Research Article Impact Factor: 0.621 ISSN: 2319-507X
Nitinkumar Rathod, IJPRET, 2014; Volume 2 (9): 251-259 IJPRET

INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

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NEURAL NETWORK TECHNIQUE FOR MONITORING AND CONTROLLING IC-ENGINE PARAMETER

NITINKUMAR RATAN RATHOD

2nd YEAR MASTER IN ENGINEERING (MPE), MGM'S COLLEGE OF ENGG, NANDED

Accepted Date: 27/02/2014 ; Published Date: 01/05/2014

Abstract: This Paper deals with artificial neural network(ANN) modeling of a diesel engine to predict the Brake Power and Indicated Power of the engine. To acquire data for training and testing to the proposed ANN, a single cylinder, four-stroke test engine was fuelled with diesel and operated at different loads. Using some of the experimental data for training, an ANN model based on feed forward neural network for the engine was developed. Then, the performance of the ANN predictions were measured by comparing the predictions with the experimental results which were not used in the training process. It was observed that the ANN model can predict the engine Brake Power and Indicated Power quite well with correlation coefficients, with very low root mean square errors and also check for different Epoch with the use of Neuro Solution Software. This paper shows that, as an alternative to classical modeling techniques, the ANN approach can be used to accurately predict the performance parameters of internal combustion engines.

Keywords: ANN, IC Engine, Break Power, Indicative Power.

Corresponding Author: MR. SHREYASH RATHI

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Nitinkumar Rathod, IJPRET, 2014; Volume 2 (9): 251-259

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INTRODUCTION

Manufacturing industries are trying to reduce the operation cost as well as better quality of product. So software inspection for monitoring the engine parameter is a new approach towards the improvement of the engine performance, since it affects the overall performance of the engine. Different methods are available to improve the performance rating. For this different type of intelligent system has been put forward by many authors. BP and IP is a very important issue in engine manufacturing industries. T Hari Prasad et. al. [2] uses the ANN modeling of a diesel engine to predict the exhaust emission of the engine. Engine manufacturers are constantly striving to find new and improved techniques for the monitoring and controlling the motor vehicles engines. Intelligent techniques such as neural network and fuzzy methods are attractive for application in this area because their capabilities in pattern recognition modeling and the control. O. Obedeh and C.I Ajuwa [5] make the calibration of aging diesel engine with Artificial Neural Network and also predict the diesel engine NO_x emissions. R. J. Howlett [6] introduces the Neural and fuzzy techniques for monitoring and controlling of engine air fuel ratio. A neural network, also known as a parallel distributed processing network, as computing paradigm that is loosely modeled after structures of the brain. Neural network theory is sometimes used to refer to a branch of computational science that uses neural networks models to simulate or analyze complex phenomena and/or study the principles of operation of neural networks analytically. It addresses problems similar to artificial intelligence (AI) except that AI uses traditional computational algorithms to solve problems whereas neural networks use 'networks of agents' (software or hardware entities linked together) as the computational architecture to solve problems. Neural networks are trainable systems that can "learn" to solve complex problems from a set of exemplars and generalize the "acquired knowledge" to solve unforeseen problems as in stock market and environmental prediction .i.e., they are self-adaptive systems.

For this reason the case of neural network in the monitoring and control of motor vehicles engines is becoming an area of research which is receiving increasing attention from the academic and commercial research communities.

MATERIALS AND METHODS

In the present study, Kirlosker, single-cylinder, four-stroke, water cooled, diesel engine was used. A schematic diagram of the experimental setup, and the test engine picture used or gathering data are shown in Fig.1

The engine specifications are listed in Table 1. The testswere conducted with variable loads at different engine speeds.

