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Parametric Analysis of Surface Roughness Studies in Turning Using Artificial Neural Network

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ABSTRACT

Neural Networks are information processing systems and can be used in several areas of engineering applications and eliminate limitations of the classical approaches by extracting the desired information using the input data. The advantage of the usage of neural networks for prediction is that they are able to learn from examples only and that after their learning is finished, they are able to catch hidden and strongly nonlinear dependencies, even when there is significant noise in the training set. One of the most specified customer requirements in a machining process is surface roughness. For efficient use of machine tools, optimum cutting parameters are required. Therefore it is necessary to find a suitable optimization method which can find optimum values of cutting parameters for minimizing surface roughness. The turning process parameter optimization is highly constrained and nonlinear. Many researchers have used an artificial neural network (ANN) model for the data obtained through experiments to predict the surface roughness. The results obtained, conclude that ANN is reliable and accurate for solving the cutting parameter optimization. The paper work presents on all studies where ANN has been used to analyse surface roughness in turning process.

Keywords: *Surface Roughness; Turning; Artificial Neural Network; Parametric Analysis*.

1.0 Introduction

The operating parameters that contribute to turning process are cutting speed, Feed rate, Depth of cut. Vibrations, tool wear, tool life, surface finish and cutting forces etc are also in direct relation with values selected for process parameters. Hence to improve the efficiency of process and quality of the product it is necessary to control the process parameters. The product quality depends very much on surface roughness. Increase of surface roughness also leads to decrease of product quality. In field of manufacturing, the surface finish quality is important and influences the functioning of a component. Surface roughness has been receiving attention for many years in the industries. It is an important design feature, such as parts subject to fatigue loads, precision fits, and fastener holes and so on. In terms of tolerances, surface roughness is one of the most crucial constraints for the machines and cutting parameters selection. Manufacturing industries are very much concerned about the quality of their products. They are focused on producing high quality products in time at minimum cost. Surface finish is one of the crucial performance parameters that have to be controlled within suitable limits for a particular process. Therefore it is necessary to find a suitable optimization method which can find optimum values of cutting parameters for minimizing surface roughness.

ANN is found to be very useful with simulations tasks which have complex and explicit relation between control factors and result of process. Artificial Neural Network can be created using feed forward back propagation technique for simulation of the process.

With assurance of accuracy of the predictive capabilities of the neural network; it may be then used for optimization. the crematorium.

This problem was shorted out by Wolfgang Scheffler who invented a new concentrator (scheffler reflector) tracking the Sun without changing it focus.

In this paper, scheffler reflector is redesigned to determine required size (Aperture Area) of the

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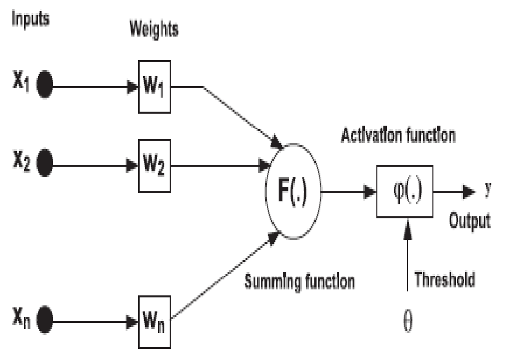
concentrator to obtain sufficient heat energy for cremating a corpse.

