UNCERTAINTY ANALYSIS OF ARTIFICIAL NEURAL NETWORK (ANN) APROXIMATED FUNCTION FOR EXPERIMENTAL DATA USING SEQUENTIAL PERTUBATION METHOD

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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Dedicated to my parents

Lecturers

Friends

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ABSTRACT

This thesis describes a comparative study of uncertainty estimation for unknown function using sequential perturbation method with Artificial Neural Network (ANN) approximated function. The objective of this project is to propose a new technique in calculating uncertainty estimation for an unknown function which is data obtains from experimental or measurement. For this research of the uncertainty analysis can be applied to calculate uncertainty value for the experiment data that not have function. The process to determine uncertainty have six step including begin from selected experiment function, generate the experiment data, function approximation using ANN, calculate the uncertainty for analytical method manually, applied the sequential perturbation method with ANN and lastly determine percent error between sequential perturbation method with ANN compare with the analytical method. Meanwhile, the variation of uncertainty error for Sequential Perturbation method without ANN is 0.0510%, but the error of sequential perturbation method with The ANN is 0.1559%. Then compare the value of Sequential Perturbation (numerical) method with ANN and value of Analytical method to validate the data. The new technique will be approving to determine the uncertainty analysis using combination of Sequential Perturbation method with artificial neural network (ANN). Any experiment also can be use, the applications of Sequential Perturbation method with ANN propose in this study. Consequently it implies the application of Sequential Perturbation method is a good as the application of the analytical method in order to calculate the propagation of uncertainty.

ABSTRAK

Tesis ini menerangkan satu perbandingan untuk belajar analisis ketidakpastian untuk fungsi yang tidak diketahui menggunakan kaedah usikan bersiri dan penghampiran fungsi rangkaian neural tiruan. Tujuan tesis ini adalah untuk menghasilkan kaedah baru dalam mengira ketidakpastian untuk fungsi yang tidak diketahui dengan mengambil data ekperiment. Untuk kajian ini dan analisis ketidakpastian boleh digunakan untuk mengira ketidakpastian untuk data eksperimen yang tidak mempunyai fungsi. Proses untuk mencari ketidakpastian ada enam tindakan termasuk memilih eksperimen fungsi, mendapatkan data, penghampiran fungsi dengan mengunakan rangkaian neural tiruan, mengira ketidakpastian untuk kaedah analisis secara manual, menggunakan kaedah usikan bersiri dengan penghampiran fungsi, dan akhir sekali kira peratusan ralat diantara kaedah usikan bersiri dengan kaedah analisis. Sementara itu, ralat dengan menggunakan kaedah usikan bersiri tanpa penghampiran fungsi adalah 0.0510%, tetapi ralat untuk kaedah usikan bersiri (berangka) dengan penghampiran fungsi adalah 0.1559%. Kemudian bandingkan nilai kaedah usikan bersiri dengan nilai kaedah analisis untuk mengesahkan data. Teknik terbaru ini boleh dipersetujui untuk mencari ketidakpastian analisis dengan menggunakan gabungan kaedah usikan bersiri dengan rangkaian neural tiruan. Lain-lain eksperimen juga boleh dijalankan dengan mengunakan kaedah usikan bersiri dengan rangkaian neural tiruan dalam pembelajaran ini. Akibatnya daripada penggunaan kaedah usikan bersiri adalah sama bagus dengan kaedah analisis dalam untuk mengira getaran ketidakpastian.

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LIST OF SYMBOLS

%	Percent
$\dot{m}$	Mass flow rate
T_1	Inlet temperature
T_2	Outlet temperature
A_m	Mean area
K	Kelvin
K_g	Kilogram
s	second
mm	millimetre

LIST OF ABBREVIATIONS

SP	Sequential Perturbation
ANN	Artificial Neural Network
J	Joule
U%	Uncertainty percent
FYP	Final Year Project
NN	Neural Network
CNS	Centre Nervous system
RBF	Radial Basic Function
MATLAB®	The Language of Technical Computing

CHAPTER 1

INTRODUCTION

1.0 PROJECT BACKGROUND

Development of the mathematical system and improve of science and the technology make the theory and researced are conduct for solution the mathematical problem are founded. So that, the uncertainty can be analysed by different method and ways. Uncertainty can be determine by manual calculation or using several method such as numerical method, analytical method and also using Artificial Neural Network(ANN). Uncertainty analysis is easy when the choosen method is suitable to the problem needed.

Artificial Neural Network(ANN) is method that to approximate the specific function from selected data before proceed to the uncertainty analysis. Neural networks have a large appeal to many researchers due to their great closeness to the structure of the brain, a characteristic not shared by more traditional systems. A neural network consists of four main parts.That all part is firstly, Processing units, weighted interconnections between the various processing units which determine how the activation of one unit leads to input for another unit, optionally, a learning rule that specifies how to adjust the weights for a given input or output pair and lastly An activation rule which acts on the set of input signals at a unit to produce a new output signal, or activation. The analysis of the uncertainty separate to the two concept of study case it is specific know function and unknown function,for the specific known function there have two method of solution which is using analytical method for simple function and using numerical method for complex function.The complex function can be solve and analyse by specific method of numerical method that is using sequential

pertubation method. For this project will propose a new method to estimate the uncertainty which is combination between of Artificial Neural Network approximated function and sequential pertubation method.

1.2 PROBLEM STATEMENT

Increasing of global technology carrying new effect to the people and to the universal.People who involved in a range of activities such as research, design and development or making data editor need interpersonal and management skills as well as student expertise because they like to know how things work and want to make them work faster, quieter and more efficiently. They like the challenge of solving practical problems and finding new and innovative solutions for the problems. Nowadays there are many situations which require us to find and to solve the problem involving uncertainty analysis for the data that have no specific equation and function, but until today there is no specific solution to ease in researching or experimental.

For education purpose such as to analyse uncertainty become quite difficult and complicated. To propose the new method of uncertainty analysis, there must have good proven . The Artificial Neural Network approximated plus the numerical method are choosed to prove the research and at same time to proposed the method that have used to calculate and analyse uncertainty without knowing the specific function of the data.

Furthermore, previous analysis of uncertainty do not have specific method to solve this problem. There is a lot of lackness in those analysis especially uncertainty analysis. Function of data consist of many types and sometimes there are complicated functions and also simple functions. So that the analysis of the experiment must include the value of data which should be at least four input and one output. The data are taken to produce and perform the experiment, should have at least 1000 data for every output and input. The largest experiment data are need to make the analysis of uncertainty, percent of uncertainty error became smaller when the largest data are taken as the analysis. The uncertainty analysis can be produced using MATLAB® software with applied the analytical method and newton approximated method or using Artificial Nueral Network approximated function with sequential pertubation numerical method.

The uncertainty analysis of the experiment data become difficult when the choosen experiment do not have specific function. The specific function are important for the experiment data because it will be as the guide line and comparing item in order to prove the uncertainty analysis. For further understanding and clarity on what uncertainty analysis is all about, a flow chart of uncertainty analysis is provided on the next page.

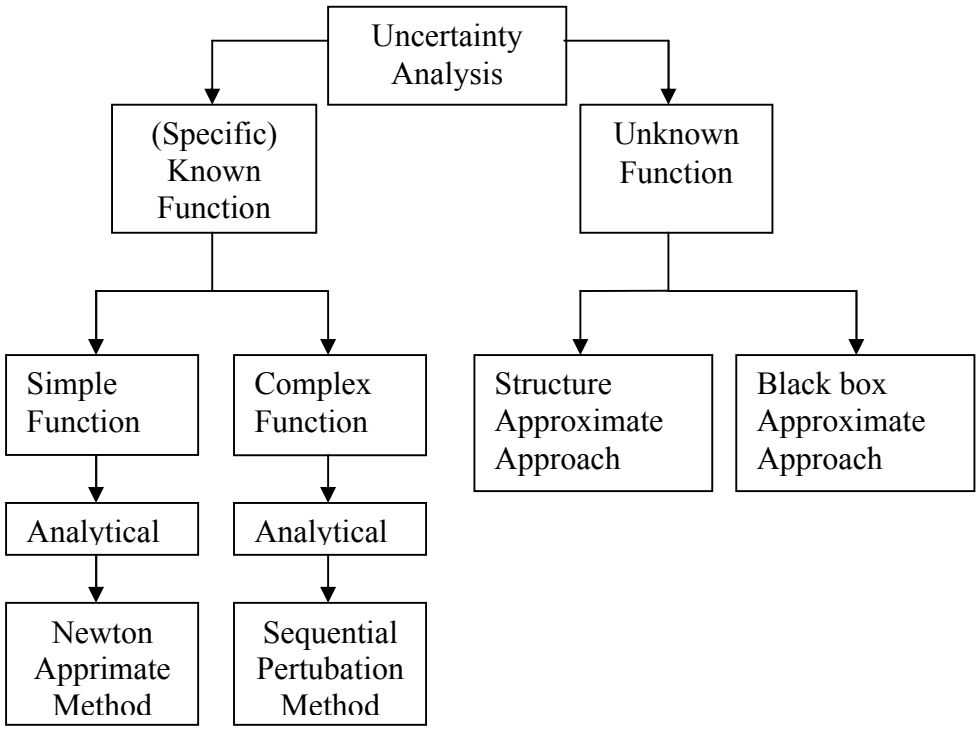

Figure 1.1: Flow chart of uncertainty analysis

1.3 OBJECTIVE

The objective for this project is to propose a method in calculating of uncertainty estimation for an unknown function which is data obtain from experimental or measurement.

The another objective for this project is to prove that uncertainty analysis can be done using sequential pertubation method in application where the unknown function is complex or multivariable and it is approximated using Artificial Neural Network (ANN).

1.4 SCOPE OF PROJECT

i) The approach in the implementation of the uncertainty analysis are to analyse the uncertainty using Artificial Neural Network (ANN) and sequential pertubation numerical method.
ii) The data are get from the running of the heat radiaton experiment.By using the Matlab sofware the analysis uncertainty are be determined .
iii) The numerical method are applied for analysis the uncertainty after the exercise to calling the data from note pad to Matlab software are satisfy the artificial Neural Network approximated method.
iv) The comparison of the analysis are making between the numerical method and analytical method,for analytical method the analysis uncertainty are produced using the function from the experiment.
v) The analysis of uncertainty are analysis using numerical method with sequential pertubation method with applied the Matlab software.
vi) From the heat radiation experiment there have 4 input and only one output.

CHAPTER 2

LITERATURE REVIEW

2.1 ARTIFICIAL NEURAL NETWORK (ANN)

An artificial neural network (ANN), or just called a "neural network" (NN), is a mathematical model or computational model based on biological neural networks. It consists of an interconnected group of artificial neurons and processes information using a connection approach to computation. In most cases an ANN is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase. There is no precise agreed-upon definition among researchers as to what a neural network is, but most would agree that it involves a network of simple processing elements neurons, which can exhibit complex global behavior, determined by the connections between the processing elements and element parameters. The examination of the central nervous system and the neuron give the original inspiration for the technique which constitute one of its most significant information processing elements this can be see in Neuroscience. In a neural network model, simple nodes that all are called variously neurons, neurodes, processing elements or units are connected together to form a network of nodeshence the term "neural network." While a neural network does not have to be adaptive , its practical use comes with algorithms designed to alter the strength of the connections in the network to produce a desired signal flow (Bishop, C.M. 1995).

At 1940’s the first neural network computing model produced by McCulloch and Pitts this research is the earliest to introduced the first neural network computing model.However the another research about neral network is In the 1950's, Rosenblatt's

work resulted in a two-layer network, the perceptron, which was capable of learning certain classifications by adjusting connection weights. Although the perceptron was successful in classifying certain patterns, it had a number of limitations. The perceptron was not able to solve the classic problem. Such limitations led to the decline of the field of neural networks. However, the perceptron had laid foundations for later work in neural computing.

In the early 1980's, Boltzmann researchers showed renewed interest in neural networks. The recent work includes such as Boltzmann machines, hopfield nets, competitive learning models, multilayer networks, and also adaptive resonance theory models. The another proven and are research are making by Frank Rosenblatt at 1962.Frank Rosenblatt are published a book,the content of the book is which combined the concepts of his original perceptron this theory are call the classic perceptron with those of adaline to come up with the classic perceptron design shown in figure 1. In contrast to adaline, perceptrons are based on repulsive learning in which only the weights on the non-active lines are changed in response to an error. In other words the weights change only in response to a misclassification. Thus the weight values are not pulled towards some defined goal but are pushed away from non-goals. Consequently each subcircuit can represent a whole class of patterns. The adaptive multiplication factors (weights) are now placed before the summation node like adaline, instead of after the node as in the original perceptron. In addition all convergent subcircuits now share a common set of inputs instead of having randomly connected inputs (although the initial values of the weights may be randomized which would effectively accomplish the same thing). These changes allowed the input pattern to dispense with the binary line signal requirement in favor of analog signals which could represent the frequency of an action potential pulse or the ionic charge on a neuron. Yet, in order for patterns to be reliably discriminated by perceptrons the pattern inputs had to be normalized, that is the numbers in each pattern had to add up to the same value, usually one. Using analog values also required that the binary threshold be replaced with a subtractive threshold.

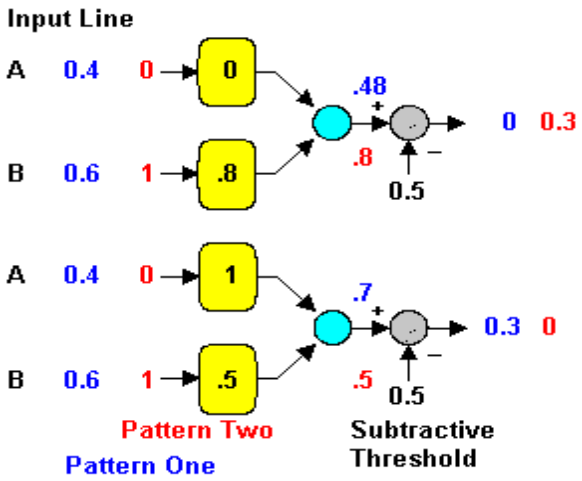

Figure 2.1: Classic Perceptron: Normalized Inputs

Source: Bishop,(1995)

Figure 2.1 shows the effect of non-normalized input patterns. The values of pattern one add up to 1.0 yet the values of pattern two add up to 1.2. No combination of weight values or threshold values will allow each of these patterns to have their own unique convergent subcircuit output. However, if an additional weight is placed after the summation operation then classifications of non-normalized patterns are possible. Yet this does not seem to have been done for the manipulation of post summation node value is not easily incorporated (mathematically) into the learning procedures used to find the pre-summation operation weight values.

As was seen with adaline changing convergent subcircuit weights only shifts the angle and height of the equal value lines but since the perceptron uses repulsive learning that equal value line now becomes the basis for defining the border between pattern classes. The equal value graph for the figure 1 example is shown in figure 3. The axis's of the graph list the values of the pattern input lines which will only produce an output from the subcircuit's threshold if they are above or to the right of their equal value line. Thus the value on input "B" must be above. 625 in order for the top subcircuit (represented by the red line) to produce an output. Since the top subcircuit has a zero valued weight on the "A" line it can be any value. In contrast the input values for the bottom subcircuit must be above the blue line for it to produce an output. Since the

greatest valued output is the one selected the input with the greatest effective distance from its equal value line is selected. Consequently, the perceptron has the same linear limitation as the adaline although in this case it is called linear separability.

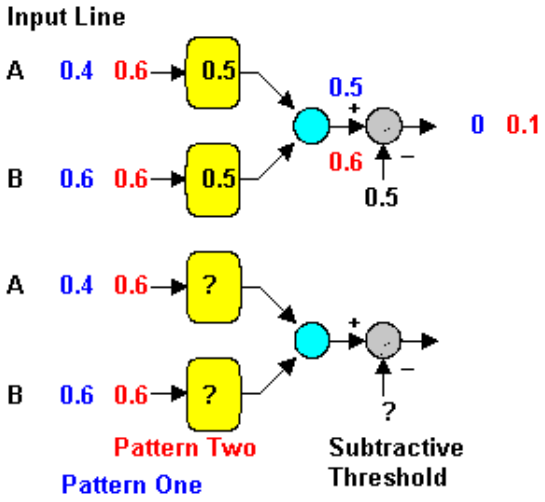

Figure 2.2: Classic Perceptron Non-Normalized Inputs.

Source: Bishop,(1995)

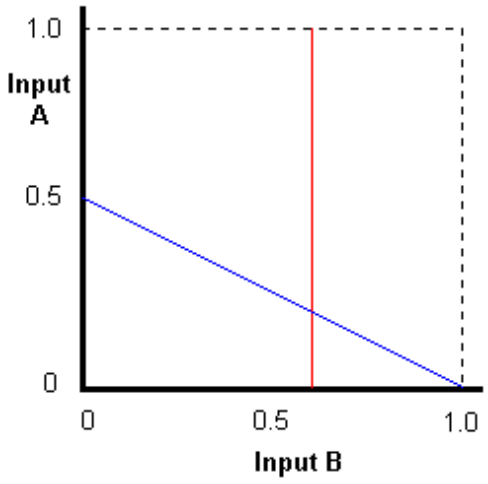

Figure 2.3: Pattern Separation Space for figure 2.1.

Source: Bishop,(1995)

The application of Artificial Neural Network (ANN) tends to refer mostly to neural network models employed in statistics, cognitive psychology and artificial intelligence. Most of Neural network models designed with emulation of the central nervous system (CNS) in mind are a subject of theoretical neuroscience with computational neuron science. Neuron networks have many types and used the types of neuron networks such as feed forward neuron networks this is 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 and to the output nodes.

There are no cycles or loops in the network. The another example types of neuron network are radial basic function networks (RBF), this is know Radial Basis Functions are powerful techniques for interpolation in multidimensional space. A radial basis function is a function which has built into a distance criterion with respect to a centre. Radial basis functions have been applied in the area of neural networks where they may be used as a replacement for the hidden layer transfer characteristic in Multi-Layer Perceptions. The Neuro-fuzzy networks also one of the Artificial neural networks, fuzzy is a inference system in the body of an artificial neural network. General structure of an ANN has the benefit from using available ANN training methods to find the parameters of a fuzzy system.

2.2 PROPAGATION ERROR

Propagation of uncertainty or propagation of error is the effect of variables' uncertainties or known as errors on the uncertainty of a function based on them. When the variables are the values of experimental measurements they have uncertainties due to measurement limitations example is instrument precision which propagate to the combination of variables in the function. The uncertainty is usually defined by the absolute error. Uncertainties can also be defined by the relative error $\frac{\Delta}{}$ which is usually written as a percentage. The uncertainty is usually defined by the absolute error.