

Type-2 Fuzzy User Interface for Artificial Neural Network based Decision Support System for Course Selection

PRITI SRINIVAS SAJJA*
Sardar Patel University

Enabling information and knowledge to the right people in right time increases productivity and effectiveness of the decisions made. This article describes design for an Artificial Neural Network (ANN) based decision support system along with fuzzy user interface based on type-2 fuzzy sets. The system supports beneficiaries to select suitable course/curriculum. The major criteria for making such decisions related to proper course selection are identified to design an ANN structure. An example set of 9 normalized input parameters and 3 output situations for the case is illustrated in this paper. Output achieved for the case is shown along with error graph and weight analyzer graph. The design framework, heuristics to decide number of neurons/layers along with fully designed neural network and fuzzy interface are also discussed here. As the ordinary fuzzy set does not capture uncertainty particularly dealing with vagueness and ambiguity in complex system, type-2 fuzzy sets are used. The discussion also includes introduction and an example of type-2 fuzzy set along with an example and application systems. The design of the system is adaptive and flexible to be used widely in fields like medicine, corporate sector, engineering, job scheduling, etc. to impart quality and productivity in decision making and offer advantages of knowledge-oriented decision making in an interactive way.

Categories and Subject Descriptors: I.0.0 [**Artificial Intelligence**]; I.2.0: [**Artificial Intelligence**]: Knowledge Representation; I.2.4: [**Artificial Intelligence**]: Knowledge Representation - *Design of Neuro-Fuzzy System*

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1. INTRODUCTION

Artificial Intelligence (AI) based systems work as tools that not only enhance human decision-making but also compensate inherent weaknesses in human decision making processes. For qualitative and holistic development, it is necessary to take productive decisions and selections. To increase productivity and effectiveness of the selection process, there is a need of an advisory system that offers advantages of

* Author's Address: Priti Srinivas Sajja, Sardar Patel University

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knowledge based approach. The database-oriented systems are comparatively less effective and offer mainly static decision support. Generalized systems may not help in providing personalized assistance and effective advisory to an individual user. Due to this reason, scope of such systems is restricted and they are not widely accepted. Moreover, the knowledge based systems can provide more effective evaluation of suitability of decisions and learns from feedback. Selection of course/career is a significant decision in one's life leading to success or failure. Such decision is to be taken within a limited time period. However, its impact can be experienced throughout the life. Such important decision-making often requires expert's support and advice. Here, an Artificial Neural Network (ANN) based decision support system using knowledge-oriented approach to aid selection of a course/career is discussed. Since ANN based system uses normalized data that is very unfriendly with user, especially for the course selection, an user interface becomes a prime necessity for such ANN based system. Moreover, the course selection process deals with linguistic parameters whose values are very difficult to mold in equivalent crisp values. For these reasons, with the base ANN system, an interface model based on Type-2 Fuzzy Systems (T2 FS) is proposed in this work.

ANN based system is a system loosely modeled on the human brain, where knowledge is stored in the interconnected processing elements called neurons. The field is also known as connectionism, parallel distributed processing, neuro-computing, natural intelligent systems, and machine learning. The network of interconnected singular processing units called neurons may be divided into multiple layers. Each neuron is linked to some other neurons by connection of different strengths known as weights. Learning in ANN is accomplished by adjusting these weights causing the network to output appropriate results. ANN can be classified as (i) pattern of connection between neurons; (ii) activation function applied to neurons; and (iii) learning algorithm. A multilayer network consists of an input layer, an output layer and one or more hidden layers between the input and output layers. Few areas where ANNs currently applied are classification, recognition, signal processing, pattern matching, forecasting, process monitoring and control. Varieties of decision-support systems and connectionist expert systems have been developed using this technique. Figure 1 presents structure of Multilayer Neural Network with 5 input nodes in its input layer, 2 hidden layers containing 3 to 4 nodes, and 2 nodes in the output layer.

