MAPPING OF KNOWLEDGE ENGINEERING PROCESS INTO THE EXPERT SYSTEM DEVELOPMENT ACTIVITIES

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Abstract— The process of developing an intelligent system is called knowledge engineering. Here we are describing the different phases of knowledge engineering process and then mapped them into the expert system development activities. The activities are describing the design and development of neural network based expert system prototype for evaluating and structuring motivational strategies from employees' perspectives on ICT human resources.

Index Terms— Expert System, Knowledge Engineering, Motivational Strategies, Neural Network.

I. INTRODUCTION

The process of building intelligent knowledge base system is called knowledge engineering. Expert systems are also considered as one type of intelligent systems. The approach for developing the conventional system is known as SDLC (System development life cycle). While the approach for developing an expert system is known as knowledge engineering. Here we are describing the phases of knowledge engineering process and mapping them into the activities we carried out for the design and development of expert system prototype. We are using neural network technology to implement the prototype. The expert system we developed is addressing the problem of human resource management and the sub domain of motivational strategies. Our expert system evaluates and structure motivational strategies from employees' perspectives on ICT human resources as compared to the conventional motivational strategies designed from employers' perspectives.

The knowledge engineering is a six phase process. [1] The phases are:

1. Problem assessment
2. Data and knowledge acquisition
3. Development of a prototype system
4. Development of a complete system
5. Evaluation and revision of the system
6. Integration and maintenance of the system

II. PHASE 1 – PROBLEM ASSESSMENT

The phase has four main activities. [2]

- Determine the problem's characteristics
- Identify the main participant in the project
- Specify the project objectives
- Determine the resources needed for building the system.

Now we are going to describe the activities carried out in this phase for design and development of the expert system prototype.

A. Determining the problem characteristics

The first step in problem assessment phase is to determine the problem type and then determine the problem characteristics. Typically problem can be of following types: diagnosis, selection, prediction, classification, clustering, optimisation and control. Our expert system prototype can be classified under the problem

type of prediction and classification. The justification for the classification of the prototype is that our expert system predicts whether an employee will prefer a particular set of motivational strategies or not and then classify set of motivational strategies into motivators and non- motivators.

B. Identifying the main participants in the project

The main participants involved in the design and development of expert system are Owner/Director/CEOs HR managers, and employees working in ICT based companies, me and my research guide, Dr. Bhushan Trivedi. HR managers act as domain expert, who helped us in listing of motivation strategies practiced in the ICT organisations. Employees have provided information about their demographics, and their preferences on motivational strategies. The information given by employees serve as a basis for our training, testing and validation data set. We, i.e. me and my research guide acted as knowledge engineers. We implemented neural network based expert system using back propagation algorithm and took decision about various parameters of algorithm like learning rate, momentum rate, number of hidden layers, number of nodes in hidden layers and activation functions.

C. Specify the project objectives

The main objective of our project is to provide automated solution which can evaluate motivational strategies from employees' perspectives and in turn helps HR managers to structure their motivational strategies in such a way to increase employee retention and reduce employee turnover ratio.

D. Determining the resources needed for building the system

The resources, which are required for developing the expert system prototype are laptop with 4 GB RAM and high processing speed, MATLAB as development tool, literatures on Neural network based expert systems, textbooks and web materials to understand and implement neural network, web hosting and server space to host our website for data collection and money to buy the above resources.

III. PHASE 2- DATA AND KNOWLEDGE ACQUISITION

The phase has two main activities. [2]

- Collect and analyse data and knowledge
- Make key concepts of the system design more explicit

Now we are going to describe the activities carried out in this phase for design and development of the expert system prototype.

A. Collect and analyze data and knowledge

The data, which we are going to collect, are from primary sources. The primary sources of data are responses from HR managers and employees working in different ICT based companies. During the collection process, we converted the data into nominal scales before storing it into the knowledgebase. The data which we require is list of motivational strategies, employees' demographic information and their preferences in yes or no for each motivational strategy. The demographic information include age, gender, education qualification, marital status, current level of hierarchy, and current salary. The conversation into the nominal scale is as follows. For example., Gender, Let say 1 for male and 2 for female. Similarly, for age, we used the following nominal scales: 1 for age from 18 to 25, 2 for age from 26 to 35, 3 for age from 36 to 50, and 4 for age above 50 years. The conversion of employees' demographic information into nominal scale is given in the table I. Similarly employees preferences for motivational strategies are stored as 1 or 0., where 1 indicates yes and 0 for no.

During the processing of collected data, if we come across the inconsistent and missing data, we have to discard the entire record set of that particular employee. Let say if employee has not provided his current salary figure, then we can't just assume an average value and convert into a nominal scale and then store it in our knowledge base. The wrong values from knowledge base into our training data set might lead to wrong training for neural network and in turn will result into wrong prediction of the output.

Table I – conversation of demographic information into nominal scale.