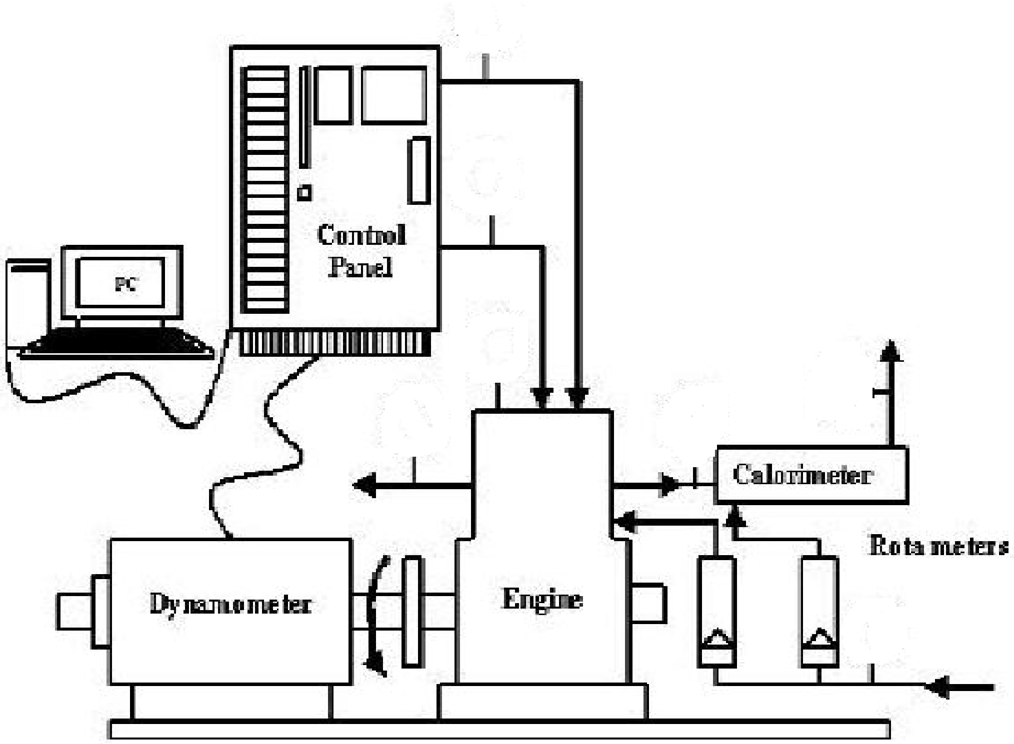


Fig.1 Experimental Set up

1. Water inlet to the calorimeter and engine
2. Water outlet from the engine jacket.
3. Water outlet from the calorimeter.
4. Exhaust gas inlet to the calorimeter.
5. Atmospheric air temperature.
6. Fuel flow.
7. Pressure Transducer.

TABLE 1: THE ENGINE SPECIFICATIONS

Engine Type	4-stroke, single cylinder diesel engine
Make	Kirloskar
Rated Power	10 BHP
Fuel used	Diesel
Bore diameter	87.5 mm
Stroke length	110 mm
Connecting rod length	150 mm
Compression ratio	17.5:1
Rated speed	1500
Cooling	Air cooled
Starting	Self start/crank
Method of ignition	Compression
Orifice diameter	20 mm
Dynamometer	Eddy current Dynamometer
Max. torque	4.6 kg-m

Back propagation neural network is a three-layered feed forward architecture. The three layers are input layer, hidden layer and output layer. Functioning of back propagation proceeds in three stages, namely learning or training, testing or inference and validation shows the 1-m-n (1 input neurons, m hidden neurons, and n output neurons) architecture of a back propagation neural network model. Input layer receives information from the external sources and passes this information to the network for processing. Hidden layer receives information from the input layer, and does all the information processing, and output layer receives proceeds information from the network and sends the results out to an external receptor. The input signals are modified by interconnections weights, known as weight factor w_{ij}, which represent the interconnections of i_{th} node of the first layer to the j_{th} node of second layer. The sum of modified normally decrease during initial phase of training, as does the training set error. However, the network begins to over fit the data; the error on the testing will typically begin to rise. When the testing error starts increasing for a specified number of iterations, the training is stopped, and the weight at the minimum value of the testing error are returned. The unseen data (validation set) is then fed to the trained network to check the percentage variation of predicted output (Brake Power and Indicated

Power) in comparison to the actual Brake Power and Indicated Power respectively.

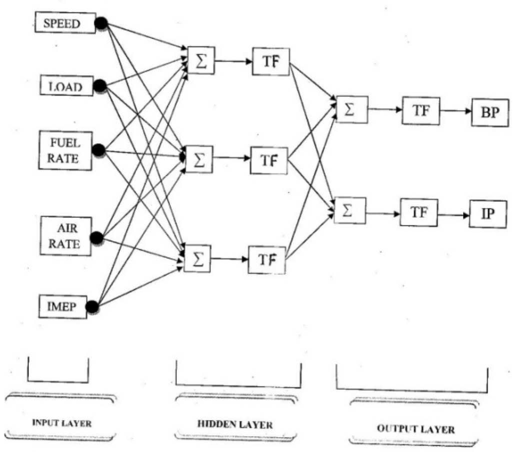


Fig. 2 Experimentation

Solution for Excel then sends messages to Neuro Solution in order to train or a test a network.

The breadboard contains all of the information that defines an experiment. The breadboard where the network construction and simulation takes place, networks can be automatically constructed using a Neural Builder utility or they can be built from scratch by selecting components from palettes and stamping them on breadboard. Note that removing component and/or adding new one from palettes can latter customize networks constructed with the Neural Builder. Fig. 3 shows the breadboard for Epoch-1500.