2.0 Artificial Neural Network

Neural network is one of the important components in Artificial Intelligence (AI). It has been studied for many years in the hope of achieving human-like performance in many fields, such as speech and image recognition as well as information retrieval. A Neural Network is an interconnected assembly of simple processing elements, units or nodes, whose functionality is loosely based on the animal neuron. The processing ability of the network is stored in the inter-unit connection strengths, or weights, obtained by a process of adaptation to, or learning from, a set of training patterns. In its most general form, a neural network is a machine that is designed to model the way in which the brain performs a particular task or function of interest; the network is usually implemented by using electronic components or is simulated in software on a digital computer. A neural network is a parallel distributed processor made up of simple processing units, which has a natural propensity for storing experiential knowledge and making it available for use. It resembles the brain in two respects: Knowledge is acquired by the network from its environment through a learning process; Interneuron connection strengths, known as synaptic weights, are used to store the acquired knowledge. In summary, neural networks are models attempt to achieve good performance via dense interconnection of simple computational elements. A neural network has three components: a network, an activation rule, and a learning rule. The *network* consists of a set of nodes (units) connected together via directed links. Each node in the network has a numeric activation level associated with it. The overall pattern vector of activation represents the current state of the network. *Activation rule* is a local procedure that each node follows in updating its activation level in the context of input from neighbouring nodes. *Learning rule* is a local procedure that describes how the weights on connections should be altered as a function of time. Types of activation functions include: threshold function; Piecewise-linear function, and sigmoid function. The sigmoid function, whose graph is s-shaped graph, is by far the most common form of activation function used in the construction of neural networks.

A simple process element of the artificial neural network has three layers; the input, hidden, and output layers. The input and output layers are defined as nodes, and the hidden layer provides a relation between the input and output layers. Initially, the weights of the nodes are random and the network has not any knowledge. For a given input pattern, the network produces an associated output pattern. Its learning and update procedure is based on a relatively simple concept: the network is provided with both a set of patterns to be learned and the desired system response for each pattern. If the network generates the wrong answer, then the weights are updated to be less error. Finally, future responses of the network are more likely to be correct. Regarding the number of layers, the only certainty is that there should be an input and an output layer so as to be able to present and obtain data to and from the ANN, respectively. The number of neurons in each of these two layers is specified by the number of input and output parameters that are used to model each problem so it is readily determined. Therefore, the objective is to find the number of hidden layers and the number of neurons in each hidden layer. Unfortunately, it is not possible to theoretically determine how many hidden layers or neurons are needed for each problem. The activation functions are chosen based on the kind of data that are available (binary, bipolar, decimal, etc.) and the type of layer. For instance, the identity function is almost always used in the input layer, while continuous non-linear sigmoid functions are used in the hidden layers (usually the hyperbolic tangent function). The training algorithm influences to a far greater extent the training speed, performance of an ANN (training error) or the necessary computing power rather than the architecture itself.

Fig 1: The Mathematical Model of Neuron

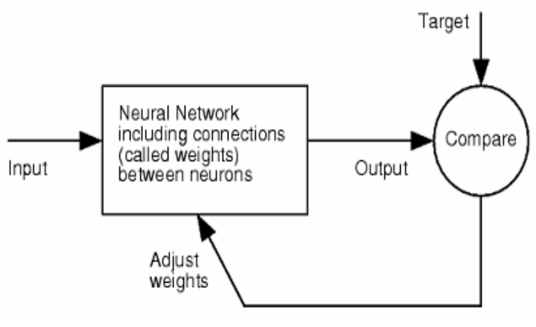


The basic rules are that neurons are added when training is slow or when the mean squared error is larger than a specified value, and that neurons are removed when a change in a neuron‟s value does not correspond to a change in the network‟s response or when the weight values that are associated with this neuron remain constant for a large number of training epochs.

Learning is the process by which the free parameters of a neural network get adapted through a process of stimulation by the environment in which the network is embedded. The type of learning is determined by the manner in which the parameter changes take place. The set of well-defined rules of the solution of a learning problem is called a learning algorithm. Each learning algorithm differ from the other in the way in which the adjustment to a synaptic weight of a neuron is formulated. Also, the manner in which a neural network is made up of inter-connected neurons relating to its environment, is also to be considered. There are various learning rules. Hebb‟s learning rule is the oldest and most famous of all learning rules. It states that, "when an axon of cell A is near enough to excite a cell B and repeatedly or persistently takes part in firing it, some growth process or metabolic changes take place in one or both cells such that A‟s efficiency as one of the cells firing B, is increased". This learning can also be called correlational learning. This statement may be split into a two-part rule: 1. If two neurons on either side of a synapse are activated simultaneously, then the strength of that synapse is selectively increased. 2. If two neurons on either side of a synapse are activated simultaneously, then that synapse is selectively weakened or eliminated. This type of synapse is called hebbian synapse. The four key mechanisms that characterize a hebbian synapse are dependent mechanism, local mechanism, interactive mechanism and correlational mechanism.