Demographic factors	Conversion into nominal scale
Age	1. 18-25 years 2. 26-35 years 3. 36-50 years 4. 50+ years
Education Qualification	1. Non graduate 2. Graduate 3. Post graduate 4. Doctoral
Level of hierarchy	1. Lower level 2. Middle level 3. Higher level
Work Experience	1. 0-2 years 2. 2-5 years 3. 5-10 years 4. 10+ years
Sex	1. Male 2. female
Current Salary (PM)	1. <20000 Rs. 2. 20000-50000 Rs. 3. 50000-100000 Rs. 4. > 100000 Rs.
Marital status	1. married 2. unmarried
Dependability status	1. independent 2. dependent
Spouse's nature of job	1. Government 2. Private 3. Temporary 4. Housewife
Nos of children	1. 0 2. 1 3. 2 4. 3+

B. Make key concepts of system design more explicit

The key knowledge areas for our project are divided into two parts. One is related to problem domain and second is related to neural network technology. The key concepts related to domain are list of motivational strategies and classifying them into different categories, employees' demographic information. The key concepts related to neural network technology are inference engine, which is the one of the component of neural network itself, and knowledge base, which consists of employees' demographic information and their response on their preferences towards the motivational strategies.

IV. PHASE 3 – DEVELOPMENT OF A PROTOTYPE SYSTEM

This phase involves creating an intelligent system or rather a small version of it – and testing it with a number of test cases. The major activities in this phase are: [2]

- Choose a tool for building an intelligent system
- Transform data and represent knowledge
- Design and implement a prototype system
- Test the prototype with test cases.

Now we are going to describe the activities carried out in this phase for design and development of the expert system prototype.

A. Choose a tool for building an intelligent system

We have chosen MATLAB as a tool for the development of the expert system prototype. The reason behind choosing MATLAB is powerful library functionalities and ability to handle large and complex data.

B. Transform data and represent knowledge

The data collected are placed in MS Excel to represent knowledge. Each motivational strategy has a separate excel file which stores relevant factors of employee demographic information for that strategy and their responses on preferences of that strategy. These record sets represent the knowledge for the expert system.

C. Design and implement a prototype system

A prototype is a small working version of the final system. It is designed to test how well we understood the problem, and our choice of problem solving strategy, the tool selected for building a system, and techniques for representing acquired data and knowledge are adequate or not.

We initially developed a prototype on a very small scale for our neural network based expert system. We called this prototype as proof of

concept our approach to solve the problem on hand. The prototype was tested successfully, but due to inherent limitation of C++ to handle large and complex data and its manipulation is very time consuming. Because of this, the learning time for the neural network increased drastically; hence we implemented our prototype using MATLAB and tested it for different test cases.

D. Test the prototype with test cases

We tested our expert system prototype with 40 test cases. The actual response of the employee's preferences for motivational strategy is known to us is compared with the response generated by our prototype model. Based on the comparison, we determine the parameters to decide the success and failure of the model. The parameters are accuracy and consistency. The accuracy and consistency is above 90% for all the cases for our prototype model, which is found to be satisfactory in line with the results of other such systems.

V. PHASE 4 – DEVELOPMENT OF A COMPLETE SYSTEM

Once the results of the prototype are functionally satisfactory, the next step is to develop a plan, schedule and budget for the complete system and define the system's performance criteria.

The major activities in this phase are as follows. [2]

- Prepare a detailed design for a full scale system.
- Collect additional data and knowledge.
- Develop the user interface.
- Implement the complete system.

Now we are going to describe the activities carried out in this phase for design and development of the expert system prototype.

A. Prepare a detailed design for a full scale system

We developed a complete knowledge base for our prototype model. Our knowledge base is in the form of MS excel where for each motivational strategy, a relevant employees' demographic information and their preference for that motivational strategy is stored. In the next step, we fine-tuned and decided the values of the important parameters like momentum rate, learning rate, activation function, number of nodes in hidden layer, number of nodes in input layer and number of hidden layers of back propagation algorithm.

B. Collect additional data and knowledge

We collected data from the primary source; employees working in ICT based industries. We received response from more than 200 employees. The data we collected was about employees' demographic information and their preferences on motivational strategies. We also collected responses from HR managers about their viewpoints on the which set of combination of demographic factors should be input for which motivational strategy.

C. Develop the user interface

In the initial stage of the prototype development, we have user interface based on command line instructions and text based inputs. In the later stage while implementing the full prototype, we switched over to Graphical User Interface (GUI). GUI enables easy to user interface for the end users where they have to select few values given from the list. The end user of our system will be HR managers who will try to find out preferences of employees on motivational strategies employed in the organisation.

D. Implement the complete system

We have implemented the complete system using MATLAB as a tool and the system is thoroughly tested and we obtained desired results in terms of accuracy and consistency.

VI. PHASE 5 – EVALUATION AND REVISION OF THE SYSTEM

The major activities in this phase are as follows: [2]

- Evaluate the system against the performance criteria.
- Revise the system as necessary

Now we are going to describe the activities carried out in this phase for design and development of the expert system prototype.

