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Modeling Human Behavior in Machine Using Type 2 Fuzzy Neural Approach

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Abstract*—This paper presents design for modeling of human behavior in machines using soft computing methodologies of artificial neural network and fuzzy inference. Modern day automated systems are becoming intelligent and they incorporate human behavior in them, so they can work like human expert. To model human behavior it is essential for machine to learn all the necessary activities of human and carry out those activities with the same precision as human. However it is very complicated to steer human behavior using existing methods of soft computing. Hence we have hybridized artificial neural network with fuzzy logic to generate hybrid fuzzy neural system which has learning capabilities of artificial neural network and generating inference on the acquired knowledge using fuzzy logic. Furthermore we have extended the scope of fuzzy logic to type 2 (second order). This increases the inference capabilities to much higher standards. To demonstrate how human behavior is modeled we have used the example of strategy game. Hence it is obvious that the objective of this strategy game is to learn player (human) moves. At each higher level the gaming system actually learns to defend human moves and then attack's the player (human) defense. This shows type 2 fuzzy neural approach successfully incorporates modeling of human behavior.

***Index Terms*—Fuzzy Neural System, Human Behavior Modeling, Machine Learning, Type 2 Fuzzy Logic.**

I. INTRODUCTION

In current global scenario, human have rapidly progressed and much importance is laid on quality and efficiency while delivering products or services. Most of the systems that provide these services use machines to achieve maximum accuracy to meet end user requirement. Most of modern day computer system incorporates the use of Artificial Intelligence (AI) [5]. Most of the simulator systems, motion sensors, electronic logic systems, planning systems, expert systems, and decision making systems are heavily dependent on AI methodologies as they offer the best solution by modeling domain expert (human) behavior through computational simulations. One such form of AI methodologies to model human behavior is also used in gaming, which gives experience of virtual reality. The virtual reality offered by modern games takes player (human) to virtual world mimicking real world. The virtual world fulfils the imaginative desire of player. But to achieve these modeling machines has to use several complex AI algorithms and methods. As interactivity, smoothness, effectiveness increases the complexity of AI methodologies also increases. To show how actually AI methods work behind modeling of human behavior we have taken an example of strategy game of Thai Boxing having 10 different level of game play simulated in computer. Thai boxing is a game where the player has to use hands and legs to attack and take defense against opponents. As each level increases the machine learns the moves of the player (human) through Artificial Neural Network (ANN) and decides to attack or defend on the basis of type 2 fuzzy logic. Artificial Neural Network (ANN) is a computational model that mimics the working of biological neural network using various algorithms and functions. Hence in context of AI based computer programs it used for the purpose of learning. As the game progresses the machine keeps record of user moves made by the player (human).

Fig 1(a): Initial Stage of Game

Fig 1(b): Advance stage of game

Fuzzy logic analyzes the moves made by player and generates decision to attack or defend. Also to keep game exciting and interesting it is important to increase difficulty at each level keeping track of biological limitation of human mind, which also going through learning process of the gaming environment simultaneously. The player may lose interest if the game is very hard or very easy to play. This functionality is offered by type 2 fuzzy logic as it can represent uncertainty

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in more efficient manner by measuring degree of similarity using its own membership functions [7]. Fig. 1(a) & fig. 1(b) shows sample screen shot of interactive game which is available on web [1].

Learning through ANN

At each level the game environment becomes more interactive by learning the moves of the player (human). During the entire course of the game the attacking nature increases as the game progresses, this can happen only when machine has learn about the weak point in players action. It is clearly seen that health line of player has decreased in fig. 1(b) as compared to fig. 1(a). Now we focus on how actually these types of strategy games learn human moves through computational simulation of ANN. An ANN uses connectionist approach to learn with the help of artificial neurons. These neurons are logically divided into three layers namely input, hidden and output layer. In our example we have used multilayer feed forward approach, in which each neuron of preceding layer is connected to every other neuron of next subsequent layer. Back propagation algorithm is used to train the neural network. The weights are adjusted as the error is back passed through the network during iteration process of learning. The hidden layers are responsible for processing of given input to required output. For our AI based game Thai Boxing we have devised artificial neural network as depicted in fig. 2. Fuzzy rules are applied to input and output broad categories of neural network. The input broad categories for our example are Game Mode, Game Environment, Game level, Player Attack and Player Defense. The output broad categories include Game Attack & Game Defense. At each stage and interval of the game, considering the current position of player, data for input broad categories is fed to ANN. The hidden layers process the data and give the result to attack or defend or perform both activities simultaneously. On the basis of analysis of output broad categories of ANN fuzzy logic is applied to make game more interactive to generate virtual reality.