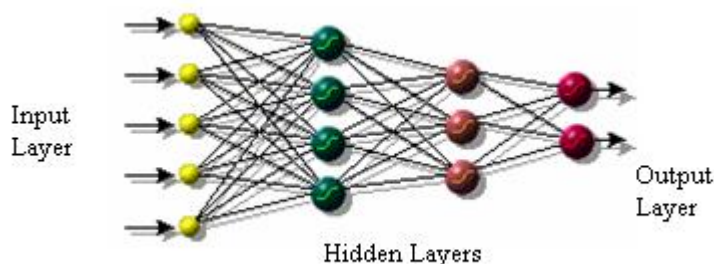


Fig. 1. Structure of multi-layer neural network

The ANN systems lack explicit explanation and reasoning facility, as knowledge is stored in the connections. Moreover, input values to ANN must be crisp and normalized unlike in real practice. Here, the values of the parameters coming from users/domain experts are vague and in the form of linguistic variables. Most of the systems developed as fuzzy interface so far are Type-1 Fuzzy Systems (T1 FS) and have no specific and customized mechanisms to deal with vague parameters. According to John and Coupland [2007], type-2 fuzzy systems take us one more step towards the goal of 'Computing with words' or the use of computers to represent human perception. Zadeh [1999] presents that perceptions of size, health and comfort cannot be modeled by traditional mathematical techniques and fuzzy logic is more suitable. Since T2 FS are based on fuzzy sets whose membership grades are non-crisp fuzzy membership functions, they can model perceptions more effectively than the type-1 fuzzy sets [John and Coupland 2007; Mendal 2007]. That is, a T1 FS has a grade of membership that is crisp; whereas a T2 FS has grades of membership that is fuzzy. Such sets are useful when it is difficult to model the exact membership function. For more imprecise or vague data, T2 FS offers a significant improvement on T1 FS fuzzy sets. View of relationship between levels of imprecision, data and techniques are shown in Figure 2.

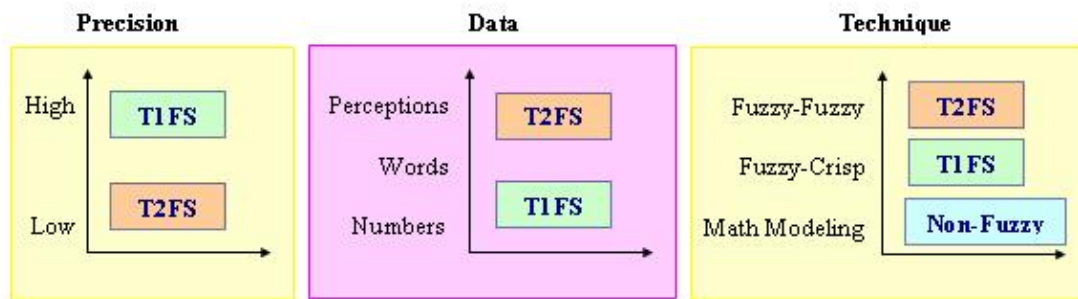


Fig. 2. Type-1 fuzzy systems and Type-2 fuzzy systems relationships

To improve understanding of perceptions in more human friendly way, a fuzzy system needs some measure of dispersion to capture more about linguistic uncertainties than just a single Membership Function (MF). T1 FS can deal with a single MF. A T2 FS provides these measures of dispersion [Mendal 2007]. For an example, suppose the variable of interest is ‘*assistance required*’ to complete the course, denoted by x , where $x \in [0, 10]$, where 0 means no assistance required and 10 means maximum assistance required. The term ‘some assistance required’ can be interpreted in different ways to different people, which is denoted in Figure 3. From the figure, it is clear that, if all uncertainty disappears, the T2 FS reduces to a T1 FS.

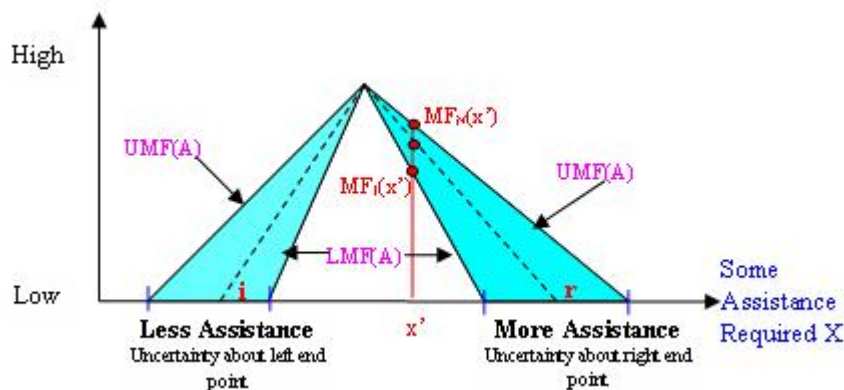


Fig. 3. Triangular MFs when base points (i) and (r) have uncertainty associated with them for the variable ‘some assistance required for learning a subject’

Defuzzification can be performed by taking the average as follows [Mendal 2007]:

1. Compute the centroid of each rule consequent. Call it c^l ($l=1, \dots, M$).
2. Compute the firing level for each fired rule. Call it f^l ($l=1, \dots, M$).
3. Compute $y_{\text{cos}}(x) = \frac{\sum c^l f^l}{\sum f^l}$.

