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EMBEDDING OF FUZZY LOGIC WITH NEURAL NET FOR IDEALISTIC RESULTS – A REVIEW

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Abstract - The main goal of this paper is to review the characteristics of fuzzy logic, neural network and neuro fuzzy systems and also it describes the application of fuzzy logic in various fields. The paper provides an idea about fuzzy set, crisp set and mechanism of neural network, highlights the importance of fuzzy logic for handling the uncertainties and their applicability for real life situations. This paper elaborates the embedding of fuzzy logic with neural network in real life situations.

I.INTRODUCTION

The term fuzzy logic was introduced with the 1965 proposal of fuzzy set theory by Lotfi Zadeh Observed that conventional computer logic was incapable of manipulating data representing subjective or vague human ideas.

Fuzzy logic has rapidly become one of the most successful of today's technologies for developing sophisticated control systems

Fuzzy logic addresses such applications perfectly as it resembles human decision making with an ability to generate precise solutions from certain or approximation information. It fills an important gap in engineering design methods left vacant by purely mathematical approaches

Fuzzy design can accommodate the ambiguities of real world human language and logic. It provides both an intuitive method for describing systems in human terms and automates the conversion of those systems specifications into effective models.

Fuzzy Set

Here “fuzzy” means vagueness, in other words, the transition among various degrees of the membership complies that the limits of the fuzzy sets are vague and ambiguous. Therefore, the membership of the elements from the universe in the set is measured against a function to identify the uncertainty and ambiguity.

Fuzzy logic

The fuzzy logic theory provides a mathematical method to apprehend the uncertainties related to the human cognitive process.

If we need to find whether the colour of the object is blue or not. But the object can have any of the shade of blue depending on the intensity of the primary colour . So, the answer would vary accordingly, such as royal blue, navy blue, sky blue, turquoise blue, azure blue, and so on. We are assigning the darkest shade of blue a value 1 and 0 to the white colour at the lowest end of the spectrum of values. Then the other shades will range in 0 to 1 according to intensities. Therefore, this kind of situation where any of the values can be accepted in a range of 0 to 1 is termed as fuzzy.

Crisp Set

The crisp set is a collection of objects (say U) having identical properties such as countability and finiteness.

Crisp Logic

a logic which demands a binary (0/1) type of handling is known as Crisp logic.

Eg. Does she have a pen? The answer of the above-given question is definite Yes or No, depending on the situation. If yes is assigned a value 1 and No is assigned a 0, the outcome of the statement could have a 0 or 1.

Difference between fuzzy set and crisp set.

Fuzzy set and crisp set are the part of the distinct set theories, where the fuzzy set implements infinite-valued logic while crisp set employs bi-valued logic. Previously, expert system principles were formulated premised on Boolean logic where crisp sets are used. But then scientists argued that human thinking does not always follow crisp “yes”/”no” logic, and it could be vague, qualitative, uncertain, imprecise or fuzzy in nature. This gave commencement to the development of the fuzzy set theory to imitate human thinking.

Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0) Boolean logic on which the modern computer is based. Fuzzy logic is a form of many-valued logic in which the truth values of variables may be any real number between 0 and 1. It is employed to handle the concept of partial truth, where the truth value may range between completely true and completely false, By contrast, in Boolean logic, the truth values of variables may only be the integer values 0 or 1.

Neural network

It's a computer system modeled the human brain and nervous system. Neural network are simplified model of the biological nervous system. Neural network is a highly interconnected network of a large number of processing elements called neurons in an architecture inspired by the brain. In neural network, several parallel processing operations is done and thus evaluate the example faster. The Neural network is robust on noisy training data, It possess the capability to generalize that is they can predict new outcome from past trends.

Why to use Fuzzy Logic in Neural Network

As we have discussed above that every neuron in ANN is connected with other neuron through a connection link and that link is associated with a weight having the information about the input signal. Hence we can say that weights have the useful information about input to solve the problems.

Following are some reasons to use fuzzy logic in neural networks –

Fuzzy logic is largely used to define the weights, from fuzzy sets, in neural networks.

When crisp values are not possible to apply, then fuzzy values are used.

The training and learning help neural networks perform better in unexpected situations. At that time fuzzy values would be more applicable than crisp values. When we use fuzzy logic in neural networks then the values must not be crisp and the processing can be done in parallel.

II. Reviews

1) In the paper Artificial Neural Networks and Fuzzy Logic in Process Modeling and Control published by Smarti Reel1 and Ashok Kumar Goel2 presented their review on application of Artificial Neural Network and Fuzzy Logic in process modeling and control. The intelligent control techniques are rapidly replacing the conventional control due to their abilities like learning, function approximation, associative memory, prediction, combinatorial optimization and non-linear system modeling etc. In this paper, research work done in process modeling and control using conventional techniques, Artificial Neural Networks, Fuzzy Logic and Neuro-Fuzzy paradigms is discussed. For each control methodology its corresponding limitations are also presented. An outline of recent alternative approaches for process modeling and control are also included. They concluded that Hybrid controllers built by combining Fuzzy logic and allied technologies like Neural Networks and Genetic Algorithms are being applied for effective desired dynamic performance of complex control applications and has resulted in possible implementation of new resources for better and efficient control. There are several learning architectures proposed whereby the neural network may be trained. Astrom and Wittenmark, and Narendra et al. proposed many adaptive control techniques to replace the conventional classical methods .Khalid and Omatu have trained neural network as an inverse dynamic model of a temperature control system and then configured it as a direct controller to the process. Water Bath Temperature Control System has been taken as an example. Luiz et al. proposed a neural network based direct inverse control for active control of vibrations of mechanical systems. Goel et al. proposed a novel, computationally efficient ANN controller for industrial temperature control system using direct inverse control .[1]

2) 1Nian Zhang, 2Daryl Beetner, 3Donald C. Wunsch II, 4Brian Hemmelman and 5Abul Hasan demonstrates on the feasibility of this neuro-fuzzy approach to mobile robot using a simple, 8-bit microcontroller. Experiments show the approach works well, as the robot was able to successfully avoid objects while seeking a goal in real-time. The neuro-fuzzy approach is code-efficient, fast, and easy to relate to the physical world. This method can effectively deal with imprecise or noisy sensor information and coordinate conflicts among multiple reactive behaviors and also they suggests the advantage of this combined fuzzy controller and RAM-based neural network approach is that it requires very little computational power or memory while still maintaining the ability to handle imprecise or complex data and they concluded that Compared with model-based navigation approaches, the neuro-fuzzy method reacts quickly and requires few computational resources.[2]

3) In the paper 'COMPARISON OF ARTIFICIAL NEURALNETWORKS AND FUZZY LOGIC

APPROACHESFOR CRACK DETECTION IN A BEAM LIKE STRUCTURE' B Prakruthi Gowd1, K Jayasree2 and Manjunath N. Hegde proposes two algorithms of crack detection one using fuzzy logic (FL) and the other artificial neural networks(ANN) since modal parameters are very sensitive to damages, the first three relative natural frequencies are used as three inputs and the corresponding relative crack location ,relative crack depth are used as the two outputs in the algorithms. The three natural frequencies for an undamaged beam and different cases of damaged beam(single crack at various locations with varying depths) were obtained by modeling and simulating the beams using a finite element based (FEM) software. Results concluded that both the approaches can be successfully employed in crack detection in a beam like structures but FL approach performed better in determining relative crack-depth whereas ANN approach performed better in determining relative crack location.[3]

4) Daniel Wu, Fakhreddine Karray Insop song discussed the water level control by Fuzzy logic and neural network Traditionally, accurate mathematical model-based strategies have been applied to deal with control problems. However, water level control system, for example, is very complex system, because of the nonlinearities and uncertainties of a system. Conventional control approaches are not convenient to solve the complexities. Fuzzy logic and neural networks control have emerged over the years and become one of the most active and fruitful areas of the research in the intelligent control applications. There are two major different types of the control rules in fuzzy control: the Mamdani type and the Sugeno type. The Mamdani control rules are significantly more linguistically intuitive while Sugeno rules appear to have more interpolation power even for a relative small number of control rules. In neural network control, the most commonly used ones are supervised control, direct inverse control and neural adaptive control. In the paper 'Water Level Control by Fuzzy Logic and Neural Networks'by Daniel Wu, Fakhreddine Karray , Insop Song elaborated the configuration of the water level control system. Then, we introduce Sugeno fuzzy control and model reference adaptive neural network control (MRANNC) strategies based on backpropagation algorithm, also they compared the Fuzzy logic control and Neural network control [4]

	FLC	NNC
Plant Math Model Unnecessary Unnecessary	Unnecessary	Unneccessary
Computation Light Heavy	Light	Heavy
Tracking Performance Good Better	Good	Better
Disturbance Rejection	Good	Better

The paper 'Reduction of Neural Network Training Time Using an Adaptive Fuzzy Approach in Real Time Applications'*by* Hamidreza Rashidy Kanan and Mahdi Yousefi Azar Khanian applies fuzzy logic for training of neural network

