Conclusion

7.1 Contributions Drawn from the Research
7.2 Outcomes and Advantages
7.3 Applications in Other Areas
7.4 Limitations and Future Scope
7.5 Dissemination
   7.5.1 International Journal Papers
   7.5.2 National/International Conferences
Artificial Neural Networks are powerful distributed information-processing systems composed of many simple computational elements interacting across weighted connections. Inspired by the architecture of the human brain, ANNs exhibit features such as ability to learn through examples and generalize learned information, and ability to interpolate from incomplete information. ANNs can model extremely complex features. ANNs contain complicated learning algorithm to solve complex problems but they lack user friendly interface as they take crisp and normalized data as input and preparation of crisp data sets is tedious task. Moreover, real world problems follow human approach that involves vagueness, imprecision and uncertainty, which cannot be implemented through ANN. The decision making algorithms in ANN assist in taking complicated decisions but does not give the justification for the decision being given as output. Hence if ANN could be integrated with a kind of interface that overcomes these limitations then overall performance of ANN can be enhanced. This chapter discusses contribution drawn from the research, benefits and application in other areas. This is followed by a brief outline of some possibilities for future research. Finally dissemination of this research is listed.

7.1 Contributions Drawn from the Research

The following summarizes the contributions drawn from this research and the objectives met:

The first broad objective set was to develop a framework and a prototype for ANN based for employee evaluation. The contributions in this regard are as follows:

- Identification of significant parameters for effective user interface and determining significance level of each one of them.

The core of the research was to prove that the ANN lacks an effective interface, for which it was necessary to understand what an effective interface is. The study in this regard led to identify significant parameters that increase effectiveness of user interface. Apart from this it was
necessary to understand that out of all parameters which parameters have significant influence in increasing effectiveness of user interface.

• Comparative study of significant parameters for effective user interface against fuzzy logic characteristics to justify how fuzzy logic can serve as an effective user interface.

The major focus of the thesis is to evaluate if fuzzy logic can serve as an effective interface. Hence second important contribution done is to identify features of fuzzy logic that go with parameters that make user interface effective.

• Identification of significant employee evaluation parameters.

A case of employee evaluation is considered to carry out the experiment to prove that fuzzy logic is effective user interface tool in general and it can serve as effective user interface tool for ANN in particular. As a part of experiment a mere ANN based employee evaluation system is developed as well as neuro-fuzzy employee evaluation system is developed. To implement employee evaluation system identification of parameters is done on the basis of which an evaluator gives ratings to an employee.

• Designing framework for ANN based employee evaluation system and implementing it to exhibit limitations of ANN from user interface perspective.

ANNs have found its application in varied fields. ANNs are suitably applicable for decision-making making problems. Employee evaluation is one such decision making problem for which ANN based system is developed. ANN with input nodes representing aggregate value for evaluation parameters based on general qualities of employee and aggregate value for evaluation parameters based on specific field of work is developed. The ANN has one output node that gives decision if an employee is to be retained, removed or has to improve. The contribution in this regard is implementation of ANN based employee evaluation system and highlighting that though ANNs have several features which make them attractive prospects for solving real world problems they are less user friendly as they lack effective user interface.
The second broad objective set was to develop a hybrid generic framework for base ANN with fuzzy interface that provides combined advantages of knowledge representation, learning and explanation. The contributions in this regard as follows:

- Designing framework for neuro-fuzzy employee evaluation system and defining membership functions and weight matrices for fuzzy evaluation parameters.

  The next contribution is overcoming user interface limitations of ANN by enhancing ANN based employee evaluation system with fuzzy interface. The evaluation parameters for evaluating an employee are more or less fuzzy. Since the evaluation parameters are fuzzy they are expressed in form of sets for which fuzzy membership functions are defined. Moreover, since evaluation parameters are not equally significant at all the levels in the organizations, weight matrix for each evaluation parameter is defined that indicate which parameter is significant at a particular organizational level.

- Implementation of neuro-fuzzy employee evaluation system to signify fuzzy logic as an effective user interface for ANN.