T2 FS use is promoted by Gorzalczany [1987], Turksen [1995; 2002], Schwartz [1985], and Klir and Folger [1988] after its introduction by Zadeh [1975]. After that, Karnik and Mendal [1998; 2001] gave a complete description of the fuzzy inference process. With this background and work of Wu and Mendal [2002] on minimax uncertainty fast execution of type-2 fuzzy systems, complex and multi-variable control application begun. Figueroa et al. [2005] used a type-2 interval control for non-autonomous robots for a robot football game. Recently a Real Time T-2 Neuro-Fuzzy Controller (RT2NFSC) was developed by Lynch et al. [2006] based on Wu and Mendal [2002] uncertainty bound model resulting in considerable improvement in its performance in comparison with type-1 systems. Similar type of performance can be achieved in advisory systems regarding important decision-making in human oriented way. In fact this is one of the few areas where a generalized T2 FS can be used in preference to T1 FS.

2. DESIGN FRAMEWORK OF THE SYSTEM

An independent agent that fuzzifies and normalizes the input parameters for the base ANN system is described in this section. Such interactive user interface receives environmental parameters from the users and propagates system's decision support to them. The user interface also helps in normalizing the environmental parameters within given range and hence smoothen the operations of the base ANN system. The structure of proposed system is described in Figure 4.

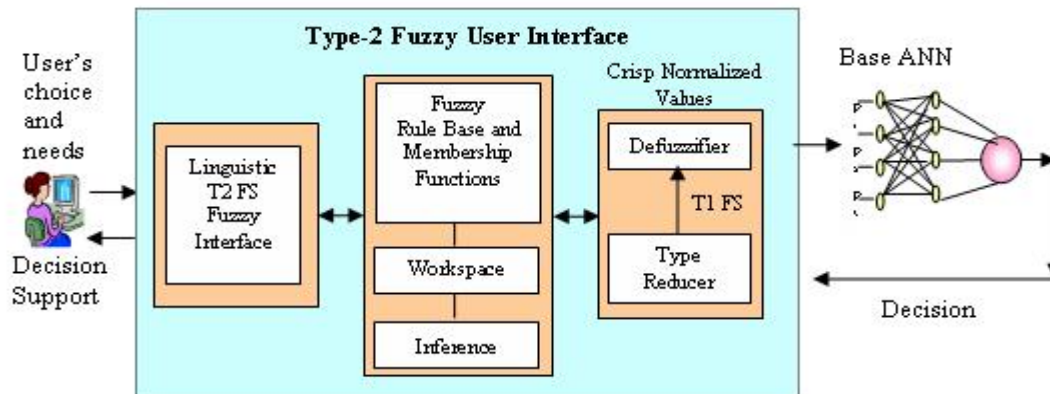


Fig. 4. Structure of system and Type-2 Fuzzy Interface

The basic objective of the above architecture is to enable users to enter their choices and requirements in fuzzy form. Since the input is in fuzzy form, there is a need to defuzzify it in crisp normalized values; so as the base ANN system process it for decision making. The ANN output again is in fuzzy and comparatively less interactive. Hence it is further required to fuzzify the output to enable friendly interaction between system and users. The interface has major components like T2 FS linguistic interface, a fully rule base, definition of membership functions and inference mechanism. Since T2 FS maps fuzzy to fuzzy, there is requirement of type reducing facility, which reduces the resulting fuzzy values from the T2 FS into crisp values with the help of T1 FS defuzzifier. The work space can be used to hold temporary results during inference and conversion.

3. AN APPLICATION ANN

As stated earlier, as an example a decision support system to select a course/career is designed and implemented with selected modules. There are different parameters that affect decision-making in the field [Sajja 2006]. The discussed system considers following parameters for decision support in selection of a course.

- Availability of expertise
- Availability of hardware/based technology
- Content/length of the course
- Degree of assistance required
- Knowledge level required for the course/depth of the course
- Market trend towards technology/course
- Personal interest
- Success history, if any
- Time taken to complete (revision)

Let the N input parameters are received in neurons of input layer named as $X_{11}, X_{12}, X_{13}, \dots, X_{1N}$, where the first subscript shows the first input layer and the second subscript shows the neuron number

in the layer. Since there may be more than one input layers such formatting strategy is required. Among many different alternative courses available, one course is to be suggested to the candidate. To present these alternatives, M output neurons denoted as O_1, O_2, \dots, O_M are considered in the output layer of the system. Number of hidden layers should not exceed number of neurons in the output layer and should be less than the number of neurons in the input layer.