For the perception learning rule, the learning rule, the learning signal is the difference between the desired and actual neuron‟s response. This type of learning is supervised. The fact that the weight vector is perpendicular to the plane separating the input patterns during the learning processes, can be used to interpret the degree of difficulty of training a perceptron for different types of input. There is a perceptron learning rule convergence theorem which states, `` if there is a weight vector w* such that f (x (p) w*) = t (p) for all p, then for any starting vector w1 the perceptron learning rule will converge to a weight vector that gives the correct response for all training patterns, and this will be done in a finite number of steps".

Fig 2: Feedback Control System in NN



The delta learning rule is also referred to as widow-hoff rule, named due to the originator. The delta learning rule is valid only for continuous activation function and in the supervised training mode. The learning signal for this rule is called delta. The delta rule may be stated as, "The adjustment made to a synaptic weight of a neuron is proportional to the product of the error signal and the input signal of the synapse". The delta rule assumes that the error signal is directly measurable. The aim of the delta rule is to minimize the error over training patterns. Delta rule can be applied for single output unit and several output units. In this learning, the output neural network complete among themselves to become active. The basic idea behind this rule is that there are a set of neurons that are similar in all aspects excepts for some randomly distributed synaptic weights, and therefore respond differently to a given set of input patterns. However, a limit is imposed on the strength of the neurons. This rule has a mechanism that permit the neuron to complete of the right to respond to a given subset of inputs, such that only one output neuron, or only one neuron per group, is active at a time. The winner neuron during competition is called winner-takes-all neuron.

2.1. Applications of artificial neural network

Neural Network in arts: The rapidly expanding field of neural networks provides a new approach to computer art applications. Rather than operate in the traditional style of pre-programmed rule-following systems, neural networks have the power to learn to produce specific types of outputs from specific inputs, based on examples they are taught. Thus, instead of having to specify how to create a certain artwork, the artist can instead teach a network examples of the desired output, and have the network generate new instances in that style. Several applications have been found in Music area, ranging from psychological models of human pitch, chord, and melody perception, to networks for algorithmic composition and performance control. Generally speaking, the applications here (and in other fields) can be divided into two classes: "input" and "output". The input side includes networks for recognition and understanding of a provided stimulus, for instance speech recognition, or modeling how humans listen to and process a melody. Such applications are useful for communication from human to machine, and for artistic analysis, of a set of inputs. The output side includes the production of novel works, applications such as music composition or drawing generation. As signal processors, networks should find wide application in image enhancement, color adjusting or altering, edge and line modification, texture processing, etc. all based on learned mappings from input pictures to desired outputs. The area of neural network handwriting recognition is also being widely explored. A network could be trained to take an image of a face as input, and produce as output an image of that face now displaying any of several chosen emotions: smiling, frowning, staring, tongue stuck out, etc. Sequential networks could be used to produce the step-by-step movements of objects following some trajectory in space. Networks can also find interesting use in real-world kinetic applications, for controlling the motion of robots and vehicles from single arms to self-driving automobiles. Art forms including kinetic sculpture, machine dance, automated music conducting, etc. are fertile areas for neural network applications.

Neural Network in Bioinformatics: With the advent of the human genome project, the area of Bioinformatics, especially protein sequencing, has become a major target for neural networks. Protein folding refers to the problem of predicting a protein‟s three-dimensional structure from a one-dimensional amino-acid sequence. So far, neural network have shown a lot of promise and initial experimental success towards the protein folding problem.

