Chapter 1
Artificial Neural Network What-If Theory

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ABSTRACT

Data sets collected independently using the same variables can be compared using a new artificial neural network called **A***rtificial neural network* **W***hat* **I***f* **T***heory, AWIT. Given a data set that is deemed the standard reference for some object, i.e. a flower, industry, disease, or galaxy, other data sets can be compared against it to identify its proximity to the standard. Thus, data that might not lend itself well to traditional methods of analysis could identify new perspectives or views of the data and thus, potentially new perceptions of novel and innovative solutions. This method comes out of the field of artificial intelligence, particularly artificial neural networks, and utilizes both machine learning and pattern recognition to display an innovative analysis.*

INTRODUCTION

A neural network typically takes a single set of data, partitions it into two non-overlapping subsets, and uses one subset to train the neural network such that the underlying behaviors of the data are identified while not overly training it such that the "noise" is treated as a component of the behavior. The other dataset is then inputted though the network to identify the actual patterns, outcomes, etc. based on the previously identified ideal behavior. In this way relationships can be discovered in large medical datasets, corporate transaction databases, law enforcement databases, and the like. In each case it is the single ideal or principal dataset itself that is used to identify relationships.

It is postulated in this paper that the method of artificial neural network (ANN) analysis can be extended to identify behaviors that could be identified as an approximation to another dataset. That is to say, given two separate datasets composed of identical variables for which data has been collected at another time, or using some different form of data collection, or data collected from a different popula-

DOI: 10.4018/978-1-7998-0414-7.ch001

tion, how close is one dataset to the other. An example of the benefit of using this kind of ANN analysis is to consider the variables associated with a particular disease. Experts have identified that a particular dataset is composed of the characteristics that typify the disease under study. In another dataset that is comprised of identical variables, the data collected from a different population that might have been given some form of treatment. Using this new method, it will be shown that it is possible to determine the proximity of the treated group with the classical dataset.

In short, using one dataset that is defined as being the ideal standard containing the relationships necessary to measure desired outcomes, another dataset can be compared to determine its degree of closeness. This opens up the possibility of providing one population with some special effect or treatment as in "what if we do x with/to this population?" We can determine the degree of closeness of the second or treated dataset with the original standard. It is in this spirit of performing "what-if" analysis that this method is called **A**rtificial Neural Network **W**hat **I**f **T**heory (AWIT).

GENERAL THEORY

Using an auto-encoder ANN we will approximate the implicit function of any dataset during the learning phase and to assign a fuzzy output to any new input during the recall phase. A fuzzy output is a value in the range [0..1] in which zero means complete absence or non-membership in the output and a one means complete membership. Any other value indicates the degree of partial membership.

Recent research has improved the auto-encoder ANNs in order to optimize a deep learning process (Hinton, Osindero & Teh, 2006) or to select the fundamental hidden features of a large dataset (Le, et. al., 2012) or to reduce the dimensionality of data (Hinton & Salakhutdinov, 2006; Raina, Madhavan & Ng, 2009; Raiko, Valpola & LeCun, 2012). Other approaches have tried to use auto-encoders as unsupervised ANNs able to perform supervised tasks (Larochelle & Bengio, 2008; Bengio, 2009).

We have chosen to look at the auto-encoders from a different point of view: we define the testing phase of a trained auto-encoder as **the interpretation** of a dataset (traditionally referred to as the Testing Dataset) using the logic present in *another* dataset (the Training Dataset). We define this point of view a seminal approach for a new theory, named AWIT (**A**rtificial Neural Networks **W**hat **I**f **T**heory).

The algorithm to implement this new approach to data analysis follows:

- Let DB1 and DB2 be two different datasets with the same types of variables but possessing different records;
- The function f() is a non-linear function optimally interpolating DB1 by means of an auto-encoder ANN consisting of one hidden layer:

$$x_{DB1} = f(h,\ v^*) \tag{1}$$

$$h = g(x_{DB1},\ w^*) \tag{2}$$

  v^*, w^* = parameters to be estimated by ANN,
  x = input variables.
- The dataset DB2 is rewritten using the ANN trained on the DB1dataset: