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Artificial Neural Intelligent Visual Inspection for Process Improvement

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Abstract:
In Industrial manufacturing, product inspection is an important step in the production process. Since product reliability is most important in mass production facilities. Visual inspection seeks to identify both functional and cosmetic defects. The visual inspection in most manufacturing process depends mainly on human operators whose performance is generally inadequate and Variable. Advances in technology have resulted in better, cheaper image analysis equipment, which enable the use of affordable automated visual inspection system. The major advantages of automatic operation are speed and diagnostic capabilities. A Neural Network is a powerful data-modeling tool that is able to capture and represent Complex input/output relationships. The objective of this paper is to enhance on modeling, integrating, and implementation of neural network technique in the bottle manufacturing industry for quality control.

Key words*: Feed Forward Neural Network, Back Propagation Network, Training, Testing.*

INTRODUCTION

Due to the complexity of today's manufacturing environment, the concurrent goals of higher production rates, lower production costs and better product quality create a tremendous challenge for manufacturers competing in the world marketplace. There are two prevalent goals related to improving current manufacturing processes. One is to develop integrated self-adjusting systems that are capable of manufacturing various products with minimal supervision and assistance from operators. The other is to improve

Product quality and reduce production cost. To achieve these goals, on-line 100% process monitoring is one of the most important requirements.

2. ARTIFICIAL NEURAL NETWORK

An artificial neural network, often just called a neural network, is a mathematical model inspired by biological neural networks. A neural network consists of an interconnected group of artificial neurons, and it processes information using a connectionist approach to computation. In most cases a neural network is an adaptive system that changes its structure during a learning phase. Neural networks are used to model complex relationships between inputs and outputs or to find patterns in data. Neural networks are being successfully applied across a wide range of application domains in business, medicine, geology and physics to solve problems of prediction, classification and control. Neurons are arranged in layers with the input data initializing the processing at the input layer. The processed data of each layer passes through the network towards the output layer. Neural networks adapt the weights of their neurons during a training period based on examples, often with a known desired solution (supervised training).

2.1.The Mathematical Model

A Neuron is an information processing unit that is fundamental to the operation of a neural network. The three basic components are the synapses of the biological neuron are modeled as weights and the synapse of the biological neuron is the one which interconnects the neural network and gives the strength of the connection. For an artificial neuron, the weight is a number, and represents the synapse. A negative weight reflects an inhibitory connection, while positive values designate excitatory connections. The following components of the model represent the actual activity of the neuron cell. All inputs are summed altogether and modified by the weights. This activity is referred as a linear combination. Finally, an activation function controls the amplitude of the output. For example, an acceptable range of output is usually between 0 and 1, or it could be -1 and 1.

Mathematically, this process is described in the figure (1)

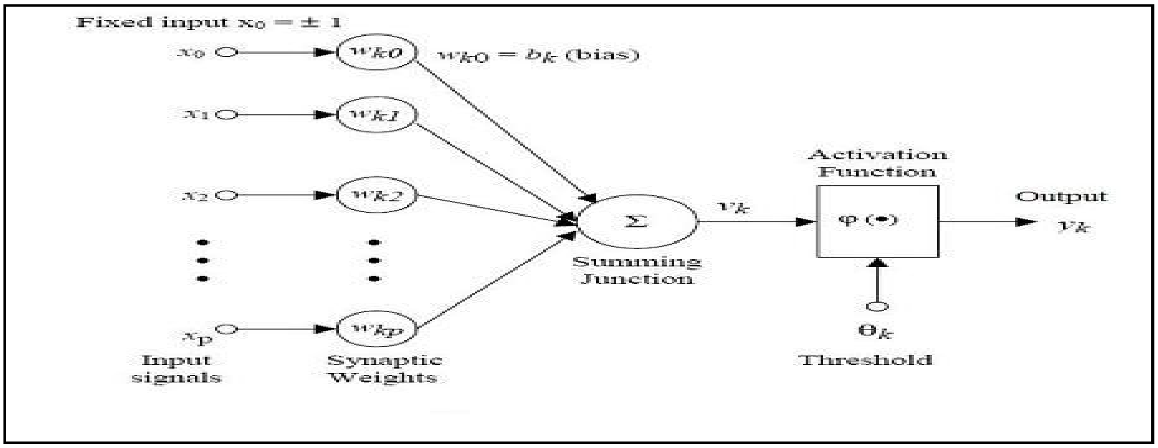

Figure 1: Mathematical Model of Neuron

From this model the interval activity of the neuron can be shown to be:

$$v_k = \sum_{j=1}^{p} w_{kj} x_j$$

The output of the neuron, yk, would therefore be the outcome of some activation function on the value of vk.

3.Feed-Forward Model

The arrangement of neurons into layers and the pattern of connection with in and in-between layer are generally called architecture of net. A feed forward neural network is an artificial neural network where connections between the units do *not* form a cycle. The feed forward neural network was the first and arguably simplest type of artificial neural network devised. In this network, the information moves in only one direction, forward, from the input nodes, through the hidden nodes (if any) and to the output nodes. There are no cycles or loops in the network.

A Generalized Network Stimulation is applied to the inputs of the first layer, and signals propagate through the middle (hidden) layer(s) to the output layer. Each link between neurons has a unique weighting value.

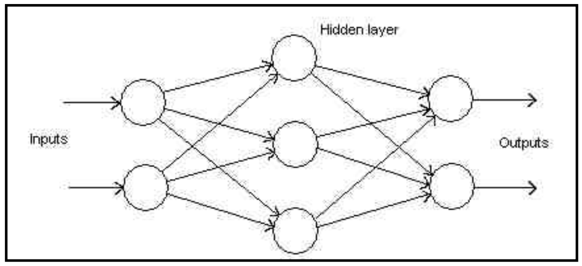

Figure 2

3.1.Back Propagation Network

Back propagation, an abbreviation for "backward propagation of errors", is a common method of training artificial neural networks. From a desired output, the network learns from many inputs.It is a supervised learning method, and is a generalization of the delta rule. It requires a dataset of the desired output for many inputs, making up the training set. It is most useful for feed-forward networks (networks that have no feedback, or simply, that have no connections that loop). Back propagation requires that the activation function used by the artificial neurons.

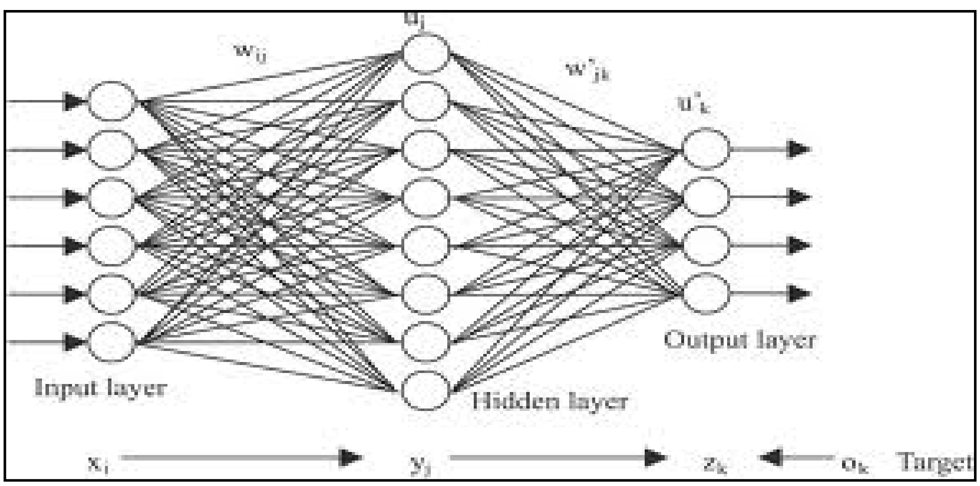

Figure 3: Back propagation neural network

4.Numerical Example

In this study we have applied the data collected from ACE glass containers pvt-ltd Company. The variable under study is height of the specific type of bottle. In data set there were 16 batches of 10 observations each shown in Table-1..The following approaches based upon the principles of neural network were applied.

Sample Data File

Input columns: 10 numeric columns (10 different observations)

Output column: Column #11

Abbreviations

TRN- Training

TST – Testing

VLD – Validation

IGN - Ignored

Neural Network Model Used For Architecture Identification

- An *Artificial Neural Network (ANN)* model having 2 layers is used.
- The input layer has 10 Nodes for the sample size of 10 inputs
- The output layer has 1 Nodes.
- The hidden layer was fixed with 6 numbers of Nodes.
- The model was trained with 75% of the normally distributed random data.
- Testing was performed with the rest 12.5% data
- Remaining 12.5% data is for Validation

	(N) Column #1	(N) Column #2	(N) Column #3	(N) Column #4	(N) Column #5	(N) Column #6	(N) Column #7	(N) Column #8	(N) Column #9	(N) Column #10	(N) Column #11
TRN	122.36	122.82	122.24	122.82	122.94	122.54	122.82	122.32	122.65	123.14	122.665
TRN	122.48	122.4	122.7	122.9	123.24	122.52	123.01	122.56	122.98	122.75	122.754
TRN	122.42	122.74	123	123.22	123.12	123.55	122.03	122.63	122.85	122.96	122.852
TST	122.48	122.96	123.84	123.02	122.76	122.36	122.52	122.58	123.58	123.05	122.915
TRN	123.04	123.1	123.36	123.34	122.82	123.05	122.96	122.85	123.25	123.01	123.078
VLD	122.75	122	121.8	122.66	122.76	122.85	122.45	122.78	122.56	122.69	122.53
TRN	123.32	122.62	123.82	123.1	123.46	123.02	122.69	122.85	122.63	122.45	122.996
TRN	122.89	122.92	122.9	122.94	123.36	122.89	122.96	122.35	123.35	122.56	122.912
TRN	122.8	125.32	122.2	122.5	122.68	122.63	122.86	123.56	123.01	122.63	123.019
TST	122.96	122.84	123.1	122.24	122.8	123.23	122.69	122.68	122.23	122.1	122.687
TRN	122.98	122.82	122.9	123.04	122.92	123.36	122.05	122.56	122.86	122.72	122.821
TRN	121.96	122.84	122.7	123	123.14	124.96	122.38	122.78	123.09	123.56	123.041
TRN	122.94	122	122.34	122.26	123.36	123.04	123.08	122.56	122.89	123.06	122.753
TRN	121.94	122.64	122.8	122.92	122.74	123.56	123.08	124.26	123.05	123.08	123.007
TRN	122.84	122.9	122.92	122.92	122.86	122.65	122.96	122.56	123.08	123.85	122.954
VLD	122.42	123.04	122.9	122.98	122.76	122.89	122.49	123.04	122.63	122.56	122.771

Table1: Data set for height of the specific type of Bottle.

4.1.Analysis Report

Data analysis results:

11 columns and 16 rows analyzed

11 columns and 16 rows accepted for neural network training

Input column: 10 numeric columns (10 different observations)

Output column: Column #11

Data partition method: Random

Data partition results:

12 records to Training set (75%), 2 records to Validation set (12.5%), 2 records to Test set (12.5%)

4.2.Preprocessing

Data preprocessing completed.

Columns before preprocessing: 11

Columns after preprocessing: 11

Input columns scaling range: [-1 1]

Output column(s) scaling range: [0 1]

Numeric columns scaling parameters:

Column #1: 1.449275 Column #2: 0.60241 Column #3: 0.980392 Column #4: 1.818182

Column #5: 2.564103 Column #6: 0.769231 Column #7: 1.904762 Column #8: 1.030928

Column #9: 1.481481 Column #10: 1.142857 Column #11: 1.824818

4.3.Selection of Architecture

8 network architectures verified

[10-6-1] architecture had the best fitness

Verified architectures:

[10-1-1] fitness: 11.447153

[10-25-1] fitness: 7.422042

[10-15-1] fitness: 8.804203

[10-9-1] fitness: 11.376691

[10-5-1] fitness: 12.135557

[10-7-1] fitness: 11.92078

[10-3-1] fitness: 11.139011

[10-6-1] fitness: 12.686308

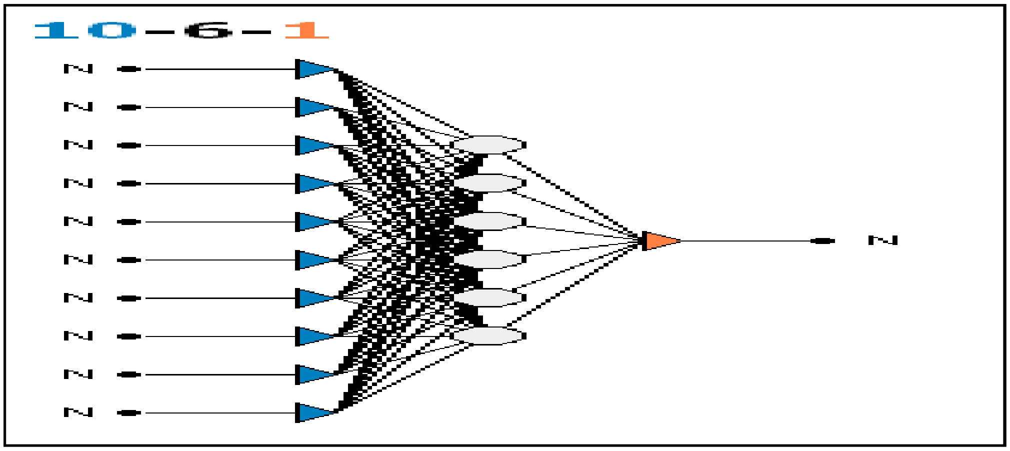

Figure 4: [10-6-1] Architecture had the Best Fitness

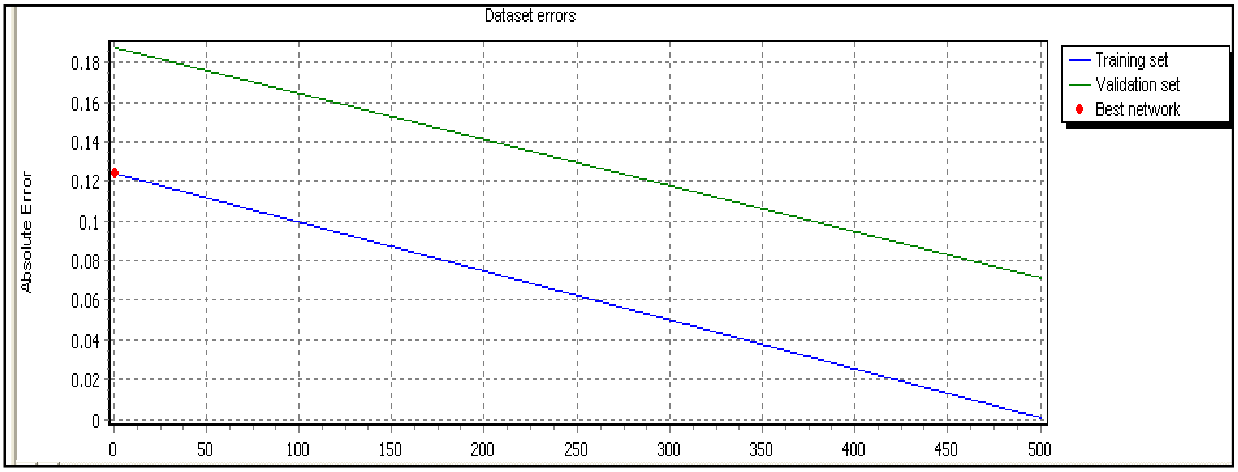

Figure 5: Training Graph

	Training	Validation
Absolute error	0.1242	0.1873
Network error	0.06718	0
Error improvement	8.01E-09	
Training algorithm	Quick propagation	
Architecture	[10-6-1] architecture	
Training stop reason	All iterations done	

Table 2: Parameters

Actual vs. Output Table

TRN VLD TST ALL | Inputs | Activations

	Row	Target	Output	AE	ARE
TRN	0	122.665	122.664991	0.000009	0.000008
TRN	1	122.754	122.739083	0.014917	0.012152
TRN	2	122.852	122.850384	0.001616	0.001315
TST	3	122.915	123.064748	0.149748	0.12183
TRN	4	123.078	123.045105	0.032895	0.026727
VLD	5	122.53	122.642031	0.112031	0.091432
TRN	6	122.996	122.994099	0.001901	0.001546
TRN	7	122.912	122.920952	0.008952	0.007283
TRN	8	123.019	123.015123	0.003877	0.003152
TST	9	122.687	122.762074	0.075074	0.061192
TRN	10	122.821	122.82193	0.00093	0.000757
TRN	11	123.041	123.028257	0.012743	0.010356
TRN	12	122.753	122.753823	0.000823	0.00067
TRN	13	123.007	123.026015	0.019015	0.015458
TRN	14	122.954	122.957392	0.003392	0.002759
VLD	15	122.771	122.768329	0.002671	0.002176

Table 3: Actual Vs Output Tabl

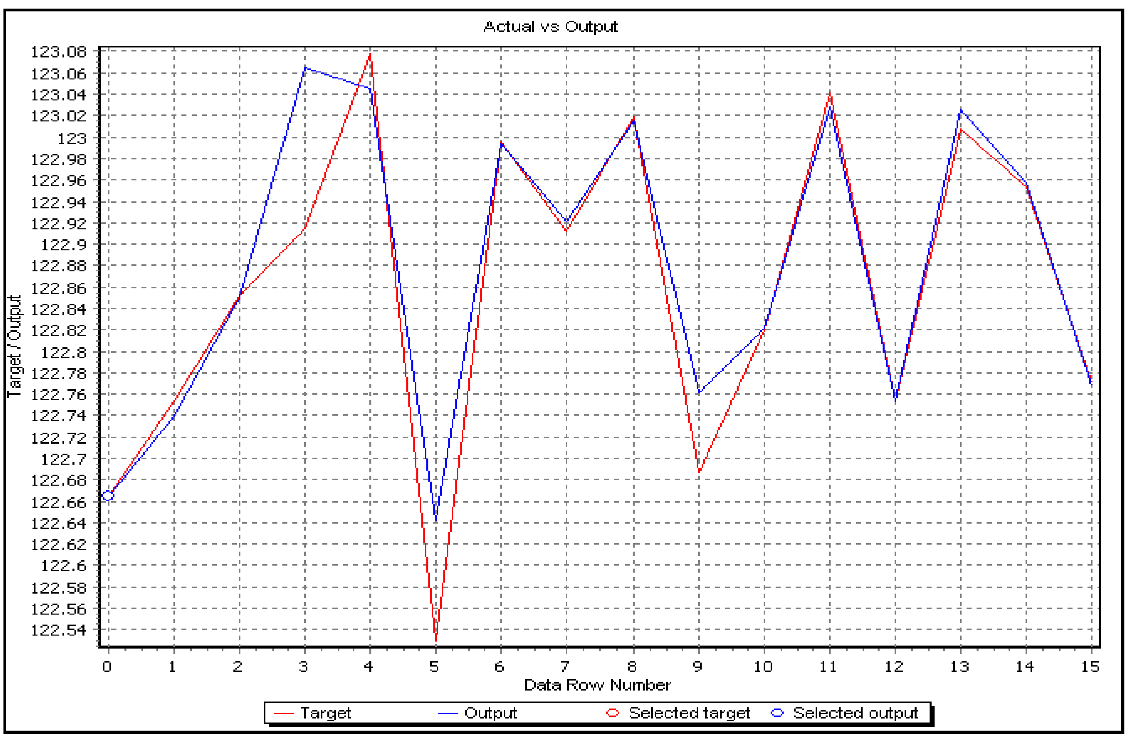

Figure 6: Actual Vs Output Graph

5.Discussion Of Result

Thus after training the ANN model with different samples of normal random sets of data, the model has become quite good at pattern recognition with no mistaken which amounts to 0% overall actual error. Although the training process takes considerable computer time, the recall process is very fast. The data used in this study may be applied to different neural network and pattern recognition techniques and result obtained from them should be compared with each other.

6.Reference

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