A major problem of neural network in real-time applications is their long training time. This paper present a modification of the neural network (NN) for reduction of training time. In this paper they suggest a new Adaptive Fuzzy technique to create ensembles of neural network using multiple projections of the same data obtained from different NNs. This paper highlights' that By using adaptive Fuzzy technique training time of neural network can be minimized. A fuzzy system is employed to control the learning parameters of a neural network to reduce the possibility of overshooting during the learning process. Hence, the learning time can be shortened. This paper compares the training efficiency and accuracy between a NN and a fuzzy controlled neural network, when they are required to carry out the same assignment. We justify the suitability of the proposed method by some experiments in soccer robot trajectory generation tasks; the resulting fuzzy controlled neural network indicates a significant reduction in the training time by 30%. This study indicated that the neural network's training time is reduced significantly by combining an adaptive fuzzy control system with a neural network in order to adaptively vary the learning parameters and reduces the training time in real-time applications.[5]

III. DISCUSSION

COMPARISON OF ANN, FUZZY LOGIC AND NEURO-FUZZY INTEGRATED APPROACH

A. Artificial Neural Network

1) Advantages

• Adaptive learning: An ability to learn how to do tasks based on the data given for training or initial experience.

• Self-Organization: An ANN can create its own organization or representation of the information it receives during learning time.
• Real Time Operation: ANN computations may be carried out in parallel, and special hardware devices are being designed and manufactured which take advantage of this capability.
• Fault Tolerance via Redundant Information Coding: Partial destruction of a network leads to the corresponding degradation of performance. However, some network capabilities may be retained even with major network damage

2) Disadvantages

• Neural networks can be used only if training data is available. It is not necessary to have a mathematical model of the problem of interest, and there is no need to provide any form of prior knowledge.
• The solution obtained from the learning process usually cannot be interpreted.
• Most neural network architectures are black boxes. They cannot be checked whether their solution is plausible, i.e. their final state cannot be interpreted in terms of rules.
• A neural network usually cannot be initialized with prior knowledge if it is available, and thus the network must learn from scratch.
• The learning process itself can take very long, and there is usually no guarantee of success.

B. Fuzzy Logic

1) Advantages

• An intelligent approach with simplicity.
• Easy to understand and implement.
• Provide the user friendly approach of presentation.
• Ease of implementation.
• Provide more "user-friendly" and efficient performance.

2) Disadvantages

• Hard to develop a model from a fuzzy system
• Require more fine tuning and simulation before operational
• Problems of finding suitable membership values for fuzzy systems
• A fuzzy system can be used to solve a problem if knowledge about the solution is
available in the form of linguistic if-then rules.

C. Neuro-Fuzzy integrated Approch

Neuro-Fuzzy computing which is judicious integration of the merits of neural and fuzzy logic, enables one to
• build more intelligent decision-making systems. This incorporates the generic advantages of artificial neural networks like massive parallelism, robustness, and learning in data-rich environments into the system. The
• modeling of imprecise and qualitative knowledge as well as the transmission of uncertainty is possible through the use of fuzzy logic.
Besides these generic advantages, the neuro-fuzzy approach also provides the
corresponding application specific merits. A notable contribution of neuro-fuzzy and soft computing is the exposure of adaptive neuro-fuzzy inference systems developed by Jang
The basic idea of combining fuzzy systems and neural networks is to design an architecture that uses a fuzzy
• system to represent knowledge in an interpretable manner and the learning ability of a neural network to optimize its parameters.
The drawbacks of both of the individual approaches - the black box behavior of neural
• networks, and the problems of finding suitable membership values for fuzzy systems - could thus be avoided.

IV.CONCLUSION

Properties of Intelligence Systems	Fuzzy systems	Neural Networks	Neuro - Fuzzy Network
Function estimators	yes	yes	yes
Trainable Dynamic	yes	yes	yes
Improvement with use	yes	yes	yes
Parallel Implementation	yes	yes	yes
Numerical	yes	yes	yes
Tolerance for imprecision	yes		yes
Explicit knowledge representation	yes		
Adaptive		yes	yes
optimizing		yes	yes
Interpolative		yes	yes
Tolerance for noise		yes	yes

A combination of Fuzzy logic and Neurak Network can constitute an interpretable model that is capable of learning and can use problem-specific prior knowledge.
Therefore, neuro-fuzzy methods are especially suited for applications, where user interaction in model design or interpretation is desired.

References

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