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IN REPLY REFER TO.

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NEURAL NETWORK FUNCTION CLASSIFIER

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT (1) CHRISTOPHER M. DeANGELIS, and (2) ROBERT C. HIGGINS, citizens of the United States of America, employees of the United States Government, a residents of (1) Cranston, County of Kent, State of Rhode Island and (2) Tiverton, County of Newport, State of Rhode Island have invented certain new and useful improvements entitled as set forth above of which the following is a specification.

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NEURAL NETWORK FUNCTION CLASSIFIER

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to a method for determining the best function with which to represent a data set and a system for carrying out the method.

(2) Description of the Prior Art

Often there is a quantitative relationship between two or more variables. For example, the water pressure on the hull of a submerged submarine is related to the operating depth, or a software metric is related to software measurement data. When given a set of independent (X's) and corresponding dependent (Y's) values, it is often convenient to represent the relationship with a mathematical expression. For example, if productivity relates to the number of computer that an organization may invest in, data that describes this relationship may have a linear trend. If so, this relationship can be represented by the equation $y = ax + b$ where "a" and "b" are constants, "x" is the number of computers, and "y" is some measure of productivity. A quadratic, cubic, or some higher order polynomial equation may represent other data sets. Often, real data does not perfectly match the equation because of measurement error or random variations in the data. Consequently, it is difficult if not impossible to visually determine the mathematical relationship (i.e., the equation) between the variables. Regression fits are often applied but may not necessarily have a mathematical expression representation.

In many applications, it is useful to know how a data set behaves; however, it may not be easy to visually discern this behavior.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a method for determining the best function with which to represent a data set.

It is a further object of the present invention to provide a system for determining the best function with which to represent a data set.

The foregoing objects are attained by the method and the system of the present invention.

In accordance with the present invention, a method for determining the best function with which to represent a data set broadly comprises the steps of providing a classifier having a plurality of neural network sets with each neural network set having a plurality of neural networks and with each of the neural networks in a particular set being trained to recognize a particular data set type, inputting data into each of the neural network sets, and determining from an output of each of the neural networks the best function representation of the data set.

Further, in accordance with the present invention, a system for determining the best function with which to represent a data set broadly comprises a plurality of sets of trained neural networks with each trained neural network set having a first neural network trained to identify a first type of data set and a second neural network trained to identify a second type of data set. The system further comprises means for determining from an output of each neural network in each trained neural network set the best function representation of the data set.

Other details of the neural network function classifier of the present invention, as well as other objects and advantages attendant thereto, are set forth in the following detailed description and the accompanying drawing wherein like reference numerals depict like elements.

BRIEF DESCRIPTION OF THE DRAWINGS

The Figure is a schematic representation of a neural network function classification system in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

To illustrate the present invention, a plurality of neural networks 10, 12, and 14 are trained using a plurality of different data sets. For example, in the case of two dimensional data sets, the neural networks 10, 12, and 14 may be trained using linear data, quadratic data, and cubic data, respectively. These data sets (x, y) may be defined by the their corresponding equations: linear which is $y = ax + b$; quadratic which is $y = ax^2 + bx + c$; and cubic which is $y = ax^3 + bx^2 + cx + d$.

To limit the amount of training data, the neural networks 10, 12, and 14 may be trained on data with "x" and "y" values greater than or equal to -1 and less than or equal to +1. Thus, the neural network that is trained to recognize linear data, for example, may be trained on normalized data that is known to be linear, defined by the equation $y = ax + b$. A sliding window function may be utilized to select segments of the linear data for processing. An example of a sliding window selection process when the input data set comprises a total of 1000 data samples is as follows: (a) the first 100 data samples are initially selected and processed by the first neural network set 10, 12, and 14; (b) the sliding window iterates over the (x,y) values (i.e., window number 1 selects samples 1 to 100, window number 2 selects samples 2 to 101, etc.) until all the data has been processed. The second neural network set uses a sliding window of 200 samples, the third neural network set uses 300 samples, etc.; with the last neural network set using window size of N samples. During the training process, the constants in the linear equation, i.e., "a" and "b", may be varied to cover all combinations between +1 and -1. These may be incremented in steps of 0.1 or some other suitable increment. In the present example, each of the neural networks 10, 12, and 14 may be trained to recognize a specific type of data: linear, quadratic, or cubic. Further, each of the neural networks 10, 12, and 14 may be trained to produce a "1" when presented with a representative data set and "0" otherwise.

