

## Applying Knowledge Reasoning Techniques In Neural Networks

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**Abstract:** The logic of abduction and deduction contribute to our conceptual understanding of a phenomenon, while the logic of induction adds quantitative details to our conceptual knowledge. In this paper, we will look into how this reasoning techniques- abduction, deduction and induction, are relevant in neural networks logic programming. Deduction simplifies the knowledge representation without affecting the knowledge contents. Abduction is the process of proceeding from data describing a set of observations or events, to a set of hypotheses which best explains or accounts for the data. Meanwhile, by using induction techniques, logical rules can be extracted from data bases. In this paper, we will review these three techniques.

**Key words:** Deduction, induction, abduction

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### INTRODUCTION

In artificial intelligence all deals with both theoretical and practical problems. The theoretical questions are mainly related to the theory of problem solving, theory of (reliable and plausible) reasoning, machine learning and knowledge acquisition. The practical problems are related to the development of intelligent assistant systems, decision support systems, high performance knowledge bases and distributive and co-operative intelligent systems.

In cognitive systems all is active in development of various methods of plausible reasoning including statistical, logical and fuzzy logic methods, case-based reasoning and methods based on analogy. These methods are used to realize abduction, deduction and induction for reasoning.

Within Peirce's (Peirce, C.S. 1900) science of inquiry, the person (or other system) develops a knowledge base by hypothesis, deduction, and induction. Although deduction and induction were commonly known forms of inference for centuries, they cannot by themselves constitute a complete system of inquiry.

Deduction is drawing logical consequences from premises, and induction is generalizing from a number of cases in which something is true and inferring that the same thing is true of a whole.

Peirce therefore created abduction as a third class of reasoning. Abduction is the process by which a person develops a hypothesis, or reasonable conjecture, about what may be happening in a field of experience. More than a category, abduction is a set of logical operations that systems can use to create hypotheses.

The philosophical notions introduced by Peirce are helpful for researchers in understanding the nature of knowledge and reality. According to Peirce, the logic of abduction and deduction enhance our conceptual understanding of a phenomenon, while the logic of induction provides us quantitative details to our conceptual knowledge. In this paper, we will concentrate on the implementation of deduction in neural symbolic integration. Some of works in this paper have been reported earlier in few publications (Saratha Sathasivam, 2008; 2010; 2011; 2011).

#### **Deduction:**

Usually deduction is considered within the scope of mathematical logic, generally propositional or first order logic. The most common form of deduction is the application of "modus ponens". An example of deduction is given below:

$$\frac{man(Socrates) \quad man(x) \rightarrow mortal(x)}{mortal(Socrates)}$$

In this case, if we assume that it is true that Socrates is a *man*, and it is also true that if something is a man then this something is mortal, we may deduce that Socrates is mortal.

The advantage of deduction in the logic approach is that it can reduce interference effects due to common neuron sharing. Deduction can be applied to remove redundant clauses leading to a simplification of the clauses. A knowledge base is redundant if it contains parts that can be inferred from the rest of it. Deduction simplifies the knowledge representation without affecting the knowledge contents. Thus, deduction makes the clauses more compact and easier to be interpreted as a large amount of redundancy may obscure the meaning of the

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represented knowledge (Ashok, K.G. 1996). Moreover, with the decrease in the number of neuron in the network, the complexity of the network will be lower. This may then leads to some computational advantage. Therefore, deduction can be very useful especially in large data sets which tend to generate more redundant clauses. In the next section we will look into how deduction is used in simplifying the induced rules without affecting the knowledge content.

**Deduction Algorithm:**

The following steps are used:

- i) List out the clauses with interference effects obtained from real life or simulated data sets using reverse analysis method (Wan Abdullah, W.A.T. 1993). Reverse analysis method is used to induce logical rules entrenched in data sets by using information about the connection strengths between the neurons in the network.
- ii) By applying deduction, represent the clauses in a simpler manner.
- iii) Check whether the clauses obtained from step (i) are similar with simplified clauses from step (ii). The consistency of the results can be checked by using the truth tables.
- iv) Check that the resulting Hopfield neural network (by the deduced clauses) (Zaki, M. J. 2000) produces the same global minima with the original network.

For an example, consider the case as illustrated below:

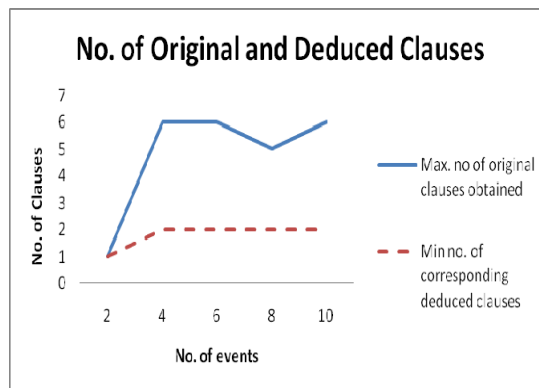
$$A \vee \neg B \wedge (C \vee \neg B) \wedge (\neg B)$$

By applying deductive technique, we expect that the set of clauses can be simplified to the clauses below:

$$(A \vee C \vee \neg B) \wedge (\neg B)$$

The logical clauses have been simplified to easier version. The logical content in both of the clauses are similar. This can be checked by using truth table (Saratha Sathasivam, 2008). By simplifying the clauses we can avoid repetition and interference effects cause by common atom sharing.

We carried out computer simulation to verify the effectiveness of the proposed algorithm of deduction. The following Figure 1 shows reduced number of clauses for simulated data sets using deduction technique.



**Fig. 1:** Maximum no. of original clauses obtained and its minimum no. of deduced clauses for different no. of events

From the simulation results that we obtain, it can be observed that deduction technique applied in the program simplify the original generated clauses which contain redundancy in knowledge representation i.e. which contain common neuron in the clauses.

**Abduction:**

Abduction is the process by which a person develops a hypothesis, or reasonable conjunction of reasoning, about what may be happening in a field of experience. More than a category, abduction is a set of logical operations that systems can use to invent hypotheses.

Abduction does not confirm a hypothesis; it is a method for making plausible explanations of observable data. Abductive hypotheses must be plausible and likely. Plausibility is the condition that the hypothesis possesses the ability to explain the observed event or activity. Likelihood concerns the condition that the hypothesis has a good chance for explaining the data, i.e., the probability of this occurring is non negative.

To test how well abduction can be used for logic recognition, the following steps are carried out (Zaki, M. J. 2000):

- i) Apply Reverse Analysis method to induce logical clauses from the datasets
- ii) Simplify the logical clauses of the referred data sets using deduction technique so that we can get simple clauses.
- iii) Abduce hypotheses clauses from this set of clauses.
- iv) Check the ‘ingrainedness’ of the abduction in the test data set, given by the average difference in the contributions to the energy from the clause, between neural configurations which satisfy the clause, and those which do not.

Let us look at an example.

Assume that we obtained the following clauses based on customers shopping habits in a departmental store using Reverse Analysis algorithm:

*Sandwich\_loaf* ← *Strawberry Jam*

*Sandwich\_loaf* ← *Peanut Butter*

*Strawberry Jam* ←

*Peanut Butter* ←

We can simplify the above clauses using deduction technique:

*Sandwich\_loaf* ← *Strawberry Jam, Peanut Butter*

*Strawberry Jam* ←

*Peanut Butter* ←

Finally, we can use abduction technique and obtain the following relationship:

*Sandwich\_loaf* ←

So, we can abduced that all the customers will buy sandwich loaf. Next we can use ingrainedness measure to calculate how much this abduced clauses is “drill” inside the data set. In the next section, we will into induction technique.

### **Induction:**

The main process of induction starts with a set of samples (of propositions, of concepts and others) that is used as a root to the general concept to be formed, by different possible techniques. Induction is the reasoning function that makes rules from the results of sample cases. As such, it

satisfies two functions in a cognitive model: it provides a validation procedure for a hypothesis assertion, and it provides the basis for learning or knowledge obtain in the cognition process (E.T. Nozawa, 2000).

Induction is a statistical construct that may not be fixed over a limited time, and is invalid when based on a single event.