II. INFERENCE OF FUZZY LOGIC

Fuzzy logic is multi valued logic derived originally from crisp logic. Fuzzy logic was designed to handle uncertainty in data [11]. Hence it included range of values to answer problem where there is lack of information. Unlike crisp logic which answers in fixed value, fuzzy logic provides answer within a certain range of values to measure the degree of similarity with actual value. However this fuzzy logic is generalization of crisp logic, hence in order to enhance the capability to measure degree of similarity of a given value, type 2 fuzzy logic was introduced. In context of virtual reality accuracy with preciseness is important with uncertain antecedents and/or consequents which are possible by incorporating type 2 fuzzy logic [2], [3]. A process called as Justification of data is carried out where crisp data are converted to fuzzy data. A block diagram of typical type 2 fuzzy system is shown in fig. 3. The fuzzifier component deals with fuzzification of data by arranging them in group of type 2 fuzzy sets. The rule base component consists of several logical conditioning statements of IF – THEN statements [12], [13]. IF part of the statement is called as antecedent whereas THEN part of the statement is called as consequent. The component of inference engine is used to deduce solution to a particular problem domain by applying rules present in the rule base. Type reducer converts data from type 2 fuzzy logic to (type 1) fuzzy logic [14], [15]. The component De-fuzzifier converts fuzzy logic data back to crisp data to get desired outputs. De-fuzzifier is need in the case where the output is required in crisp number form.