The Figure illustrates a general block diagram representation of a neural network function classifier 100. The classifier 100 and its various functions are carried out on a computer which has been programmed in any suitable language known in the art to perform the functions outlined below. As can be seen from the Figure, data is inputted in x, y coordinate pairs into a module 20 where it is normalized. The normalization module 20 and its functions may be implemented in any suitable manner known in the art. Data normalization may be implemented in the module 20 by dividing the "x" and "y" values in the data set by the absolute value of their respective maximum values.

As can be seen from the Figure, the main processing region 22 of the classifier system consists of a plurality of sets 23 of neural networks 10, 12, and 14 with each of the neural networks being trained to recognize a different data set such as linear, quadratic, or cubic. Each of the neural networks 10, 12, and 14 may have any desired architecture known in the art.

After normalization, the normalized data is transmitted from the module 20 to a data organization module 21. In the data organization module 21, the sliding window process discussed earlier may be implemented to select the data to be received by each set 23 of neural networks 10, 12, and 14. As shown in the Figure, the sliding window function may be performed for 100, 200, up to N samples, where the value of N is defined during the neural network training process. Several different sized sliding windows are used because at some point the output of each neural network is expected to be less sensitive to changes in window size. It is at this point that the average output value will become more reliable.

In the Figure, each set 23 of artificial neural networks (ANN) includes a neural network 10 trained on linear data (ANN Linear), a neural network 12 trained on quadratic data (ANN quadratic), and a plurality of neural networks 14 trained on higher order polynomials, respectively. The order of the polynomial is denoted by “n” in the Figure. Each neural network 10, 12, and 14 in each set 23 has been trained to produce a “1” when the trend of the unknown data adequately matches the type of data that was used during training and "0" otherwise. As the sliding window process performed in the data organizational module 21 selects new data, each neural network 10, 12, and 14 produces a stream of output values between “0” and “1”.

As shown in the Figure, the classifier 100 also includes a decision aide 30. The decision aide 30 determines which sliding window has produced the most reliable neural network output by computing an estimate of its variability and making the best selection. It then decides which neural network 10, 12, or 14 produced the highest average output value. If the linear neural network’s average output, for example, is 0.9 and all the other outputs were 0.1, the linear equation is selected as the best functional representation.

The data organizational module 21 for carrying out sliding window process and the decision aide module 30 and its functions may be carried out on any suitable computer known in the art which has been preprogrammed in any suitable language known in the art to carry out the aforementioned functions. Similarly, the neural networks 10, 12, and 14 in each set 23 may be implemented using a preprogrammed computer.

In accordance with the present invention, a set of data with unknown functional characteristics is processed and evaluated by an intelligent processor 30 that will determine the best functional representation.

In implementing the present invention, window sizes can vary. While the embodiment discussed here specifically discusses using different orders of polynomial functions as the basis for the neural networks, this same technique could be applied using other functions. For example, the method could be applied using periodic functions such as sinuisoids of different orders or exponential functions of different orders. Neural networks can be trained using these functions with or instead of the disclosed polynomial functions.

It is apparent that there has been provided in accordance with the present invention a neural network function classifier which fully satisfies the objects, means, and advantages set forth hereinbefore. While the present invention has been described in the context of specific embodiments thereof, other alternatives, modifications, and variations will become apparent to those skilled in the art having read the foregoing description. Accordingly, it is intended to embrace those alternatives, modifications, and variations as fall within the broad scope of the appended claims.