In this paper, we define a machine learning method: Reverse Analysis Method, which uses Hopfield neural network to discover trends in datasets. This method is used to induce logical rules lies in a data set.

This method consists of these following steps:

- i) Enumerate number of neurons and patterns in the database.
- ii) Initialize number of trials, energy relaxation loops, number of patterns.
- iii) Extract the events from the database and represent in binary/bipolar pattern, where 0 indicates false state and 1 indicates true state (for bipolar -1 represent false state and 1 represent true state).
- iv) Calculate the connection strengths for the events using Hebbian learning.
- v) List out all the connection strengths obtained for third order connections until first order connections.
- vi) Capture all the nonzero values (connection strengths) for third order connection.
- vii) List out all the corresponding clauses for (vi).
- viii) Calculate the connection strengths for the extracted clauses in step (vii) and deduct the value of the corresponding clauses connection strengths from (v).
- ix) Repeat the similar steps to extract the clauses corresponding to the first order and second order connections.

Reverse analysis method has been tested in a small data set as shown in Table 1. The logical rules induced from the method seem to agree with the frequent observations.

**Table 1:** Customers daily purchased from a supermarket:

	Sandwich Loaf	Peanut Butter	Strawberry Jam	Sausages	Burger
Sara	√				
Mike		√	√	√	
John	√				√
Lena		√			√
Susan	√		√	√	

By using Reverse Analysis method approached we was discussed previously, we obtained the following rules:

Sandwich Loaf  $\leftarrow$  Peanut Butter, Strawberry Jam

Burger  $\leftarrow$  Sausages, Strawberry Jam

From the rules, we can interpret that a customer who purchased peanut butter and strawberry jam has a high probability of purchasing sandwich loaf also. Meanwhile, a customer who purchased sausages and strawberry jam has a high probability of purchasing burger.

The logical rules that were induced by using Reverse Analysis method can help the departmental store in monitoring their stock according to the customers demand. Significant patterns or trends in the data set have been identified by using reverse analysis. The departmental store can apply the patterns to improve its sales process according to customers shopping trends. Furthermore, the knowledge obtained may suggest new initiatives and provide information that improves future decision making.

### **Conclusion:**

In this paper we have review three main reasoning techniques: abduction, deduction and induction. The logic of abduction and deduction contribute to our conceptual understanding of a phenomenon, while the logic of induction adds quantitative details to our conceptual knowledge. Induction, abduction and deduction have different merits and shortcomings. Yet the combination of all these three reasoning approaches provides researchers a powerful tool of inquiry.

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### **REFERENCES**

- Ashok, K.G., 1996. A Neural Architecture for a Class of Abduction Problems. IEEE Transactions on Systems, Man, and Cybernetics, 26(6): 854-860.
- Nozawa, E.T., 2000. Reflexive Control Theory and the Scientific Philosophy of Charles Sanders Peirce; LM Aero, Marietta Ga. International Reflexive Control Symposium.
- Peirce, C.S., 1900. Collected papers of Charles Sanders Peirce. Cambridge: Harvard University Press.
- Saratha Sathasivam, 2008. Mining Logic from Neural Networks, 2nd Engineering Conference on Sustainable Engineering Infrastructures Development and Managemant, Kuching, Sarawak, 1-4
- Saratha Sathasivam, 2010. Deduction in Neural Networks, 3rd International Conference on Science and Technology, Penang, 1-4.
- Saratha Sathasivam, 2011. Application of Neural Networks in Predictive Data Mining, 2nd International Conference in Business Economic and Research, Holiday Villa, Langkawi, Malaysia, 371-376.
- Saratha Sathasivam, 2011. Knowledge Extraction in Hopfield Network, International Conference on Management and Artificial Intelligence, Bali, 1-5
- Wan Abdullah, W.A.T., 1993. The Logic of Neural Networks. Phys. Lett. A., 176: 202-206.
- Zaki, M.J., 2000. Generating non-redundant association rules. Proceedings of the sixth ACM SIGKDD international conference on Knowledge discovery and data mining, pp: 34-43.