A. Evaluate the system against the performance criteria

We evaluated our system against the performance criteria set up by such other neural

network based system. From the literature review, we found out that if such system achieves the 80% of the accuracy, then system is considered to be functioning properly. [3] Our prototype model has been able to achieve the performance criteria.

B. Revise the system as necessary

Once the performance criteria have been achieved, we implemented the system in the live environment of the organisation. We revised the system later on to add the functionalities like knowledge update facility, and explanation facility. Knowledge update facility will add the new knowledge into the existing knowledge base.

Conventional neural network based systems do not have explanation facility, but in our prototype model, we introduced the explanation facility where the model states the reason for the answer predicted in the form of explanation.

Later on, we also added batch processing functionality for learning of our neural network based model. As of we have total 47 motivational strategies in different categories. Before testing, neural network model has to go through the process of learning. The process of learning may take time of few minutes to few hours depending on the set of values and size of the training data set. We introduces the batch processing learning mode, so that when system is in idle state, it can run for all motivational strategies one by one in sequential manner. Once learning is over, system is ready for the use; hence when HR mangers want to use they don't have to waste their time while system learns.

VII. PHASE 6 – INTEGRATION AND MAINTENANCE OF THE SYSTEM

This is the last phase in the process of knowledge engineering. It involves integrating the system into the environment where it will operate and establishing an effective maintenance program for the future.

The phase has following main activities. [2]

- Make arrangement of technology transfer
- Establish an effective maintenance program

Now we are going to describe the activities carried out in this phase for design and development of the expert system prototype

A. Make arrangement of technology transfer

By integrating means, we need to provide interface for our prototype model with existing systems in the organisation. In our case there is no existing system which can automate the task of evaluation of motivational strategies from employees' perspectives.

B. Establish an effective maintenance program

Maintenance activities mainly consist of two parts. They are: corrective maintenance and preventive maintenance. We have thoroughly tested the system and after removing errors, we implemented it in the live environment of the organisation.

As knowledge base system evolves over time because of change in knowledge. Hence there is need for knowledge update facility. In our system, we have provided knowledge update facility where new knowledge is incorporated into the existing knowledge. Once the new knowledge is incorporated, the neural network model needs to relearn before it is ready for the testing. For this reason, we provided learning facility in the batch mode. The above remedy act as preventive maintenance and prevent our system to become obsolete in the short time.

VIII. CONCLUSION

The figure 1 shows the phases of process engineering and mapping of its activities into the design and development of neural network based expert system for evaluating and structuring motivational strategies from employees' perspectives. The developed expert system will help HR managers to design and implement customized motivational strategies and hence in turn help them to reduce employee turnover ratio.

The main purpose of this research is to showcase the path to the developers of the intelligent system on how to follow the process of knowledge engineering through the case study of our neural network based expert system. Based on our case study of knowledge engineering

process, we are here by able to form the guidelines for the process of knowledge engineering. The guidelines are given below.

- Determining the problem domain, definition and characteristics are the first activities for the starting of knowledge engineering process.
- The identification of knowledge engineering teams especially the domain experts and knowledge engineer is important.
- Data collection and choice of the tool for development is the most critical aspect of the entire knowledge engineering process.
- Setting up the performance evaluation criteria which is at par with the other similar kind of system is very crucial for determining the success and failure of the system.
- Design of easy to use GUI is equally important to technical configuration of the system.
- Maintenance activities need to be planned in advance for the knowledge base systems.

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Phases	Activities	Mapping
Problem Assessment	Determine the problem characteristics	Problem type is prediction and classification.
	Identify the main participant in the project	HR mangers as domain experts, ICT employees, me and my research guide as knowledge engineers
	Specify the project objectives	Increase employee retention and reduce employee turnover ratio
	Determine the resources needed for building the system	Hardware, software, web materials, text books, web server and money
Data and knowledge acquisition	Collect and analyze data and knowledge	Employees' demographic information and their preferences on motivational strategies
	Make key concepts of system design more explicit	Inference engine and knowledge base
Development of a prototype system	Choose a tool for building an intelligent system	C++ and MATLAB
	Transfer data and represent knowledge	Knowledge base in the form of excel sheet
	Design and implement a prototype system	Prototype with limited set of records and proof of concept
	Test the prototype with test cases	40 test cases and tested for the parameters of accuracy and consistency
Development of a complete system	Prepare a detailed design for a full scale system	Fine tunning the parameters of back propagation netwrork
	Collect additional data and knowledge	More than 2000 records in the training data set of neural network
	Develop the user interface	GUI based user interface
	Implement the complete system	Implemented in the live environment of organisation
Evaluate and revision of the system	Evaluate the system against the performance criteria	80% and above accuracy and consistency
	Revise the system as necessary	Knowledge update facility, explanation facility and batch processing mode for relearning
Integration and maintenance of the system	Make arrengement of technology transfer	No old existing system
	Establishing an effective maintenance program	Preventive maintenace in the form knowledge evolution and updation

Figure 1: Mapping of knowledge Engineering process into knowledge engineering activities