The heuristic used to determine number of hidden layer neuron is as follows:

$$N_h = 1/2 \{N_i + N_o\} \dots\dots\dots [1]$$

where N_h = Number of neurons in hidden layers

N_i = Number of neurons in an input layer

N_o = Number of neurons in an output layer

To demonstrate the design, let us consider cases of selecting an elective subject for a postgraduate course, where above parameters are applicable. In the situation, there are three elective subjects available for the students in the final year of the course. Here, the number of neurons at the input layers are 9 (total applicable parameters) and number of neurons in the output layer are 3 (number of alternatives available). Using the design heuristic given in the above formula, the 2 hidden layers are designed containing 6 neurons each. The network initialized with random weights is illustrated in Figure 5. After the network is trained by training set, the system can be used to extend decision support to the users. The network receives values about the selected parameters and constraints for a student through neurons of input layer and outputs suggestion regarding the course to be selected through its output layer. The data for the training set is collected from the ex-students of the Master of Computer Applications of Sardar Patel University, India. This data is utilized as a training data to train the network.

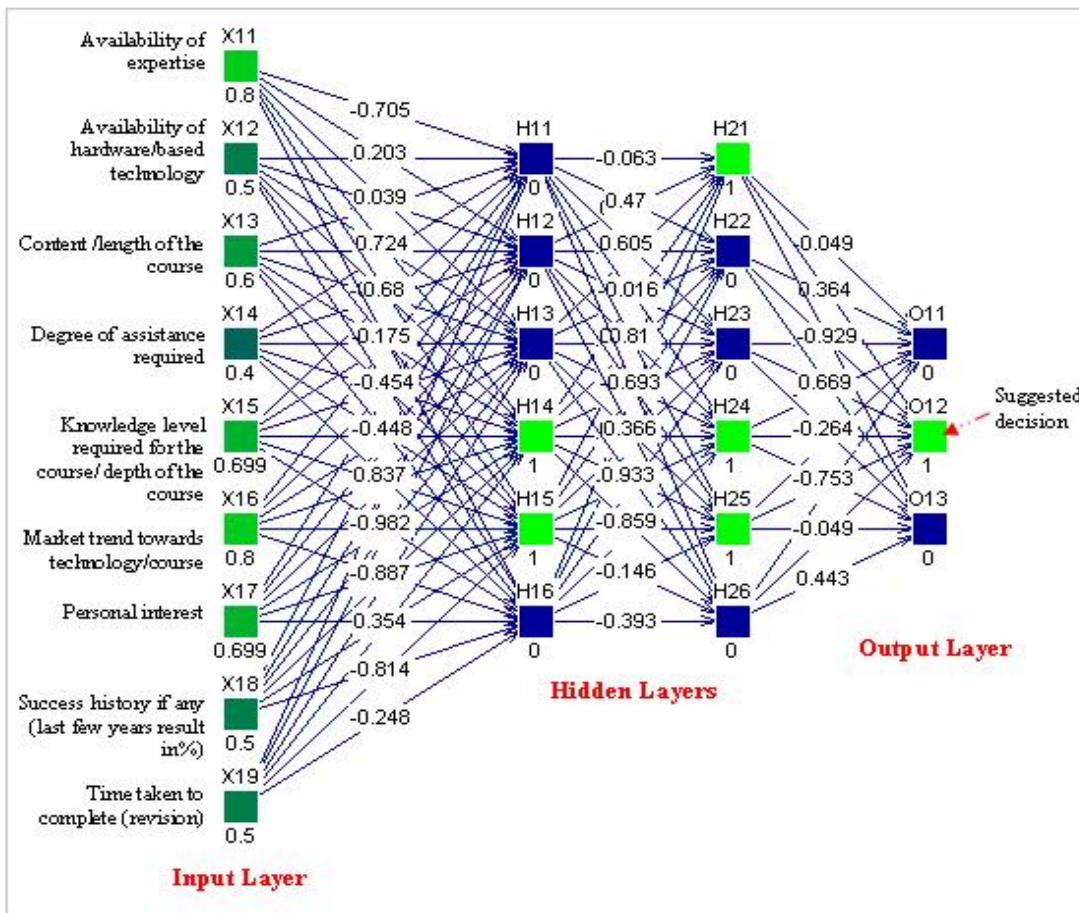


Fig. 5. Network structure with input pattern and sample output

Java Neural Network Simulator (JavaNNS) [URL 2008] for neural networks is developed at the Wilhelm-Schickard-Institute for Computer Science (WSI) in Tübingen University, Germany. It is based on the Stuttgart Neural Network Simulator (SNNS) 4.2 kernel. The simulator is used to implement the design. The simulator software used provides options for creating neurons in different layers, initialization, generation of pattern files and learning from the pattern set. Figure 6 describes (i) a screen for fuzzy interface to provide training data to the neural network; and (ii) simulation of the trained neural network.