  Implementation of neuro-fuzzy employee evaluation system comprise of fuzzy acquisition utility to give employee ratings for fuzzy evaluation parameters. Weighted average method is used to obtain aggregate values of parameters based on general abilities and field specific parameters. These values are passed on to ANN to give the evaluation output for which further explanation facility is designed. The neuro-fuzzy employee evaluation system exhibit features such as inputting vague and imprecise data, human perception based information representation, and explanation facility. Hence neuro-fuzzy employee evaluation system is closer to real world, user friendly and has wider user acceptance than mere ANN based employee evaluation system.
The third broad objective set was to establish significance of fuzzy logic as effective interface for ANN by doing comparative analysis of effectiveness of ANN based system for employee evaluation and ANN based system for employee evaluation with fuzzy interface.

- To establish significance of fuzzy logic as an effective interface for ANN a review process is conducted whereby both ANN based employee evaluation system and neuro-fuzzy employee evaluation system are operated by different users. Different users were asked to rate which system is more effective, user friendly and satisfactory. The respondents clearly rated neuro-fuzzy system as better, effective, user friendly and satisfactory against ANN based system.

The fourth broad objective was to document the findings in the form of publications such as research papers, articles and books for future use and training, the list of which is presented in section 7.5 further in this chapter.

7.2 Outcomes and Advantages

The research work signifies fuzzy logic as an effective user interface for enhancing ANN based system. To solve real world problems, people generally follow their perception that involves vagueness, imprecision and uncertainty. Fuzzy logic allows people to provide vague inputs since they follow imprecise heuristics for solving problems and gives justification for the outcome.

The hybridization of fuzzy logic and ANN offers combined advantages of both the techniques. ANN offers advantages of training and self learning and fuzzy logic offers advantages of user-friendliness and explicit knowledge representation for better justification of the given result. Neuro-fuzzy system for employee evaluation is a generic product suitable to different companies. Since the knowledge base is empty, user can define company specific evaluation parameters and evaluation criteria and ANN is trained with company specific data. Thus it is user friendly and flexible. The system provides an opportunity to
make more data driven decision-making that learns from large amount of data, generates employee evaluation output. Thus it supports process of employee reward system, retains key people in organization, motivates employees to perform better, creates healthy competitive environment.

7.3 Applications in Other Areas
The neuro-fuzzy employee evaluation system is a generic product as it considers evaluation parameters that are more or less applicable to any organization in general. Moreover, the knowledge base is empty so the system can be easily implemented for different other domains whereby evaluation parameters and evaluation criteria for a specific domain can be easily defined. The system can be used for different other domains like student evaluation, product evaluation, software quality assurance, performance evaluation of a company, website evaluation, etc with minor modifications.

7.4 Limitations and Future Scope
Although the study has reached the objectives that have been outlined, some limitations have been found that makes possible potential avenues of further research. These are outlined below:

1. In neuro-fuzzy system fuzzy membership functions are predefined and may not equally be applicable to every other domain. Hence, future work can be done in area of extracting dynamic domain specific fuzzy membership functions through interactive user interface.

2. Type-1 membership functions are defined for employee evaluation parameters. However, these parameters are very intricate by nature and as future work type-2 membership functions can be defined.

3. The neuro-fuzzy model for employee evaluation considers only two input nodes for ANN whereby one node takes aggregate value for parameters based on general abilities and second node takes aggregate value for field specific parameters. This can be further extended and each evaluation parameter can be taken as input node to ANN.
4. Neuro-fuzzy approach with rule extraction can be applied where fuzzy rules for employee evaluation can be extracted.

5. The objectivation of fuzzy scales of evaluation parameters is done by defining weights for these fuzzy scales for each evaluation parameter. The system considers manual entry of weights. As future scope ANN can be made to learn assigning weights to evaluation parameters.

7.5 Dissemination
The research described in this thesis has been used in various conference and journal papers. The following is the list of publications and presentations derived from this work.

7.5.1 International Journal Papers
   IMPACT FACTOR: 1.753


   IMPACT FACTOR: 2.080

IMPACT FACTOR: 1.895


7.5.2 National/International Conferences
