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Rule Extraction in Artificial Neural Network

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Abstract-

Neural network is very accurate in results that's why it is mainly used for decision making but because of its black box nature we cannot see its internal working. So, rule extraction is a way to solve this issue. This could be seen as the root for rule extraction investigation in neural network. To describe the inference process, we need to follow a routine to take out rules from a neural network. Three commonly algorithms used for extracting rules from a simple network. This includes decompositional approach, pedagogical approach, eclectic methods. The main criticism of neural networks is that it is difficult to understand the decision-making process in neural networks. One of the most widely considered limitations of ANNs is their inability to explain. Nonetheless, the basis of decisions must be considered, as this computer support systems are often used in decision-making applications like medical diagnosis. The best way to represent extracted knowledge from neural networks is by using IF THEN rules. To describe a neural network, IF-THEN rule is the best way to eliminate decision tree from a network. In this paper, I have discussed three extraction algorithms and also about how decision tree is helping in reaching to particular decision.

Keywords: ANN, MLP, Neurons.

1. Introduction

Neural networks, which are considered a branch of Artificial Intelligence, are essentially a computer program designed to learn the human brain in a similar way. The human brain consists of billion of cells called neurons and trillions of connections between them. Artificial neural network operates on the following two grounds after the human brain, first, by acquiring knowledge through a learning process through the network, and second, by using the strengths of the interneuron link to store the acquired knowledge.

1.1. Neural-Network

Neural networks are now a day's increasingly used as a generic model for decision making in practical applications like medical applications, image processing, pattern recognition, voice recognition, classification problems etc. The major issue against neural networks is that human being's decisions by neural networks are hard to interpret. The reason is that the information in the neural network is stored as real established parameters (biases, weight) [1]. Their greatest weakness is that the

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information they obtained is portrayed in a manmade shape that is incomprehensible. By extracting rules from trained neural networks, researchers tried to address this issue. The biggest lead of Neural Networks is its good generalization capability. Generalization is the ability of neural networks to gives accurate results for those data which are not seen in the training period. The main weak point of neural networks is that these are black box in nature. Black box nature of neural networks means that we cannot see the internal working of the neural networks. It is not easy to understand the reasoning behind the output of a Neural Network. Knowledge acquired by a Neural Network is defined by its topology, the link weights, hidden and output node activation functions. Such representations are not easily understandable[2]. Even for an ANN with a single hidden layer, because of the nature of the network, it is usually not possible to describe about why a specific pattern is labelled as a member of one class and another as a member of another class[3]. So if neural networks are black box in nature and does not support their decision making process so why we should use neural networks, the reason is that estimated exactness of neural networks is greater than human experts. Extracting data from qualified neural networks is useful in many applications so that users can gain a better understanding of the solution. Such judgments are particularly useful when it comes to human understanding.It is a good way to describe the extracted information in the form of ' if then ' rules[4].

1.2.Applications

I) Signal processing: There are many applications of neural networks one of which is signal processing. Its first commercial application was on reducing noise from telephone lines.

II) Control: The control of plant is another learning task that can be done by neural Network

III) Filtering: In filtering we refer to device or algorithms used to extract information from a collection of noisy data about the specified amount of interest.

IV) Pattern recognition: Character recognition and face recognition is most important application of pattern recognition.

V) Medicine: Neural network is also used in medicine as instant physician. Where we Provides symptoms to the trained neural network and according to inputs it provides Disease name in no time. So it is faster in processing then an expert system[5, 6].

2. Rules Extraction Categories

2.1.Decomposition technique: This technique is also known as local method. Local and decompositional method take out rules from level of individual, hidden and output

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units within the network. Network is broken down into small networks (one unit). To form a global relationship, the rules derived from these compact networks are integrated. This method can be lengthy, resulting in descriptions that are large and complex. Regulations are first extracted in decompositional techniques within the ANN solution at the individual (hidden and output) unit level. To form global relationships then these sub-regulations are aggregated. The downside of the decompositional method is more time-consuming and more complex computation.

