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Expert System based on Back propagation Network for evaluating Motivational Strategies on Human Resources

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ABSTRACT

The employee turnover ratio is comparatively very high in Information Technology industry. Because of time constraint, HR managers are not able to identify the preferences of each employee in the process of designing motivational strategies. Hence, there is need for an expert system, which can help HR managers in designing motivation strategies. We are working on development of expert system on Human Resource domain, which can help in reducing employee turnover ratio by knowing the employee's preferences on motivational strategies.Evaluation of motivational strategies is a real world problem where we try to evaluate whether an employee will prefer motivational strategies or not. It is extremely difficult to generalize the employees' preferences on motivational strategies, and when generalization is difficult, literature suggest that back propagation network is the best-suited method. The paper presents the use of back propagation network for developing an expert system for evaluating motivational strategies on human resources. We use MATLAB for implementing our Expert system based on Back propagation algorithm. The personal data of around 200 employees are collected from six companies to form an input. Current implementation is a prototype with two motivational strategies is evaluated. The output would be yes or not for each motivational strategy for each individual employee. The yes indicates that employee will prefer the motivational strategy, and no indicates that employee will not prefer the motivational strategy. The back propagation network used the record set of 200 employees for learning. Then we tested additional 20 records based on the weight set generated while learning. We repeated the entire process twice to compare the results for accuracy and consistency. To generate two different weight set, we make algorithm learn on the same input record set twice. We observed 85% to 90% consistency while comparing the results for both motivational strategies. It indicates that employees' preferences are correctly identified in favour of motivational strategies by using our expert system.

The record set used as an input has private and confidential information of employees, so we are not in a position to disclose those details in the paper.

Key Words

Back propagation algorithm, Expert system, Self learning Networks, Generalization, Motivational strategies, and human resources

1.0 INTRODUCTION

First, we should try to understand the terms Artificial Neural Networks, Back propagation Networks and Expert system.

1.1 Artificial Neural Networks (ANN)

Artificial Neural Networks (ANN) are loosely modeled after the brain. It is mostly used for complex problem solving where there are multidimensional inputs, which are real valued, and output, which is also real valued, but designing the process logic is very complicated.

ANNs are networks of interconnected simple units that are based on simplified model of brain. The human brain is an interconnected network of 10^{11} neurons. There are mainly two types of ANN networks. Feed forward networks and recurrent networks. Each ANN is composed of collection of perceptrons grouped in layers. (Negnevitsky, 2008) There are three layers in ANN. Input layer, hidden layer and output layer. The three-layer network can be converted into multilayered ANN by placing more than one hidden layer between input and output layer.

ANNs provides suitable solution where problem domain is complex, where training data is noisy. ANNs are effective in solving problems whose solutions are very difficult to determine. The ANN is widely used when problem solving involves human characteristics that are difficult to simulate using logical and analytical techniques. (F.D. Nittis, 1998)

1.2 Back propagation Network

Back propagation network is the most commonly used learning technique of ANN. It is multilayered feed forward network of ANN. It has three layers of units. Input layer, hidden layer and output layer. Typically, units are connected in feed forward fashion where input units are fully connected to units in hidden layers and units in hidden layers are connected to units in output layers. (chakraborthy, 2010) It is a systematic method of training multilayer neural network. It is also considered as generalization of delta rule for non-linear activation functions and multi layer networks, because it is

capable of expressing rich variety of nonlinear decision surfaces. It is mainly used in supervise learning where target outcome is already known.

Back propagation algorithm is the mostly used when higher accuracy is required for the solution in problem domain. (Networks, 2007) Back propagation is must when generalization of rules is a serious issue. (Zhang Zhiyu, 2010) In the domain of human resources, in which we are working to evaluate employee's preferences on motivational strategies, where framing of rules like if... then; else... then are very difficult.

1.3 Expert systems

Expert systems are system, which mimics human expert. Expert systems need substantial domain knowledge like human expert to solve problems. (Elaine Rich, 2009) Expert systems are the most suitable when we need to automate human based expert processing, either when the experts are scarce or cost benefit analysis is not in favor of using human experts. ANN based Expert systems are useful when it is very difficult to derive and acquire rules which drives the decision making process. This is more important when, the expert system requires experience to learn and improve their decision making process. (Padhy, 2005) Expert system only work for the domain in which it has acquired knowledge. The problem outside the domain knowledge cannot be solved by the expert system.

Hence, we will first try to define the problem statement and domain in which the proposed expert system is developed.

