Detailed Design of Neuro-Fuzzy Development Framework

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4.1 Introduction

This chapter focuses on design and development of neuro-fuzzy frame work that includes the design and development of source codes for neuro-fuzzy libraries.

The main objective of this chapter is to present design and development of generic library for generation of different kinds of neuro-fuzzy system in various domain areas like education, investment, engineering, medical diagnosis. The generic library discussed in the thesis works in conjunction with designed architecture that generates a framework that helps in automating the development of fuzzy, neuro or neuro-fuzzy system on demand in respective domain area by interactively acquiring different parameters. The chapter includes generic architecture and detailed methodology used for development.

As stated earlier, Artificial Intelligence is gaining importance in the current world scenario due to increasing needs of expert and intelligent system for bias free and human error free working in various domain areas. Neuro-fuzzy is an approach of Artificial Intelligence that deals with designing of expert decision making system that mimics working of a human expert. Artificial neural network consists of group of interconnected neurons which helps in processing information with the help of learning strategies. Artificial neural network is used to computationally simulate working of human brain. Fuzzy logic helps in dealing with the uncertainty which is often acquired by human brain naturally. To provide justification for uncertainty, fuzzy logic uses its logical reasoning capabilities based on rules and membership functions. Type 2 fuzzy logic is extension of fuzzy logic which provides a much better approximation of uncertain conditions. Hybridizing of artificial neural network with fuzzy logic helps in developing of intelligent systems in respective domain areas. The advantage of neuro-fuzzy system is that it can be applied to any domain area like medical, engineering, simulations, biotechnology, biometrics, aviation, robotics, astronomical calculation and many more[1],[14],[15],[16],[20],[21],[22]. Neuro-fuzzy systems are widely used in situation where input conditions are not clearly defined and based on some partial information, proper output is required. Since the introduction of artificial neural networks and fuzzy logic, researches have been carried out on their uses and future extension of these techniques. Intelligent systems have been developed in the individual area of fuzzy logic and artificial
intelligence. Fuzzy systems are broadly used in the areas of linear and non-linear control, pattern recognition, financial systems, operation research, data analysis, health analysis and many more. Artificial neural network based systems are widely used in areas of mathematical problem solving, pattern matching, engineering, simulations, forecasting, deciding space trajectories and areas where the input and output are not clearly defined. Hybridization of these two components gives a neuro-fuzzy based hybrid system. However design of artificial neural network is complicated task and its training consumes time and effort. The artificial neural network will not give proper output until it is trained properly. In similar context when dealing with fuzzy logic it is necessary to apply appropriate rule to generate fuzzy inference on given criteria. Hence there is a need of generic library that aids in development of neuro, fuzzy and neuro-fuzzy systems, the generic library saves much of the time and effort in development as well as training and reduces the man power cost. The generic library also supports in design and development of generic framework for development of neuro-fuzzy system. With the use of the framework it would be easy to create various neuro-fuzzy systems on web or desktop in different domain areas. Till today no such library or tool is available for development of neuro-fuzzy systems. The library consists of reusable codes and can be updated with new research and development in future leading to further research work in artificial intelligence. The library includes existing methodologies [2], [11], [12] and newly researched methodologies [4], [5], [6] in artificial neural network, fuzzy logic and neuro-fuzzy hybridization. The generic library defrays the development cost and even a layman can develop neuro-fuzzy expert advisory system.

4.2 Limitation of Existing Work

Research in the field of artificial neural network and fuzzy logic are being carried out continuously to develop expert systems to aid routine activities of human beings. Researchers came up with various methods to improve learning capability of artificial neural network [2],[10],[17],[22],[24]. Similarly in the area of fuzzy systems various fuzzification and defuzzification methods were proposed by researchers [7],[8],[12],[13],[23]. Type 2 fuzzy logic is an extension of fuzzy logic which helps in understanding the uncertainties in given condition in more reliable manner than conventional fuzzy logic. Using Artificial neural network and fuzzy logic, expert
system were generated in specified domain areas. However these systems were lacking the hybridization of artificial neural network and fuzzy logic. Much later software packages like ANFIS and DENFIS were introduced in MATLAB software [3],[19]. Further these software’s had fixed set of activation function and fixed methods of learning, hence to generate new activation function or learning methods coding had to be done from the beginning [1],[11],[20]. Moreover the MATLAB files are not easy to configure with other programming languages or to deploy them on web. Also MATLAB files lacked type 2 fuzzy functionalities for which recently a separate tool box is made available. Hence there is a need to have generic neuro-fuzzy libraries that can be modified and extended easily, moreover the codes in generic library is used to create web and desktop based neuro-fuzzy systems.

