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Neuro-Fuzzy Model for Strategic Intellectual Property Cost Management

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Abstract : Strategic Intellectual property (IP) management requires strategic IP creation cost management. It is ideal to be able to proactively estimate the cost of creating IP. This would facilitate the alignment of IP creation activities in order to meet strategic management objectives. This paper proposes the use of Neuro-fuzzy model for strategic management of IP cost management. The extraction of the variables for the model is based on the Activity Based Costing techniques.
Keywords: Neuro-fuzzy; Intellectual Property; Cost Management.

1. INTRODUCTION

Intellectual property (IP) describes ideas, inventions, technologies, artworks, music and literature, all of which are intangible when created, but become valuable in the intangible form as product or service [1]. IP is a crucial contributor for the knowledge economy and generates monopoly position in return for providing payoffs to innovation. Identifying managing, protecting and exploiting valuable IP are the core elements of success of any organization [2]

Good IP management is important not only because of the financial return that it can help generate for a firm, but because it can also contribute to their corporate aims and objectives [3][4]. Strategic IP management requires effective IP cost management [5].

This requires appropriate models for estimating, validating and predicting IP creation cost. Cost prediction would help IP managers and organizations to identify aspect of IP creation that has to be adjusted to align IP R & D budget to IP strategy.

This paper proposes a Neuro-fuzzy for strategic IP creation cost management.

2. NEURO-FIZZY MODELS

Neural network (NN) consist of an Interconnected group of neurons [6]. Artificial Neural Networks (ANN) is made up of interconnecting artificial neurons (programming constructs that mimic the properties of biological neurons). A Neural network is an analog and parallel computing system. A neural network is made up of a number of very simple processing elements that communicate through a rich set of interconnection with variable weights or strength. ANN (or NN) is used in solving artificial intelligence problems without creating a model of a real biological system.

NN processes information using connectionist approach to computation [7]. It changes its structures based on internal or external information that flows through the network during the learning phase.

NN can be used to model complex relationship between input and output or find patterns in data.

The term network in the term "Artificial Neural Network" arises because the function f(x) is defined as a composition of other function g1(x) which can further be defined as a composition of the other function.

Figure 1 presents a simple NN which comprises of the three layers (input, Hidden and output layers).

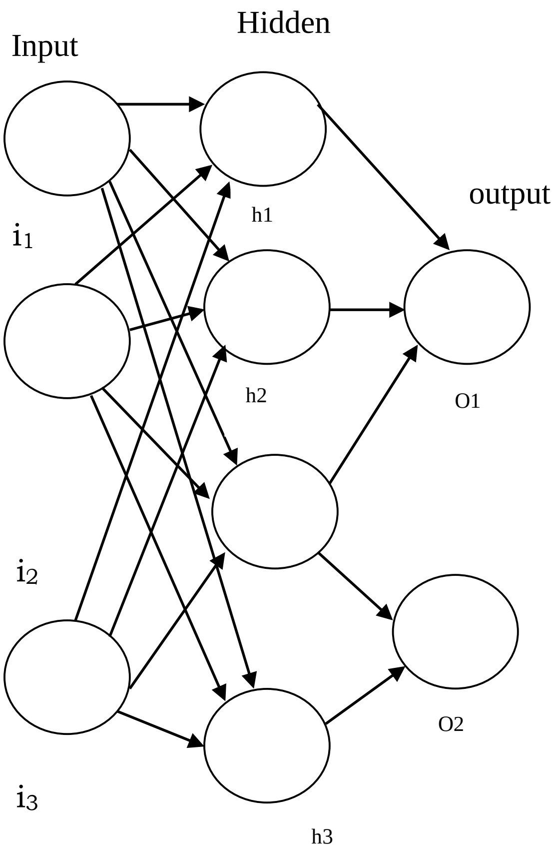

Figure 1: A Simple Neural

The NN presented in figure 1, comprises of a layer of "input" connected to a layer of "hidden" units which is in turn connected to a layer of "output" units. The activity of the input unit represent the raw information that is fed into the network: the activity of the hidden units is determined by the activity of the input unit and the weights between the hidden and output units. The hidden units are free to construct their own representation of the input: the weight between the input and hidden units determine when each hidden unit is active, and so by modifying these weights, a hidden unit can choose what it represents [8].

NN employs learning paradigm that includes supervised, unsupervised and reinforced learning [9]. NN has been applied in stock market prediction, credit assignment, monitoring the condition of machinery and medical diagnosis [7][10[11].

NN learn by example, hence details of how to recognize cost variation patterns in intellectual property creation is not needed. What is needed is some example that are representatives of all the variation of cost patterns.

However, NN cannot handle linguistic information and also cannot manage imprecise or vague information [12].

Fuzzy Logic (FL) is a branch of machine intelligence (Artificial intelligence) that helps computers paint vivid pictures of the uncertain world. Fuzzy sets were introduced as a means of representing and manipulating data that are not precise, but rather fuzzy. Fuzzy logic provides an inference morphology that helps appropriate human reasoning capabilities to be applied to knowledge-based systems. The theory of fuzzy logic provides a mathematical strength to capture the uncertainties associated with human cognitive processes, such as thinking and reasoning. A fuzzy set is called fuzzy number (figure 2) with peak (center) a, left width □ >O and right width β > O if its membership function has the form:

$$A(t) = 1 \begin{cases} 1 - a - t/\square & \text{if } \square \leq + \leq \square \\ (t-a)/\beta & \text{if } \square \leq + \leq \alpha + \beta \\ 0 \text{ otherwise} & \end{cases}$$

and the notation A = (a, □, β_. It can be easily shown that

$$[A]y = [\, a - (1-y)\,\square,\ a + (1-y)\,\beta],\ VgE\{0,1\}$$

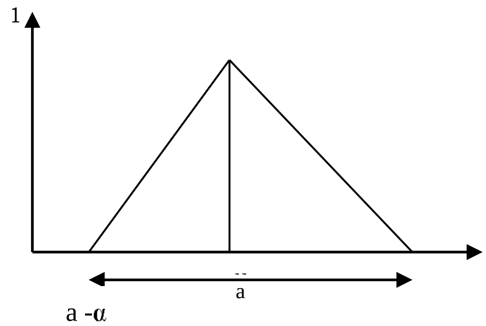

Figure 2: Triangular fuzzy membership number

Fuzzy systems often learn their rules from experts when no expert gives the rules, adaptive fuzzy systems learn by observing how people regulate real systems [13]. The difference between classical and fuzzy logic is something called "the law of excluded" [14][15]. In standard set theory, an object cannot belong to both its set and its compliment set or to neither of them. This principle presents the structure of the logic and avoids the contradiction of object that both is and is not a thing at the same time [16]. However, fuzzy logic is highly abstract and employs heuristic (experiment) requiring human expert to discover rules about data relationship. Fuzzy Neural network or Neuro-fuzzy system is a learning machine that finds the parameters of a fuzzy system (i.e., Fuzzy sets, fuzzy rules) by exploiting approximate techniques from neural networks [17]. Neuro-fuzzy refers to the combination of artificial neural network and fuzzy logic. It eliminates the individual weaknesses of neural network and fuzzy logic while making most of their best advantages. Fusion of neural network and fuzzy logic (Neuro-fuzzy) is therefore beneficial [18][19][20][21].

3 MODEL DEVELOPMENT

In order to generate variables for the Neuro-fuzzy systems, the Activity Based Costing (ABC) model is used to allocate cost for the IP creation activities. The ABC framework is depicted in figure 3.

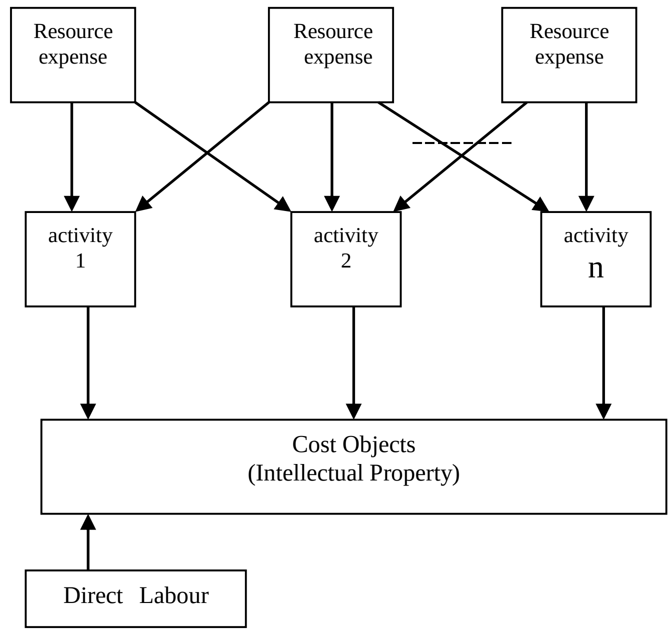

Figure 3: Activity based costing applied to IP Creation.