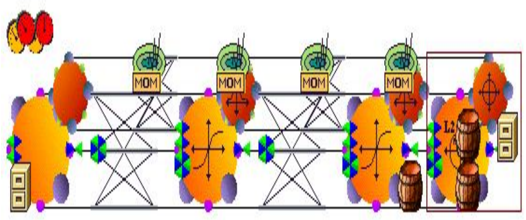


Fig: 3 Train neural network diagram- Epoch-1500

RESULT & DISCUSSION

A neural network is an adaptable system that can learn relationship through repeated presentation of data, and is capable of generalizing to new, previously unseen data. Some networks are supervised, in that human must determine what the network should learn from data. Other networks are supervised, in that the way they organize information is hard-coded into their architecture.

Neuro Solution for Excel is an Excel adds- in that allows user to construct, train, and test neural networks entirely from Excel. The user simply selects columns of data as input or target, and rows of data as training, testing, or cross validation.

The aim of this paper has been to show the possibility of using the neural networks for predictions of Brake Power and Indicated Power of the engine. Results show that, in most of the cases, the network produces results parallel to the experimental ones: therefore they can be used as an alternative way in these systems. The RMS error values are smaller than 0.02 and R2 values are about 0.999, which may easily be considered within the acceptable range. One deduction made from our experimental results and the prediction produced by ANNs is that, if the experiments are producing steady results (i.e. repeating an experiment under the same conditions produces almost the same result), the usage of ANNs may be highly recommended. Also in some cases, the usage of neural networks may not be appropriate. To be able to train a neural network, there must be either a logical linear relation or a logical non-linear relation between the input and the output.

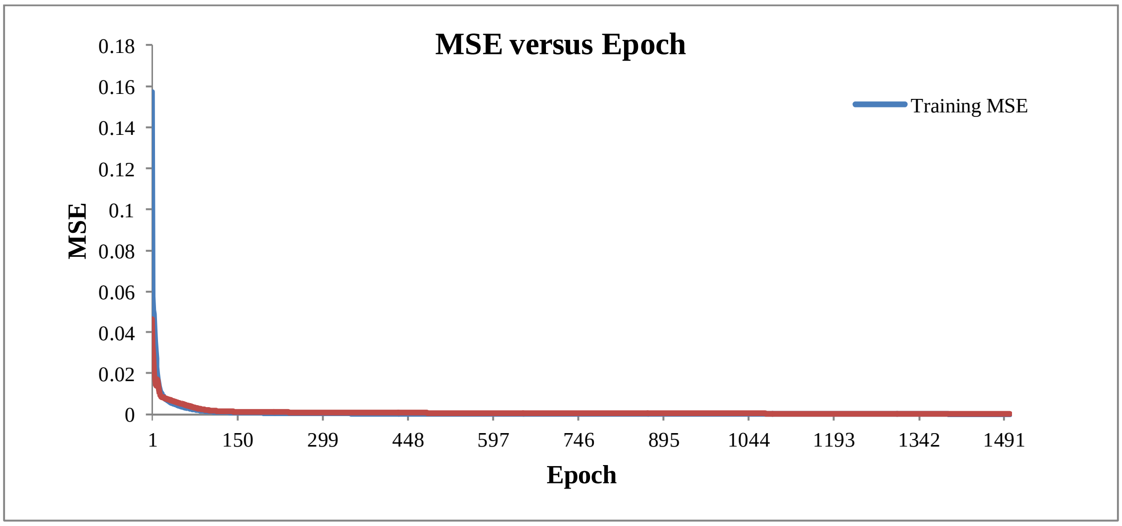
Normalize the original data i.e. experimental reading and feed into the Excel sheet. Randomize the normalized data and tag the column by input column as input & output column as desired. In this some of the rows are tagged as Training, some are taken as Cross Validation and remaining are as Testing, here we consider, 1-24 as Training, 25-30 as cross validation, 31-40 as Testing and predict the output by apply production dataset, shown in Table 2.