Neural Network in Forecasting: The purpose of using neural networks is to be able to forecast data patterns that are too complex for the traditional statistical models. The learning ability of neural networks allows them to adjust to dynamic and changing market environments and is a much more flexible forecasting tool than traditional statistical models. An example of this level of flexibility is in area of forecasting net asset values of mutual funds. Many areas of business, especially finance, utilize neural networks to improve forecasting of their business applications and to create new methods of evaluating financial data and investment decisions. Neural networks are being used specially by companies for improved forecasting capabilities in analysis of the stock market. Neural network systems are being used to predict short-term stock performance. Neural networks have also been used in determining bond ratings. Bank loan decisions are another area in which neural networks are proving useful. Because the decision to make or deny a loan is very subjective or non-linear in nature, the use of neural networks resulted in a significant improvement in this decision making process. The ability to forecast server downtime has been advantageous to companies such as Computer Associates because such predictions make it possible for the company to fix any potential network problem prior to complete computer network failure. Forecasting (GDP) with neural networks was proven to provide more accurate predictions when compared to traditional statistical forecasting techniques. Neural network systems are being used by manufacturers to better determine adequate raw material levels and credit card companies are utilizing the technology for discovering and monitoring fraudulent activities. Sales forecasts are also being improved through neural network technology at both the wholesale and retail levels.

Neural Network in Healthcare: Neural networks have been applied within the medical domain for clinical diagnosis, image analysis and interpretation, signal analysis and interpretation, and drug development. Papnet is a commercial neural network-based computer program for assisted screening of Pap (cervical) smears. A Pap smear test examines cells taken from the uterine cervix for signs of precancerous and cancerous changes. Traditionally, Pap smear testing relies on the human eye to look for abnormal cells under a microscope. Relying on manual inspection alone makes it inevitable that some abnormal Pap smear will be missed. Papnet-assisted reviews of [cervical] smears result in a more accurate screening process than the current practice, leading to an early and more effective detection of pre-cancerous and cancerous cells in the cervix.

An Entropy Maximization Network (EMN) has been applied to the prediction of metastases in breast cancer patients. A multilayer feed forward network trained with back propagation learning algorithm was used for differential diagnosis of brain disease (multiple sclerosis and cerebrovascular disease). Imaging is an important area for the application of ANN pattern recognition techniques. Particularly in medicine, pattern recognition is widely used to identify and extract important features in radiographies, ECTs, MRIs, etc. Neural networks are also used for segmentation and classification of multi-spectral MRI images of normal and pathological human brain. Neural network determines the optimal diagnostic strategy for colorectal cancer using MRI and tumour markers. It is also used to detect four ECG waveforms.

Application of Neural Networks to Intrusion Detection: Intrusion Detection System are becoming largely employed as a fundamental security systems to secure company networks. Ideally, an IDS has the capacity to detect in real-time all (attempted) intrusions, and to execute work to stop the attack (for example, modifying firewall rules). Commercial tools available today have limitations in detecting real intrusions, and neural network is an efficient way to improve the performances of IDS systems which are based on the misuse detection model and the anomaly detection model.

Neural Network in Communication: Typical RF and wireless circuits comprise a large number of linear and non-linear components. Complexity of RF portion of a wireless system continues to increase in order to support multiple standards, multiple frequency bands, need for higher bandwidth and stringent adjacent channel specifications. The time required to carry out a virtual prototyping of such complex circuits and their trade-off analysis with the baseband circuitry, can be unacceptably long, because both the circuit simulation and optimization procedures can be very time-consuming. Typically, one divides the task into that of designing the non-linear elements or sub-circuits at module level. Neural network speeds up the modeling RF circuits.

Neural Network in Robotics: A novel topological world model and region-filling algorithm is used for autonomous vacuuming robots. Humans, and other animals, model their environment using topologies of landmarks. This type of representation does not rely solely on an absolute coordinate system. Therefore, a coherent world model can be constructed with noisy sensor data as long as the landmarks are properly recognized. Landmark recognition is central to the implementation of the proposed world model on a real robot. A neural network can easily recognize the natural landmarks selected. Two types of neural network (multi-layer perceptron and learning vector quantisation) were trained and tested on a real robot for a natural landmark recognition task.