2.2. Pedagogical approach: A qualified network is regarded as a black box by pedagogical or international approaches. This approach's methods derive information that directly characterizes the output groups from the inputs. In this approach extraction is done by mapping inputs directly to outputs. Saito and Nakano's method of searching for combinations of input values that activate each output unit. This technique is faster than decompostional technique. The problem with this approach is that with number of input values, the size of the search space will expand exponentially. Authors used two heuristics to deal with this issue, which limited the search space. Another drawback is that it is only possible to use this approach for discrete valued features .

2.3. Eclectic method: The previous techniques were mixed by eclectic methods. They evaluate the ANN at the each unit level, but they also take out rules at the global level. Method suggested by Tickle et al is one example of this approach which is known as DEDEC. DEDEC take out “if then” ruling from Multilayer perceptron network trained with backpropagationalgorithm. This approach integrates information found in the weight of the network with rules taken from a symbolic algorithm .

3. RELATED WORK

3.1. Rule Extraction: Neural networks are not used in applications related to safety for example medical domain. Trained neural networks are hard to interpret for a human being and function as black boxes. Multilayer perceptron(MLP), a lack of transparency is the greatest weakness in their decision making process. So to extract the knowledge behind the neural networks decision making process some techniques are used called Rule extraction. The aim of Rule extraction is to reduce an ANN's complexity to a more understandable symbolic type. There are two types of rules extraction algorithms, One that directly apply to data and one that apply to trained artificial neural networks. Prof. Gallant's thesis on connectionist expert systems was the first attempt to take out rules from neural-networks. Since then, a number of rule extraction methods have been developed to resolve the neural networks of the black

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box type. The rule extraction techniques classifies into three classifications based upon the vision provided by the underlying network topology algorithm. It may be decomposing, Pedagogical and Eclectic. Eclectic approach is hybrid in nature; it means it is a combination of decompositional and pedagogical approaches. The algorithms which directly apply on data set are:

3.1.1 CLS (Concept learning system): The first algorithm that produces decision trees from a data set. Data consist of attributes (variable) that have a corresponding value along with class memberships. The CLS algorithm starts with the random selection of an attribute of the data set as a node at the root of the decision tree. Example how CLS works over collection of C training instances.

First step: If every C instance is positive build YES node and halt. If every C instance is negative, build a NO node and halt. Otherwise, pick a variable, F with values v1, ..., vn and establish a decision node.

Second step: The learning instances in C are partitioned into sub-sets C1, C2, Cn according to V values.

Third step: Recursively apply the algorithm to each of the Ci sets. Note, what feature to pick is determined by the trainer (the expert).

3.1.2. ID3 Algorithm: ID3 enhances Concept learning system by introducing a heuristic selection feature. ID3 scans the attributes and extracts the attribute that best distinguishes the examples shown. If the training sets are correctly defined by the attribute, ID3 can stop. Otherwise it acts recursively on the partitioned subsets in order to obtain their "best" attribute.

3.1.3. SUBSET ALGORTHIM: Subset algorithm is based on decompostional approach of rules extraction. Subset is an algorithm based on searches that extracts the IF THEN rules from neural networks. Subset algorithm used in some specific application because of its binary nature. These algorithms start its working by finding the positive weights from a unit that cause it to fire. Then the sets of these connections combined with negative weights to form the rules that will set the system on fire. The drawback of this algorithm is that number of calculations increases exponentially with number of inputs to the node[7].

3.1.4. M OF N ALGORITHM: Another Decompostional algorithm KBANN (knowledge based artificial neural networks) is developed to improve the comprehensibility of rules extracted and decrease the computational complexity of

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the algorithm. Towell observed that in real example single attribute rarely have an influence on activations or output of node. M OF N algorithm extracts these equivalence classes in more compact way.eg set of rules such as IF ({P^Q^T, P^R^T, P^S^T, Which can be reduced to

IF (any 3 of {P, Q, R} THEN A)

The major disadvantage of M OF N algorithm is it can only works on knowledge based neural networks and it only accepts binary values. This is a very big disadvantage since inputs other than binary numbers are needed for most real life applications.