2.0 PROBLEM DEFINITION

The problem statement is as follows:
"Whether an employee will prefer in favour of the motivational strategies formulated by employers or HR managers"

2.1 Problem Description

When we interacted with friends from the IT industry or alumni of our institute, who has become entrepreneur, we found out that the biggest challenge lying with HR managers or Employers is to reduce the employee turnover ratio in their department or organization. To counter the problem successfully, they devise motivational strategies. However, the devised strategies only represent the employers or HR manager's perspectives and preferences. (Swansor, 2001) At the same time, when we interacted with employees of the companies, we came to know that while devised motivational strategies, HR mangers neglect the preferences of employees (Human resource). The Expert system, which we developed, is evaluating motivational strategies from the preferences of individual employees.

The process of development of an expert system will result into framing of better motivational strategies for employee retention and likely to result in reducing employee turnover ratio.

2.2 Problem justification

Human Resource is a domain where deriving and acquiring rules for motivational strategy and employees' preferences are very difficult. It requires human expertise. HR managers and employers possess the required expertise and they frame motivational strategies with the input from employees. But imagine a scenario in a medium sized company where on an average more than 200 employees are working. If HR manager spend on an average one hour to interact with each individual employee and in a day if he can interact with four employees, then he requires around two months time to complete one round of interaction with employees. Hence, it is very difficult for HR Managers and employers to devote time and to know the preferences of each individual employee. Moreover, the preferences of an employee change over a period because of change in their perception. Hence its tough job for HR managers or employers to keep track of it.

Thus, it is very hard to find either enough numbers of experts who can do it or experts who have enough time to interact regularly with employees. Hence, this problem is ideally suitable for a development of Expert System.

3.0 RESEARCH METHODOLOGY AND PREREQUISITE

The research methodology used here is the combination of experiment, quantitative data collection and analysis.

Here MATLAB is used as a development platform for an expert system. For creating a learning set of data for back propagation network, we collected records of more than 200 employees from six IT companies based in Ahmadabad. The record collected includes the personal details of employees and their preferences in favor of Motivational strategy. The system here is at prototype stage, so we evaluated two motivational strategies for test data.

We apply back propagation algorithm on learning set data and generated two different weight sets. For each weight set, the test data are tested, which result in to two answers. If both the answers are similar then, you can verify the accuracy and consistency of the result.

3.1 Justification of MATLAB as tool: -

The following are the features, which MATLAB provides.

- It is mathematical scripting language where syntax are like C/C++.
- It supports object-oriented programming.
- It provides API which includes GUI and interface building.
- It is an interactive tool whose basic data elements in array that doesn't require dimensioning.
- MATLAB can handle matrix up to 500 rows and 500 columns, and all the matrix manipulation functions are defined, which in turn reduced the coding complexity.
- MATLAB runs 2.5 time faster than C/C++. (Jamshid Nazari, 1992)

3.2 Short coming of conventional rule based approach and need for new approach

We have two options. Either develop rule based expert system or use back propagation network to develop expert system. Knowledge in a rule base expert system is represented by If-Then logic rules. The knowledge here can be collected from human experts, which is very difficult task in our proposed expert system. Second once the knowledge is stored in knowledge base, then it is difficult to adapt to the new

environment by adding, changing or deleting rules. (Negnevitsky, 2008)
The knowledge in neural network is stored as synaptic weights between neurons. The knowledge here obtained in learning phase when training set of data is presented to the network. Every time new data set is added, you can make neural network learn again and over period of time, the learning improves. Thus, new knowledge can be incorporated every time network learns.

HR managers told us that framing a generalize rule base for evaluating motivational strategies from employees' preferences is very difficult task. In that case, one need to adopt the approach which not only provide accuracy, but also adapt to the changing environment as employee's preferences are going to change over a period of time. Considering the above facts, we decided to use back propagation network for development of expert system

4.0 DESIGN OF EXPERT SYSTEM

In this section, we are going to describe how we developed expert system to evaluate motivational strategies on human resources.

4.1 Input

Employee's motivation depends on their unique talent and aspiration. (Norgarrd, 2001) Employee's personal factors and family factors influence on their preference in favor of motivational strategies. We interacted with HR managers and employers to find out these personal factors and family factors. Based on the interaction, we considered above factors as an input for our expert system. We recorded the personal details and family details of almost 200 employees from six IT companies. The factors are mentioned below.

Employee name, Employee Date of Birth, Sex, Present Location, Education Qualification, Current level of hierarchy, Work experience (years), Current Gross salary(CtC), Marital Status, No of years of marriage life(if married), Parents' dependability, Parent's salary (if parent's are independent), Spouse' Occupation (if married), spouse's nature of job, spouse's salary, No. Of Children, Child's status (Dependent/Independent), Number of other Dependent family members, total family income (per month).

The above-mentioned detailed might not be applicable to each employees. For example, if person is unmarried then he might not be able to provide the details about spouse job, salary and no of children.