Neural Network in Image Processing and Compression: Windows based neural network image compression and restoration, Real time data compression, Image compression using direct solution method (DSM) method based neural network, Application of NN to wavelet filter selection in multispectral image compression, Human face detection in visual scenes, Rotation invariant neural network-based face detection

Neural Network in Control: The neural network can be act as NN controller and can be used in the feedback path as NN estimator for parameter estimation. The applications included are: Neural network based controller for induction motor. In this application the neural networks are used as controller to control the speed of the induction motor. Neural network control of the neutralization system. In this application the pH value is used to control the neutralization of the system. The pH value is controlled by controlling the flow rate of the base. Neural network based controller for broom stick balancer. In this application the position and angle of broom stick is used to control the balance of the broom stick.

Neural Network in Pattern Recognition: Pattern recognition is the association of an observation to past experience or knowledge. It involves many stages such as making the measurements, pre-processing and segmenting, finding a suitable numerical representation for the objects we are interested in and finally classifying them on these representations.

3.0 Literature Review

Diwakar Reddy V. *et al*, [8] have carried out machining process on Mild steel material in dry cutting condition in a lathe machine and surface roughness was measured using Surface Roughness Tester. To predict the surface roughness, an artificial neural network (ANN) model was designed through back propagation network for the data obtained. Comparison of the experimental data and ANN results showed that there is no significant difference and ANN was used confidently. Three cutting parameters speed, feed, depth of cut have been considered. The machining tests have been carried out by straight turning of medium carbon steel (mild steel) on a lathe by a standard HSS uncoated and carbide insert with ISO designation-SNMG 120408 at different speed-feed and depth combinations. By using the MATLAB command „postmnmx" the network values have been predicted, regression analysis was adopted to find the coefficient of determination value (R2) for both training and testing phases to judge performance of each network. The multilayer feed forward network consisting of three inputs, 25 hidden neurons (tangent sigmoid neurons) and one output (network architecture represented as 3-25-1) was found to be the optimum network for the model developed in their study. They concluded from their results obtained that ANN is reliable and accurate for solving the cutting parameter optimization. A. V. N. L. Sharma *et al*, [1] studied prediction of surface roughness, using an Artificial Neural Network (ANN) model which was designed through back propagation network using MATLAB 7.1 software for the data obtained. Experimental details and specifications used in their study were, Machine tool : Engine Lathe, Work material: Mild steel, Cutting tool : High speed steel, Cemented carbide tipped tool.

Cutting conditions: Dry environment Surface roughness measuring instrument Mitutoyo SJ-201P Traverse Speed: 1mm/sec, Measurement: Metric/Inch. Three cutting parameters speed, feed, depth of cut have been considered .They have concluded in their studies that the approach is suitable for fast determination of optimum cutting parameters during machining, where there is not enough time for deep analysis. U. Natarajan *et al,* [22] analyzed the feasibility of fully automated futuristic actories. Their research studies deals with the use of machine vision techniques to inspect surface roughness of a work piece under a variation of turning operations. The surface image of the work piece is first acquired using a digital camera and then the feature of the surface image has been extracted. A neural fuzzy network using a self-organizing adaptive modeling method have been applied to constructing the relationships between the feature of the surface mage and actual surface roughness under various parameters of turning operations. They have, concluded from their results obtained that ANN is reliable and accurate for solving the cutting parameter optimization.

Sita Rama Raju K *et al*, [20] studied three soft computing techniques namely Adaptive Neuro Fuzzy Inference System ANFIS, Neural Networks NN and regression in predicting the surface roughness in turning process. The work piece material used was AA 6063 aluminum alloy. Here 27 data sets were considered for training and 9 data sets were considered for testing

The predicted surface roughness values computed from ANFIS, NN and regression are compared with experimental data. Based on the their experimental results they observed that, surface roughness value increases as the feed and depth of cut increases and as the spindle speed increases the surface roughness value decreases. The minimum surface roughness value is observed at spindle speed of 150 rpm, feed of 0.05 mm/rev and a depth of cut of 0.2 mm respectively. Zsolt Janos and Viharos, [25] applied ANN models to estimate the roughness of a given finishing operation.