3.1.5. RULENEG ALGORITHM: This algorithm is based upon pedagogical approach of rule extraction. This algorithm can be applied to arbitrary network without bothering about the types of learning used in training the networks. The method extracts conjunctive rules only. The main drawback of this algorithm is that it is based only on binary values. Here is a simple example for explaining how the algorithm works:If the input is (1 0 0) and is classified as C by NN, the first featureis negated. The new instance will be (0 0 0). The new instance ispassed through NN and its class is found. If it is not C, the rulewill be if f1 then C. This is repeated for all the features. If thenew instance with negated second feature is not classified as C therule will become if f1 AND not f2 then C. If the new instance with negated third feature is classified as C, the final rule will be if f1 AND not f2 then C. If an instance like (1 0 1) is tested, it will be classified by the rule found previously [8].

3.1.6. C4.5 ALGORTHIM OR J48: This algorithm is most commonly utilized decision tree learning algorithm which is evolved by Quinlan. It is software extension of ID3 learning algorithm. This algorithm works on Greedy Search approach which select the better attribute and never sees back to reassess the early selections. An important part of any algorithm is that to construct a decision tree from a data set in which it select an attribute at each node of tree for splitting so that deepness of tree is minimised. ID3 works on the idea of information gain to choose the best attributes. Gain measure how well a given attribute splits training sets into its target classes. Entropy measure about information in any attribute. Higher the entropy, more knowledge needed to describe the data completely [9].

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3.1.7. Ex Tree algorithm: The Ex Tree is used for extracting Decision trees from trained networks. Ex Tree is one of instance of the pedagogical approach to rule extraction. Ex tree utilizes sampling method and craven's querying, but unalike craven trepan which uses M OF N formed splits, Ex Tree utilizes standard splitting test for example C4.5 and CART. But these standard decision tree algorithms have a disadvantage that the splitting of node is based upon the lesser instances as the trees expand towards lower level. So, because there is less data to choose, the splitting tests that are near the bottom of trees are poorly selected. Ex trees remove this issue by creating new instances and then querying the artificial neural networks with recently generated instances. Ex tree can then choose a splitting test based upon the recently generated instances as well as the original dataset. Ex trees do not requires the artificial neural network to use a particular training algorithm or architecture[10].

3.2 Decision trees: Decision trees can be easily interpreted as ' if-then ' rules and therefore the extraction of decision trees may be one of the better ways to interpret a neural- network. The predictive exactness achieved through neural-networks are considerably higher than those acheived through additional paradigms of learning, especially decision trees.These are chosen where, for example in medical diagnosis, it is necessary to have a good understanding of the decision process.Decision tree algorithms execute efficiently. These can handle a large count of records with consistent response timing, control numerical and symbolic information well. These can easily be translated into other codes and also better understood. In this, we extract Decision Trees from trained Feedforward Neural Networks. At the end of the 1980s, Gallant developed connectionist expert systems that considered the knowledge base to be the neural network.

CONCLUSION

Lack of ability to explain is one of the main reason why there is no need for artificial neural networks in some part of the industry. So in this research we extract rules in symbolic forms from neural networks to overcome this problem. These rules are easy to understand by human beings so provide explanation capability. At the end i come to know that researchers have overlooked that the rule extraction purpose is twofold, and the model definition should be accurate and understandable. To explain the inference process in the model, he provided a routine to extract propositional rules from a simple network. This could be seen as

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the root of the neural network rule extraction investigation. Explanation of decision process in ANNs in the forms of symbolic rules is done and also identified the existing rule extraction techniques in ANNs for the comparison of relative merits and demerits of each technique in application domain.

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