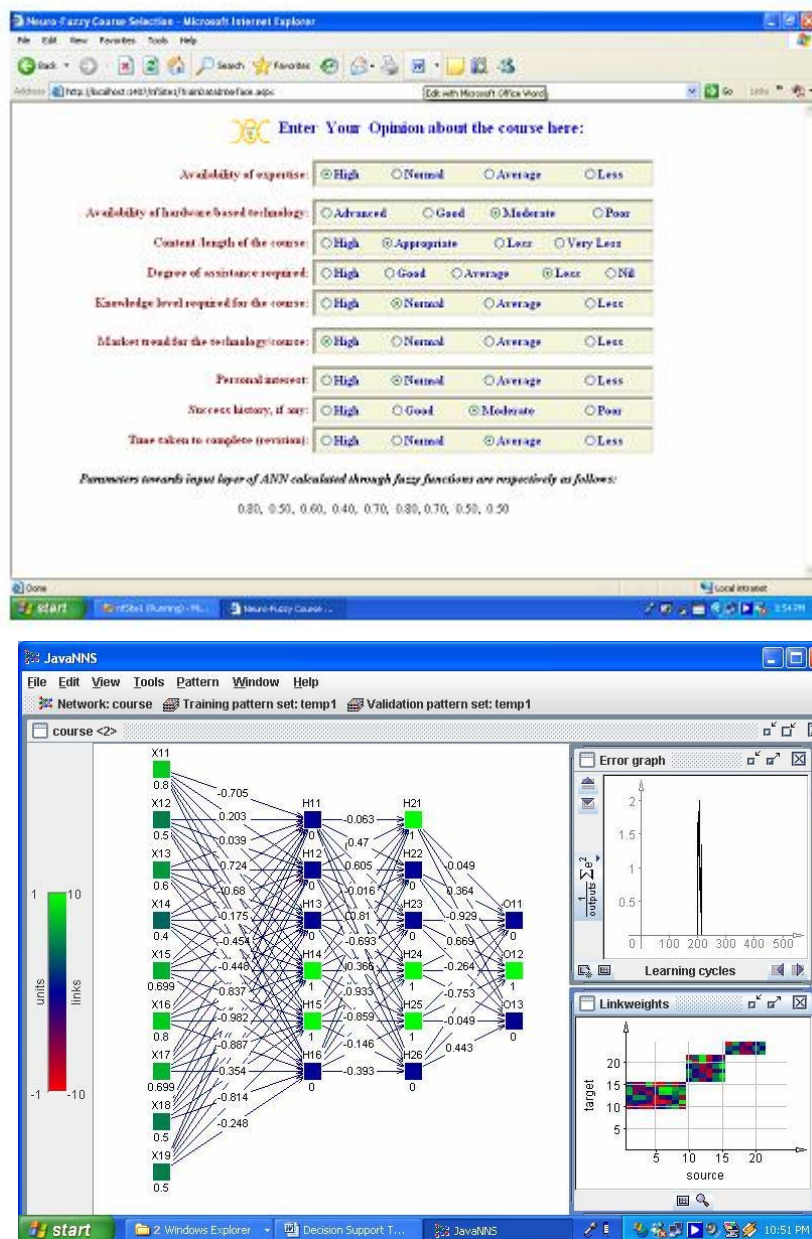


Fig. 6. Sample screens for course selection system

Using the interface discussed earlier, fuzzy training data can be converted into crisp form from the linguistic form. Received output is also in the linguistic form. A sample training data set is shown in Table I.

Table I. Sample Training Data Set

Crisp Training data	Fuzzy Training data
# Input pattern 1:	# Input pattern 1:
0.8 0.5 0.6 0.3 0.7 0.8 0.7 0.5 0.5	high moderate good poor good high good moderate moderate
# Output pattern 1:	# Output pattern 1:
0 1 0	low high low

4. CONCLUSION

Neural networks are performing successfully where other methods do not. There are many areas viz. medicine, weather forecasting, classification, resource allocation, and stock market predication; where such decision support system can help in setting priorities and making effective and productive decisions. Since the traditional connectionist systems do not provide explicit fuzzy interface, the proposed hybrid systems have wider scope/acceptability and presents dual advantages of a type-2 fuzzy logic based decision support using ANN techniques.

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