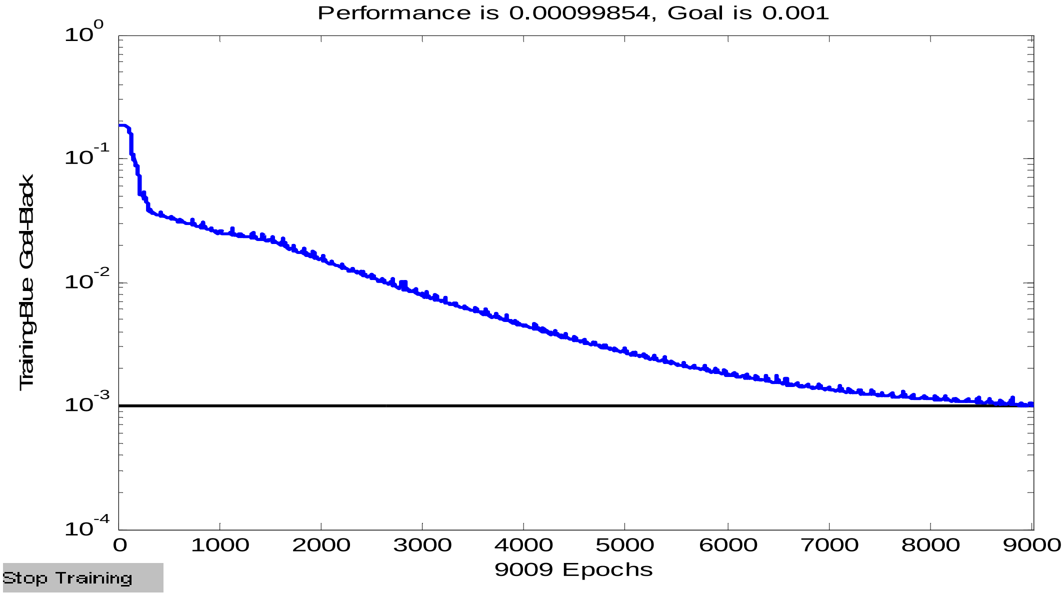

Figure 3. Changes in error during training of neural networks.

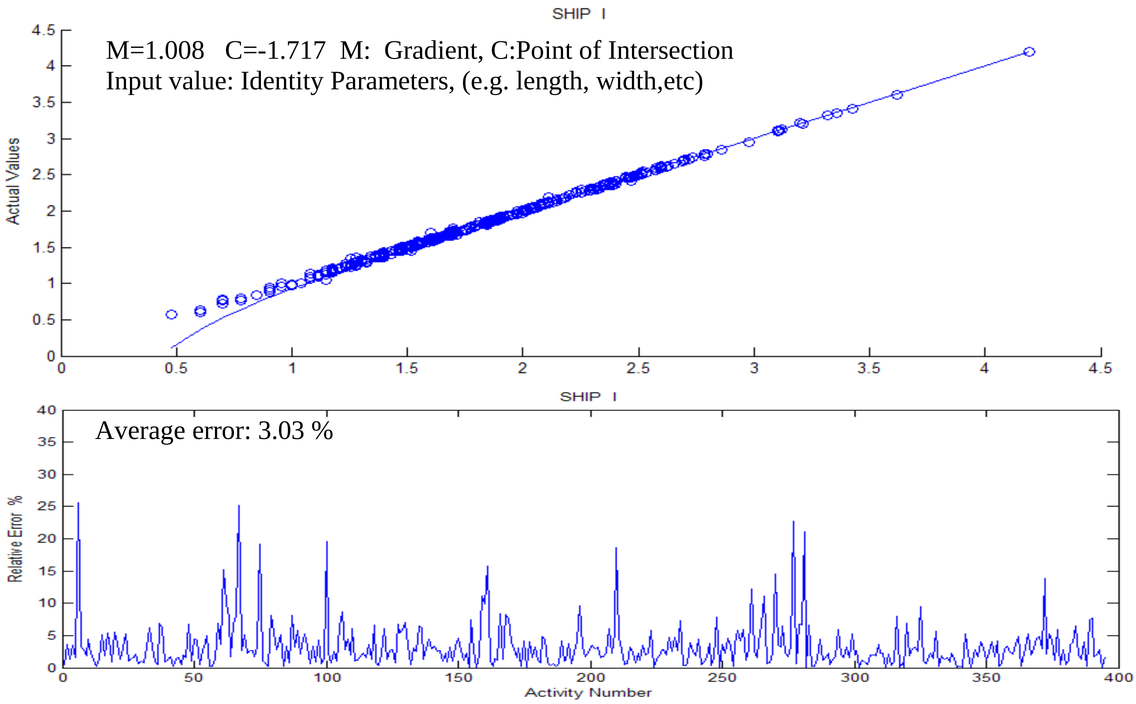

Figure 4. Regression Line for training data Vs. Actual output values

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