4.3 Generic Library

The generic library consists of source codes developed in Microsoft Visual Studio 2010 framework. The generic library has modular design and object oriented approach. Figure 4.1 represents the structure diagram of generic library.

![Figure 4.1: Structure of Generic Library](image)

C# programming language and MS SQL database are selected for development because they offer user friendly facilities in coding and designing the desktop as well as web based systems. Further, the developed systems can be easily maintained,
upgraded and documented in future. Figure 4.2 & 4.3 shows the class library for artificial neural network systems and fuzzy logic respectively.

Since library is developed with object oriented approach and modular design, it becomes very easy to add any newly research methods to any of the existing modules. On the basis of such strong and effective design it was possible to generate a generic framework which could automatically generate web and desktop based systems in neuro, fuzzy and neuro-fuzzy areas. The common interface has three buttons when clicked opens interactive interfaces for each of the neuro, fuzzy and neuro-fuzzy system were generated. With the help of these interactive interfaces it was much easier to rapidly generate neuro-fuzzy systems. To automate the development process, the generic framework includes following facilities:

- Interactive development of neuro, fuzzy and neuro-fuzzy systems in respective domain areas by gathering required information through user friendly interface.
- As the framework automize the generation of neuro, fuzzy or neuro-fuzzy system, it saves time and reduces the total man power effort. Hence developer can concentrate on domain knowledge acquisition and training data sets.
- The framework incorporates generic library hence there is no need for users to go into technical details about working of the system, they can use researched methods incorporated in the library and hence improve the working functionality of the generated system.
- Furthermore well tested, standardize and professional codes are available; which makes system development smooth and user friendly.
Figure 4.2: Class Library for Artificial Neural Network System
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Figure 4.3: Class Library for Type 2 Fuzzy Logic System
4.4 Framework Layout

The framework is designed with different learning algorithms for artificial neural network which also allows control over different respective learning parameters. The main interface will provide three options to choose development in one of these three categories. The interface of framework is displayed in Figure. 4.4. There are three buttons respectively for three different systems. Pressing any one of these button will open an interface of the selected button’s development approach.

![Figure 4.4: Main Interface of Neuro-Fuzzy Development Framework](image)

The developed framework allows generation of neuro, fuzzy and neuro-fuzzy systems as follows:

(i) **Artificial Neural Network System**: When the required system needs to be trained artificial neural networks are to be used. Artificial neural networks have self learning mechanism based on their learning strategy. The artificial neural networks are broadly divided into two types of learning supervised and unsupervised. In supervised learning artificial neural network is trained offline
under supervision, in such kind of system users have to specify input and output broad categories along with training sets. In un-supervised learning user needs to specify only input and output broad categories, here training sets are not required as neural network is trained at the time of execution. The generic framework provides facilities through its user friendly interface to collect data in textual form, which can be saved for later use. The artificial neural network part of the framework allows development of system that requires learning. The developed library contains built in algorithm and learning paradigms. The developers of such system need to specify the input and output broad categories and training data sets required to train the artificial neural network [18]. The user can choose from available different learning paradigms of the library to decide learning strategy [11], [17], [24]. Once the parameters of the chosen learning strategy are decided the system will train the artificial neural network which can be saved for future use of the same artificial neural network.

(ii) **Fuzzy Logic System:** Those systems with imprecision and vagueness require extensive usage of logical conditions are developed under fuzzy logic systems. Fuzzy system compromise of type 1 fuzzy sets which are generalizations of crisp sets whose *membership grades* can only be 0 or 1. Hence type 2 fuzzy sets are used in the library to model the uncertainty [9]. Type 2 fuzzy sets have advantage over conventional fuzzy sets as the membership grades of type 2 fuzzy sets are able to cover the second order derivatives which was not possible of type 1 fuzzy set[8]. The framework developed using this library allows user to specify the rules in a interactive fashion. The framework allows its users to dynamically select the appropriate membership functions like linear, trapezoidal, gaussian and triangular. Based on the membership function the degree of uncertainty is handled by the fuzzy rule base through inference engine[3] and [19]. Appropriate output is given to user in human (English) language.