They have used acoustic emission sensor as an information source to improve the estimation capability of the ANN model. To avoid the problem of overlapping and non-invertable dependencies they have used a new approach for building the ANN model. To estimate the surface roughness parameters describing the energy content of the Acoustic Emission signals sensor were used beside the three machining parameters depth of cut (a), feed per revolution (f) and cutting speed (v).Four parameters related to different frequency range were used to describe the energy content.

Tugrul Ozel *et al*, [21] studied the effects of tool corner design on the surface finish and productivity in turning of steel parts. Surface finishing has been investigated in finish turning of AISI 1045 steel using conventional and wiper (multi-radii) design inserts.

Multiple linear regression models and neural network models have been developed for predicting surface roughness, mean force and cutting Power. The Levenberg-Marquardt method was used together with Bayesian regularization in training neural networks in order to obtain neural networks with good generalization capability.

Neural network based predictions of surface roughness were carried out and compared with a non-training experimental data. These results showed that neural network models are suitable to predict surface roughness patterns for a range of cutting conditions in turning with conventional and wiper inserts.

Fig 3: Multilayer Feed-forward Neural Network

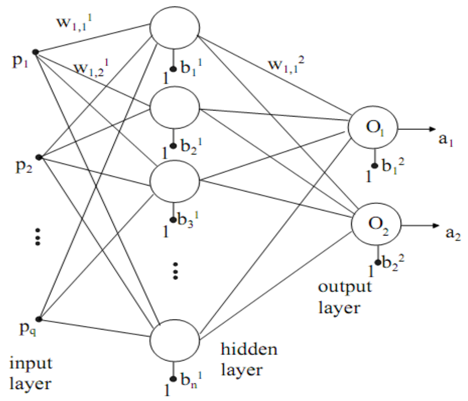
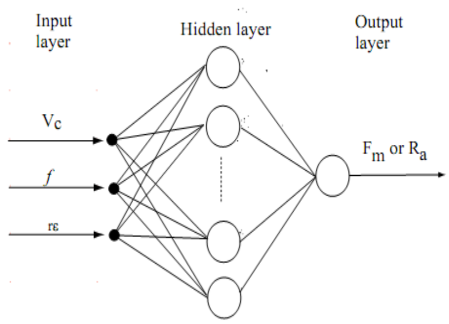


Fig 4: Architecture of Multilayer Feed-Forward Neural Network used for Predictions



Yue Jiao *et al*, [24] used combined neural - fuzzy approach (fuzzy adaptive network, FAN), to model surface roughness in turning operations. The FAN network has both the learning ability of neural network and linguistic representation of complex, not well-understood, vague phenomenon. A model representing the influences of machining parameters on surface roughness have been established and verified by the use of the results of pilot experiments. Ilhan Asiltürk and Mehmet Çunkas [10] used artificial neural networks (ANN) and multiple regression approaches to model the surface roughness of AISI 1040 steel. Full factorial experimental design is implemented to investigate the effect of the cutting parameters (i.e. cutting speed, feed rate, and depth of cut) on the surface roughness. In order to predict the surface roughness, the second-order regression equation can be expressed as: $Ra = \beta 0 + \beta 1 . V + \beta 2 . f + \beta 3 . a + \beta 4 . V2 + \beta 5 . f2 + \beta 6 . a2 + \beta 7 . V. f + \beta 8 . V . a + \beta 9 . a . f$

The multiple regression models are tested by aiding the analysis of variance (ANOVA). The data have been used to build the multiple regression model. The coefficients $\beta 0, \beta 1, \beta 2 \dots \beta 9$ are estimated with the least square method using MINITAB 14. Multilayer perception (MLP) architecture with back-propagation algorithm having two different variants is used in neural network. The performances of multiple regression and neural network-based models are compared by means of statistical methods. In this study, ANN structure is used for modeling and predicting surface roughness in turning operations. This fully connected hierarchical network structure has an input layer, a hidden layer, and an output layer. The back-propagation learning algorithms such as scaled conjugate gradient (SCG) and Levenberg–Marquardt (LM) were used to update the parameters in feed forward single hidden layers.