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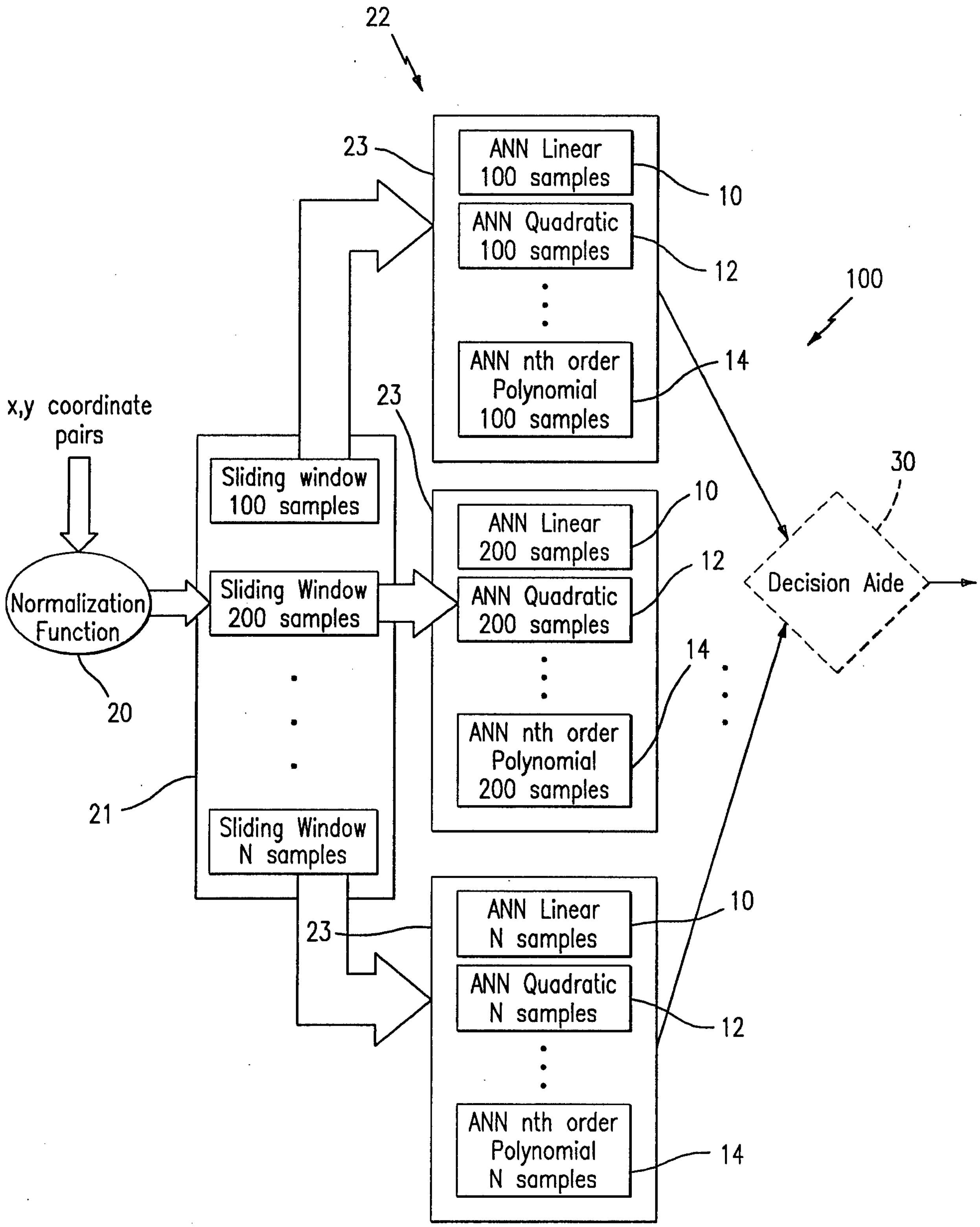
NEURAL NETWORK FUNCTION CLASSIFIER

ABSTRACT OF THE DISCLOSURE

A method and a system for determining a best function for representing a data set. The method includes providing a classifier having a plurality of neural network sets. Each of the neural networks in a particular set is trained to recognize a particular data set type. The best function representation of the data set is determined from the neural network output. The system comprises sets of trained neural networks having neural networks trained to identify different types of data. The number of neural networks within each neural network set will depend on the number of function types that are represented. The system further comprises an aide for determining based on the best function representation of the data set.



22
23
ANN Linear
100 samples
10
ANN Quadratic
100 samples
12
100
ANN nth order
Polynomial
100 samples
14
x,y coordinate
pairs
23
Sliding window
100 samples
30
10
ANN Linear
200 samples
12
Normalization
Function
Sliding Window
200 samples
ANN Quadratic
200 samples
Decision Aide
20
14
ANN nth order
Polynomial
200 samples
21
Sliding Window
N samples
10
ANN Linear
N samples
23
ANN Quadratic
N samples
12
ANN nth order
Polynomial
N samples
14