4.2 Motivational strategies

Motivational strategies are classified mainly into four categories. (Nagori, Analysis of impementation of incentive strategies based on motivational theories in the Indian IT inudstry., 2007)

1. Perks/incentive
2. Stress reliever and performance booster activities
3. Training and development activities
4. HR policies

As expert system is at prototype stage, we decided to focus on only one category, i.e. Training and development activities.
Under training and development activities, there are various sub policies, which act as motivators are mentioned below. (Nagori, Training and development activities: A tool for employee retention, analysis of SME of Indian IT industry., 2009)

i. Orientation/ induction training
ii. Employee exchange program
iii. Off shore training
iv. Allocation to on site projects or foreign projects
v. Arrangement of workshops/ seminars to acquire skills
vi. Refresher program
vii. Soft skills training
viii. Personality development program
ix. Financial assistance/ course fees for short term course or further studies

Out of the above mentioned, we selected the following two policies for evaluation by an expert system.

i. Allocation to on site projects or foreign projects (Policy 1)
ii. Financial assistance/ course fees for short-term course or further studies (Policy 2)

4.3 Additional inputs

For the evaluation of above policies, the following important factors also act as an input.
For the policy 'allocation to on site projects or foreign projects', we collected the details like Employee expectation of increment from current salary and employee's expectation of reallocated designation.

For the policy 'financial assistance/ course fees for short term course or further studies', we collected the following details in addition to the above mentioned details like reallocation location and distance in kilometers between present location and reallocated location.

4.4 Output

For both the policies, the output will be either yes or no, where yes indicates employee's preference for the policy in favour and no indicates employees preference against of the policy.

5.0 Development of Expert System

We use MATLAB as a development platform for the expert system.

For evaluation of policy 'financial assistance/ course fees for short term course or further studies' the following factors are considered as an input. Age, current city, sex, Education qualification, current level of hierarchy, work experience, current salary, expected increment in salary after completion of course, reallocated hierarchy after completion of course, reallocation location, distance in kilometers between present location and reallocation location, marital status, and no of years of marriage(if married).

For evaluation of policy 'allocation to onsite projects/ foreign projects' the following factors are considered as an input. Age, Sex, current city, education qualification, current level of hierarchy, work experience, current salary, expected increment in salary if allocated to foreign projects, reallocated

hierarchy in project assignment, parent's dependability, parents' salary (if independent), marital status, spouse's nature of job, spouse's salary, No. Of Children, Child's status (Dependent/Independent), Number of other Dependent family members, total family income (per month).

The summarization of input is given in the following table.

Table 1. Summarization of input

Policy 1 'allocation to onsite projects/ foreign projects'	**Policy 2 'financial assistance/ course fees for short term course or further studies'**
Age	Age
current city	current city
sex	sex
Education qualification	Education qualification
current level of hierarchy	current level of hierarchy
work experience	work experience
current salary	current salary
expected increment in salary if allocated to foreign projects	expected increment in salary after completion of course
reallocated hierarchy in project assignment,	reallocated hierarchy after completion of course,
parent's dependability	reallocation location
parents' salary (if independent)	distance in kilometres from present location
marital status	marital status
spouse's nature of job	no of years of marriage(if married)
spouse's salary	
No. Of Children	
Child's status (Dependent/Independent)	
Number of other Dependent family members	
total family income (per month)	

For programming purpose all inputs are converted in numbers. Age can be derived from Date of birth. We considered three levels for education qualification. 1 for non graduate, 2 for graduate, and 3 for postgraduate. Similarly, for level of hierarch, we considered 1 for lower level, 2 for middle level and 3 for top level. For sex, we considered 1 for male and 2 for female. For reallocation location, we considered following levels. 1 for the same city, 2 for different city, but same state, 3 for different state, and 4 for another country. For marital status, we considered 1 for married and 2 for unmarried. For dependability status, we considered 1 for independent and 2 for dependent.

The following table will summarize the above details.

Table 2. Conversion of input into numeric's for programming purpose

Actual input	**Input in program**
Education Qualification	1- Non graduate 2- Graduate 3- Post graduate
Level of hierarchy	1- Lower level 2- Middle level 3- Higher level
Sex	1- Male 2- female

Reallocation location	1- same city 2- different city, but same state 3- different city, different state 4- different country
Marital status	1- married 2- unmarried
Dependability status	1- independent 2- dependent

5.1 DEVELOPMENT PROCESS

Expert system development based on back propagation algorithm has two steps. Learning and testing. We did learning based on 200 records and considered it as a training data set. For the learning three parameters are passed in the algorithm. Learning rate, momentum rate and error. Learning rate is kept at 0.35 throughout the learning. While momentum rate is kept zero for the first thousands iteration and then it is kept at 0.90 for the remaining iteration. Error is kept at 0.01. The numbers of nodes in input layer are kept at 4 and number of nodes in hidden layers are kept at two in back propagation network. The maximum 2000000 iterations are allowed.

The following table will summarize the development process.

Table 3. Summarization of variable values for development process

Criteria	Value
No of records in training data set	200
Learning rate	0.35
Momentum rate first 1000 iterations remaining iterations	 0 0.90
Error	0.01
Nodes in input layer Policy 1 Policy 2	 13 18
Nodes in hidden layer	4
Maximum iterations	20,00,000
Learning on training data set	twice

Initially random weights are assigned to all the layers. The learning process of algorithm will stop when either maximum numbers of iterations are completed or the error falls below 0.01. When learning is over, final weights are stored for testing the test data set. The entire learning process is repeated twice, so that result generated for test data set based on two weights can be compared and analyzed.

For the policy 1, learning stop at 20,00,000 iteration, at that time the error was 0.0385. For the policy 2, learning stop when error falls below 0.01, at that time the iteration were 19,29,311.

The testing has been done for 20 records which were termed as test data set. The test data set is different from the learning data set.

The following result will summarize the learning process on training data set.

Table 4. Summarization of variable values for learning process

Policy	Iterations	Error
Policy 1	20,00,000	0.0385
Policy 2	19,29,311.	0.01

The output generated by the back propagation algorithm ranges between 0 to 1. Where zero indicated that employee will not prefer the motivational strategies and 1 indicates that employee will absolutely prefer the motivational strategies. When output is greater than 0.50, we considered answer as yes and for the output less than 0.50, we considered answer as no.

Table 5. Criteria for output classification

Output Value	Output
>=0.50	Yes
<0.50	No

5.2 Result analysis

The following table will provide the result analysis.

Table 6. Result analysis after testing

Parameters	Policy 1	Policy 2
No of records Tested	20	20
No of records where answers generated by two weight set are similar	17	18
No of records where answers generated by two weight set are different	3	2
No of records where answer generated by two weight set and actual answer is similar	16	15

The above table indicated that in 16 test cases out of 20, answer generated by expert system and actual answer by employees is similar for policy 1. It means an expert system is able to evaluate motivational strategy from an employee's preferences. Similarly, for policy2, in 15 test cases out of 20, it is able to evaluate motivational strategy correctly. It means the accuracy for policy 1 is 80% and accuracy for policy 2 is 75%. In addition to that, If we take the scenario into consideration when answers generated by both weight set are similar and compare it with actually answer by an employee then for policy 1, 16 out of 17 are meeting consistency criteria. Similarly for policy 2, 15 out of 18 are meeting the consistency criteria. It means that consistency for policy 1 is close to 94% and for policy 2, consistency is 83%.

Considering further analysis of the test cases where the answers given by both the weight set are different, the following results were obtained.

Table 7. Result analysis when in numeric values when answers generated by two weight set are different

Policy	No of records where answers generated by two weight set are different	Numeric value when answer is yes		Numeric value when answer is no		Difference in numeric terms when answer is different	
Policy 1	3	Test case	Answer	Test case	Answer	Test case	Difference
		1	0.56	1	0.48	1	0.08
		2	0.52	2	0.46	2	0.06
		3	0.59	3	0.38	3	0.21
Policy 2	2	Test case	Answer	Test case	Answer	Test case	Difference
		0.54		1	0.47	1	0.07
		2	0.51	2	0.49	2	0.02

The above result indicates that when answers of the test cased generated from two-weight set are different, the difference is less than 0.1 in four cases out of total five cases.

5.3 Result interpretation

If any system developed using ANN then accuracy and consistency of about 80% is acceptable. (Sharda, 1994) The expert system developed by us is meeting the standards. In addition, in remaining test cases, the difference is less than 0.1, which is acceptable. We can obtain better accuracy and consistency if more no of records are used for learning process in training data set. The following table will summarize the result based on accuracy and consistency.

Table 8. Summary of result based on the parameters of accuracy and consistency.

Parameters	Policy 1	Policy 2
Standard Accuracy (%)	80	80
Actual accuracy (%)	80	75
Standard consistency (%)	80	80
Actual consistency (%)	94	83

The employee's actual preferences in Yes or No for policies are known for the test data set. The employees personal details and family details collected for learning data set and test data set are not revealed here to their maintain their privacy and confidentiality.

6.0 LIMITATIONS

Expert system should have two major components: Inference Engine and Explanation facility. (Viral Nagori, Dec, 2011) Here ANN acts as an inference engine. However, the basic limitation of ANN is that it cannot provide explanation facility. Hence the expert system developed by us based using back propagation algorithm doesn't have explanation facility.

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