The cutting speed (V), feed (f), and depth of cut (d) were considered as the process parameters. The input layers of the neural network consist of three neurons whereas the output layer had a single neuron that represents the predicted value of surface roughness. The logsig processing function and single hidden layer had been used. A trial and error scheme had been used to determine the appropriate number of hidden neurons. The number of hidden neurons was determined as four and five neurons. The maximum number of epochs and the learning rate value for each run were selected as 10,000 and 0.9, respectively.

Table 1: Neural Networks Multilayer Perceptron [16]

Sr. No	s	f	d	Ra	Pred. Ra
1	1700	0.1	0.2	0.82	0.83
2	1700	0.1	0.3	0.94	0.86
3	1700	0.1	0.4	0.96	0.87
4	1700	0.13	0.2	1.12	0.99
5	1700	0.13	0.3	1.06	1.09
6	1700	0.13	0.4	1.1	1.1
7	1700	0.15	0.2	1.44	1.38
8	1700	0.15	0.3	1.54	1.44
9	1700	0.15	0.4	1.5	1.45
10	1900	0.1	0.2	0.86	0.84
11	1900	0.1	0.3	0.92	0.88
12	1900	0.1	0.4	0.76	0.88
13	1900	0.13	0.2	1.04	1.01
14	1900	0.13	0.3	1.2	1.12
15	1900	0.13	0.4	1.1	1.13
16	1900	0.15	0.2	1.44	1.4
17	1900	0.15	0.3	1.6	1.46
18	1900	0.15	0.4	1.5	1.46
19	2100	0.1	0.2	0.88	0.84
20	2100	0.1	0.3	0.78	0.88
21	2100	0.1	0.4	1.16	0.89
22	2100	0.13	0.2	1.08	1.03
23	2100	0.13	0.3	1.14	1.14
24	2100	0.13	0.4	1.26	1.15
25	2100	0.15	0.2	0.58	1.41
26	2100	0.15	0.3	1.42	1.46
27	2100	0.15	0.4	1.86	1.47

Ten independent runs having different initial random weights were performed to achieve a good solution. Data sets were from experiments conducted on a CNC turning machine. After each turning operation, the surface roughness (Ra) was measured with Surface Roughness Tester Mitotoyo (SJ-301). The measurements were taken three times for each work piece.

A National Instruments portable E Series NI DAQCard-6036E with maximum acquisition rate of 200,000 samples per second and 16 channels, data acquisition card was used to transmit the data to PC. A software called as ilhan_daq_v01 was developed using Matlab 6.5 program. The constants and cutting parameters were entered to the interface.

The outputs were measured as 80 samples/sec, and their average values were recorded as one datum. Consequently, tests were performed with 27 experimental runs. They concluded that ANN is a powerful tool in predicting surface roughness.

Ruturaj Kulkarni *et al*, [18], carried out tests on AISI 4140 steel. 12 speed Jones and Lamson Lathe model was used for turning operation. The specimen with a diameter of 60mm, 500mm length and hardened 35 HRC is used.

The operating parameters that contribute to turning process are cutting speed, Feed rate, Depth of cut, Vibrations, tool wear, tool life, surface finish and cutting forces. These readings were used to train and validate the Neural Network.