The activities that goes into IP creation is used as the basis of cost estimation and management.

The consideration is the focus on activities that result from events or decisions, and consume resources in order to produce output. That is cost allocation for IP creation is moved from central cost centers to discrete units of activity. A database whose schema is designed to manage data based on the ABC model would be suitable.

The proposed neuro-fuzzy model is developed in three main stages – the first using statistical method to pre-process the data on the cost of IP creation, the second using neural networks to develop relative final cost weighing of predictors and lastly using fuzzy sets to predict final cost. These stages are detailed below:

3.1 Stage one: Data and Data pre-processing

Historic data of IP creation cost is required here. It is assumed that the data base logical storage structure corresponds to the Activity Based Costing structure, where the cost of IP creation is not seen as a single value but broken into activities, in which cost or resource is allocated to each activity.

The data required for the model is collected from such a database. The collected data is processed so as to structure and present the data to the model in the most suitable way. For the model, extreme values and others are either removed or deleted from the sample set and missing values replaced with the mean or mode. The activities that make up the creation of the IP constitutes the variables in this model, for instance if n activities is required to create an intellectual property, they n variables are used in the model.

3.2 Stage two: Neural network stage of the modeling is developed to determine a consistent numerical weighting for all the predictors depending on their relative contribution to determining the final cost of the intellectual property creation activities. A given number (possibly 10) of initial predictors is used in a 3-layered feed-forward back-propagation in neural network architecture with final Target cost as output of the model. The samples from the IP cost database is split into three portions probably in ratio of 75:15:102) for training, testing and validation respectively. The best model is developed through an iterative procedure of continually tweaking the neural network parameters i.e hidden nodes and activations, function to produce improved model performance.

Model performance is measured using the correlation coefficient between presented IP cost estimate and output values as well as the sum of squares (S0S) of errors:

SOS = Σ(Ti – Oi)2---------------------------(1)

were Oi is the prediction (network output) Ti is the target (actual value) of the ith data case.

3.3. Stage three: Fuzzy sets modeling.

fuzzy set theory is applied at this stage of the modeling to evaluate the subjective measures of each of the cost predictors in order to predict the final cost. Using,

$$\Sigma \text{ Normalized ranking } = \frac{wi}{\Sigma w} = 1 \text{ ------(2)}$$

the average weighted ranking for each of the variables from the IP cost database sample is normalized to unity in order to generate a standardized index for the subsequent fuzzy set computations (see table 1)

In equation (2), Wi is the average relative weighting of the ith predictor, Σw is the sum of relative weighting of all predictors.

Table 1: Normalized weighted values of the IP cost predictors from the neural network model.

IP creation activity	Activity 1	Acti-v-ity 2	Activi-ty 3	……………	Act-ivity n
Norm-alized ranking	r1	r2	r3	…………….	r n

With mean target cost to predictor plots, all predictors are fuzzified using a set range. The next stage of the fuzzy modeling involves developing membership functions. In developing these, the tolerance index is particularly relevant and constraining the range of possibilities subject to a complex set of influencing variables, quantitatively or qualitatively defined. The tolerance index is vital in order to model the uncertainly in the cost values within a realistic continuum as opposed to a single figure-of-merit.

The IP creation cost prediction from the neuro-fuzzy model would be vital to strategic IP cost management. This would help by providing important information for strategy formulation, evaluation of strategy implementation and highlighting the practical limitation or problems with the adopted IP management strategy.

4. CONCLUSION

Intellectual property is a vital asset of a company. Strategic IP management require strategic IP cost management. This paper proposes a neuro-fuzzy model for predicting IP creating cost. This is to enable Strategic alignment of IP creation activities, IP creation cost with the organization IP management strategy. In the specification of this model, the Activity Based costing model is used as input the model building. This work laid out the framework of the system. This included the extraction, pre processing of the IP cost variables from database, the fuzzification procedure of the variable and through the neural network training procedure. This is in order for the inference engine to output a final cost prediction. This prediction is vital to strategic IP cost management.

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