Table 2: Predicted Output

SR.NO.	Load	Speed	Fuel Rate	Air Rate	IMEP	BP	IP	BP Output	IP Output
1	0.482134	0.133846	0.390909	0.366666	0.332258	0.402439	0.149230	0.408931	0.144068
2	0.68858	0.127692	0.354545	0.633333	0.358064	0.568292	0.153333	0.578192	0.151865
3	0.188337	0.152307	0.463636	0.9	0.332258	0.168292	0.153333	0.140604	0.162983
4	0.155583	0.152307	0.9	0.9	0.538709	0.148780	0.194358	0.130119	0.227827
5	0.685607	0.133846	0.427272	0.633333	0.409677	0.568292	0.165641	0.576964	0.166555
6	0.601240	0.118461	0.3909	0.366666	0.5	0.5	0.177948	0.502083	0.176301

7	0.609181	0.118461	0.390909	0.366666	0.435483	0.5	0.165641	0.504274	0.161929
8	0.212158	0.143076	0.427272	0.633333	0.177419	0.187804	0.120512	0.205223	0.129282
9	0.480148	0.143076	0.354545	0.633333	0.280645	0.402439	0.141025	0.400404	0.138599
10	0.103970	0.143076	0.112121	0.9	0.190322	0.1	0.124615	0.111639	0.139299

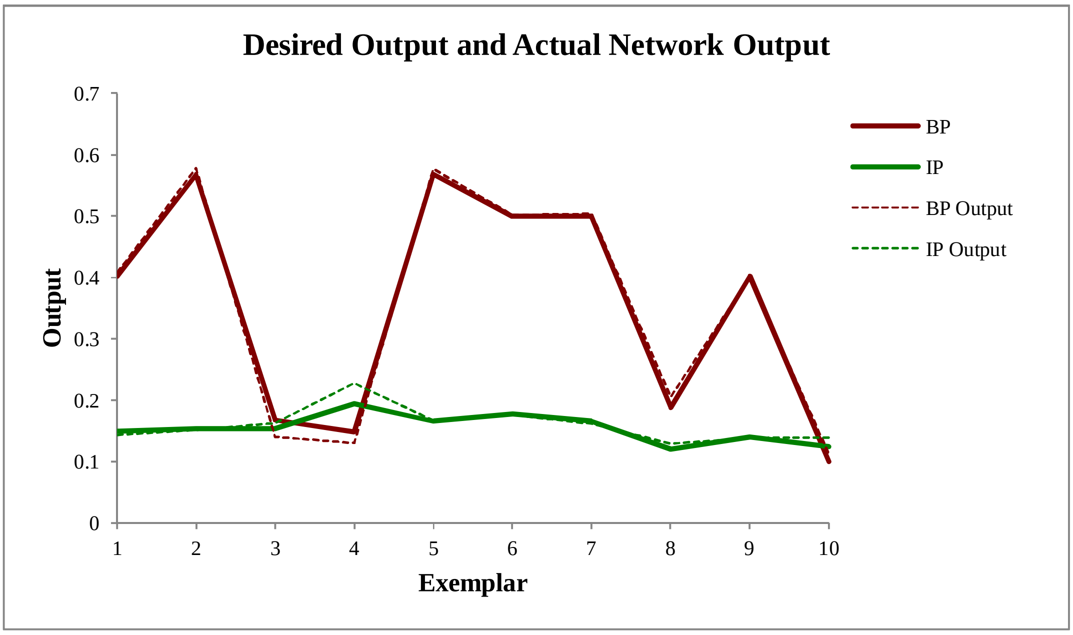
Graph 1: MSE (mean square error) Vs Epoch



Best Networks	*Training*	*Cross Validation*
Epoch #	1500	1500
Minimum MSE	0.000168014	0.000398521
Final MSE	0.000168014	0.000398521

The following graph gives the relation between the normalized input values (i.e. output parameters), and the normalized predicted output which are given by the Neuro solution.

Graph 2: Desired output and Actual Network output



The result of testing is as below:

Performance	BP	IP
MSE	0.000179588	0.000155784
NMSE	0.005832622	0.335231219
MAE	0.010886424	0.00819035
Min Abs Error	0.002034509	0.0009147
Max Abs Error	0.027688253	0.033468704
r	0.997604204	0.910811359

CONCLUSION

In this paper, the Artificial Neural Network is used for prediction of performance of diesel engine. The back propagation neural network has been developed for prediction of BP and IP. Effect of various parameters like torque, speed, fuel rate, air rate, Indicated mean effective pressure has been studied. Present study shows that back propagation neural network could be trained for future prediction of BP and IP. The predicted BP and IP from neural network are very close to the actual BP and IP measured experimentally.

Following observations were made regarding neural network-

1. Torque, Speed, Fuel Rate, Air Rate and IMEP were given as input and BP and IP was estimated using different structures of ANN. These can be used to train the neural network for getting the estimated values of BP and IP.

2. The comparative analysis has been done between the actual values of BP and IP with estimated values obtained by neural network analysis.

3. Foraepoch-1500

a. The RMS error values are smaller than 0.0276 and R2 values are about 0.9976 for BP.

b. The RMS error values are smaller than 0.0334 and R2 values are about 0.9108 for IP.

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