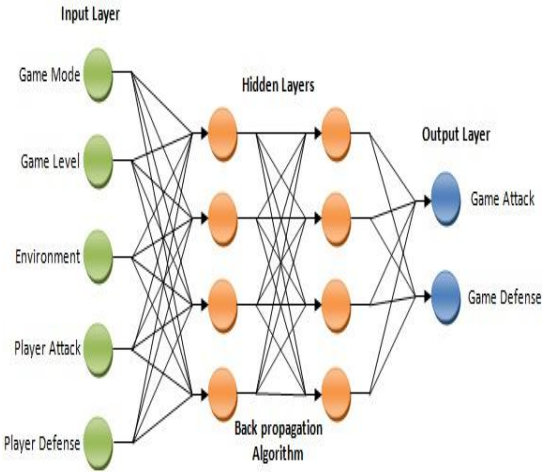

Fig 2: ANN for Thai Boxing Strategy Game

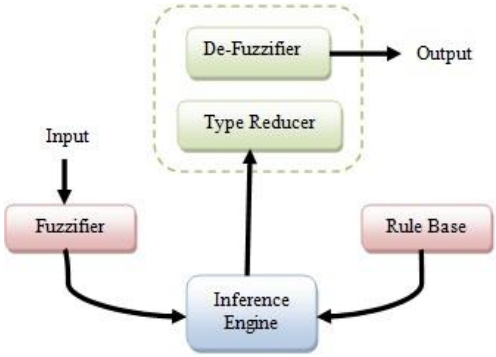

Fig 3: Block Diagram of Type 2 Fuzzy System

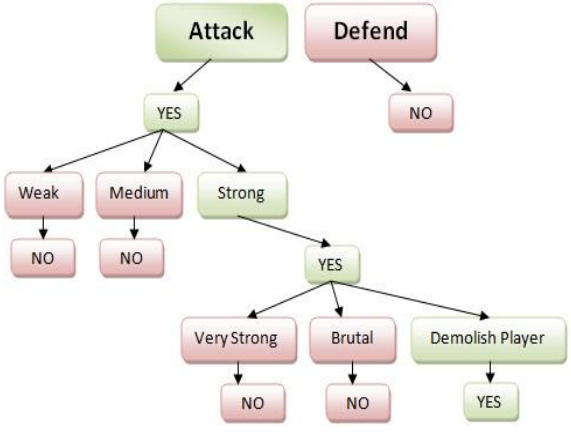

Fig 4: Decision tree to attack player

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In our example, suppose the output broad category of the ANN suggest attacking the player then for game attack, linguistic variables with corresponding type 2 fuzzy value are shown in Table 1. Parameters shown in table 1 are merged with other linguistic variables to form decision tree to make a decision. The decision tree helps in deciding the level of attack to be inflicted upon the player. The best decision tree minimizes entropy, a measure to show disordered actions of the player. For each decision tree attribute the inference engine maps a rule from its rule base to give answers in yes or no. on this basis the final decision is taken and interactive playing environment is generated. Fig. 4 shows a decision tree in final stage of the game where the player is attacked by game brutally to demolish him, which might eventually end player's further progress to the game and thus end the game.

III. FUZZY NEURAL HYBRIDIZATION

Hybridization of ANN with type 2 fuzzy logic generates hybrid expert system that has ability to learn and infer the learned knowledge [4]. In our example of Thai Boxing game when input and output broad categories of ANN are hybridized with type 2 fuzzy logic rules, an interactive game is obtained which is able to learn and match player's moves. This game gives experience of virtual reality by increasing toughness at each level by modeling player's (human) behavior (actions).

Table 1: Linguistic Variables to Attack Player

Linguistic Variable	Fuzzy Value
No Attack	F0 = (0.0,0.0,0.0)
Very Weak Attack	F1 = (0.0,0.1,0.1)
Weak Attack	F2 = (0.0,0.2,0.3)
Slightly Weak Attack	F3 = (0.1,0.2,0.4)
Medium Attack	F4 = (0.4,0.4,0.5)
Slightly Strong Attack	F5 = (0.5,0.6,0.5)
Strong Attack	F6 = (0.6,0.5,0.7)
Very Strong Attack	F7 = (0.7,0.6,0.8)
Brutal Attack	F8 = (0.8,0.9,1.0)
Demolish Player	F9 = (1.0,1.0,1.0)

At each level the player's skill of playing the game increases, hence accordingly data are fed into input broad category of neural network. These data are processed by hidden layer by using learning algorithm like back propagation. Finally from the output broad categories it is determined that whether to attack or defend against the player. Now fuzzy logic is applied on the output broad category of the artificial neural network which is depicted in form of decision tree in fig. 4. Hence we obtain an interactive multi level game.

IV. FUTURE SCOPE

The paper discusses about modeling human behavior in machine using a hybridized type 2 neural fuzzy approach. This includes the usage of two major components of soft computing i.e. artificial neural network & fuzzy logic. However in future it is possible to extend the scope and application of paper by hybridizing other branches of soft computing like genetics, ACO, swarm computing, chaos theory with the method introduced in paper, this will result into development of many intelligent and expert systems which will have human characteristics of domain knowledge, reasoning and ability to understand. Hence we can improve the automation of machines in more human like approach, which will deal with day to day routine activities of human beings to enhance their current living standard to a higher level continuously. Furthermore the neural fuzzy hybridized approach as discussed in paper can be applied to many other domain areas to generate various expert systems.

V. CONCLUSION

With the growth of modern day computing system, much importance is laid on the quality of the system. To enhance quality and end service of the system, it is essential that system is intelligent and skillful equivalent to human domain expert. Hence it is important to model human behavior in computer system. By taking simple example of thai boxing we have proved how type 2 fuzzy neural approach can be used to model human behavior. The same can be used in future for other simulation and virtual training programs like flight simulators, space travelers, virtual art galleries and many more. Modeling of human behavior is also useful in expert systems [6], [8], [10] and decision making systems [9] where domain expert's knowledge is required.

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