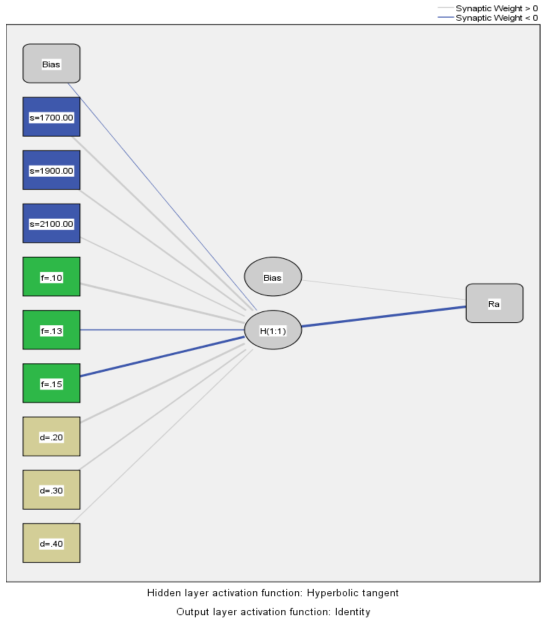
They found ANN to be very useful with simulations tasks which have complex and explicit relation between control factors and result of process. They created Neural Network using feed forward back propagation technique for simulation of the process using the Matlab Neural network toolbox. With assurance of accuracy of the predictive capabilities of the neural network, it was then used for optimization.

Particle Swarm Optimization Algorithm, an evolutionary computation technique is used to find out the optimum values of the input parameters to achieve the minimum surface roughness.

The objective function used here is to minimize the surface roughness. Limits of the operational variables are used as constraints for developing the code for optimization algorithm. Ranganath M S *et al*, [16] analyzed surface roughness of Aluminium (6061) through neural network model. To predict the surface roughness, neural network model was designed through Multilayer Perceptron network for the data obtained.

The predicted surface roughness values computed from ANN, were compared with experimental data and the results obtained showed that neural network model is reliable and accurate for solving the cutting parameter optimization.

Fig 5: Network Layers [16]



They concluded that the appropriate cutting parameters can be determined for a desired value of surface roughness. Durmus Karayel [9], has used neural network approach for the prediction and control of surface roughness in a computer numerically controlled (CNC) lathe. A feed forward multi-layered neural network was developed and the network model was trained using the scaled conjugate gradient algorithm (SCGA), which is a type of back-propagation. The adaptive learning rate was used. He concluded that the appropriate cutting parameters can be determined for a desired value of surface roughness. Anna Zawada and Tomkiewicz [3], have estimated the surface roughness parameter with use of a neural network (NN). The optical method suggested in this paper is based on the vision system created to acquire an image of the machined surface during the cutting process. The acquired image is analyzed to correlate its parameters with surface parameters. In the application of machined surface image analysis, the wavelet methods were introduced. A digital image of a machined surface was described using the one-dimensional Digital Wavelet Transform with the basic wavelet as Coiflet. The increment of machined surface image parameters was applied as input for the neural network estimator. Five cross-sections of the image were loaded, from which six statistical parameters of the six levels of wavelet decomposition were computed. These six parameters were chosen via the Optimal Brain Surgeon Method. They found that by applying the increments of these parameters and of the estimated value in a given time, it made possible to establish the *Ra* estimator for the points in time when the surface roughness parameters were unknown. Ranganath M S *et al*, [15], have reviewed the works related to Artificial Neural Networks ANN, in predicting the surface roughness in turning process. They studied in papers that some of the machining variables that have a major impact on the surface roughness in turning process, such as spindle speed, feed rate and depth of cut were considered as inputs and surface roughness as output for a neural network model. They found that the predicted surface roughness values computed from ANN, were compared with experimental data and the results obtained. These results showed that the neural network model is reliable and accurate for solving the cutting parameter optimization.

4.0 Conclusions

The conclusions made on the basis of results obtained from parametric analysis of surface roughness studies in turning using Artificial Neural Network have proved that ANN is a powerful tool and used for accurate prediction better than other techniques. Many of the researches have used MATLAB software for prediction of ANN.

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