The membership functions for type 1 and type 2 fuzzy systems are available in generic library which enables the generic frame work to generate expert fuzzy rule based system. Hence it is easy for users of this system to specify
the rules for the required problem domain. Users can enter rules through graphical user interface of generic framework.

These rules are further processed by the inference engine which decides rule applicability in given situation. The rules are saved in database to document knowledge processing for future requirements. Hence, fuzzy logic systems are useful to support critical decision making in uncertain conditions which aids in development of expert systems.

(iii) **Neuro-fuzzy System:** The hybridization of artificial neural network and fuzzy logic system falls into these types of system. Fuzzy logic and artificial neural network systems are capable to generate experts systems in respective domain areas, however to extract advantages of both these systems, hybridization was done. Hence a neuro-fuzzy system has capability of logical conditioning to provide decision support and learning mechanism of artificial neural network. The generic framework facilitates automatic hybridization features for non-computer professionals and advance user can select the custom hybridization approach.

The neuro-fuzzy system uses libraries of fuzzy logic and artificial neural network. The framework provides different hybridization techniques to fuse artificial neural network with fuzzy logic to achieve the goal. The hybridization of artificial neural network and fuzzy logic generates expert advisory system that helps in decision support [2] and [16]. After collection of data it is hybridized in such a way that input and output broad categories of artificial neural network are merged with fuzzy rules to make interactive input and output for the generated system in a given domain area.

**4.5 Conclusion**

It is clear that with increasing need of expert system, we need a common interface to generate expert system in different fields. The focus for development of generic neuro-fuzzy library is to facilitate development of common neuro-fuzzy system without going into manual of developing each source code from beginning for
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separate expert systems. Currently much of time is wasted in development and modification of neuro-fuzzy systems, but with the help of generic library emphasis can be laid in proper training of artificial neural network and rule development for fuzzy system. The advantages of generic library can be stated as follows:

- Generic library act as an instrument/tool for development of framework for development of neuro, fuzzy and neuro-fuzzy systems, which in turn creates user friendly web based and desktop based (windows supported) system in Neural Network, Fuzzy and Neuro-fuzzy area with respective problem domain.
- Object oriented programming approach helps in reusability of the code for new development and modification in current systems.
- The code developed for generic library is well organized, tested and helps in improving the overall quality of the system by providing the required components during development of neuro, fuzzy and neuro-fuzzy systems.
- The generic library is updatable with future developments in areas other than artificial neural network and fuzzy logic.
- The generic library used for development of framework contains library of functions and algorithms that will help to develop other major system in the field of computer science.
- Modular design of the library helps in modification and addition of other extended code in the modules of artificial neural network and fuzzy logic respectively.
- The system developer who is using the library will specify what method to use and apply for development of the system, there is no need to specify how to apply.
- Due to generic library, the developer will be able to concentrate on working of the system rather than making of the system and hence total man power required to build neuro-fuzzy system is reduced and it will also save time and save manual programming work.
- The neuro-fuzzy system generated from the library in respective domain area will be used by layman to solve their daily dilemma and help their life better with proper guidance.
The generated neuro-fuzzy system combines different expert’s knowledge, to produce neuro-fuzzy system that will be at finger tips of the user of generated system.

The generated system using generic framework has no retirement date, once the system is in stable state the developer can continuously monitor and improve its performance by changing parameters and adding rules to the system.

This generic library and framework are developed using Microsoft’s Dot Net technology (Visual Studio 2010) and this can be updated easily to future release of versions.

Hence the proposed generic library and framework will boost in faster development of neuro-fuzzy system and hence provide common man to take advice of field expert of the respective problem domain at finger tips at any place and at any time. In future it is possible to add methodologies other than artificial neural network and fuzzy logic by adding separate to extend the scope of library by using other methods of artificial intelligence like genetics, swarm computing, and ant colony optimization. Further, the parts of the generic library may be used to aid future research work in other fields of sciences like medicine, biotechnology, and electronics and in engineering fields like mechanical, instrumental, robotics and in many more day to day routine systems. Chapter 5, 6 and 7 shows working of each of these components with a case study.

References


Chapter 4: Detailed Design of Neuro-Fuzzy Development Framework


