

UNCERTAINTY PROPAGATION ANALYSIS OF ARTIFICIAL NEURAL  
NETWORK (ANN) APPROXIMATED FUNCTION USING NUMERICAL AND  
ANALYTICAL METHOD

KAMAL ARIFFIN BIN MOHAMAD

Report submitted in partial fulfilment of the requirements  
for the award of the degree of  
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering  
UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2009

### **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.

Signature

Name of Supervisor: Mr. WAN AZMI BIN WAN HAMZAH

Position: LECTURER

Date: 30 NOVEMBER 2009

**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.

Signature

Name: KAMAL ARIFFIN BIN MOHAMAD

ID Number: MA06111

Date: 30 NOVEMBER 2009

**To my beloved father and mother**  
**Mr Mohamad Bin Abdullah**  
**Mrs Fatimah Binti Mohamad**

## ACKNOWLEDGEMENTS

I am grateful and would like to express my sincere gratitude to my supervisor Mr. Wan Azmi Bin wan Hamzah for germinal ideas, invaluable guidance, continuous encouragement and constant support in making this research possible. He has always impressed me with his outstanding professional conduct, his strong conviction for science, and his belief that a Degree program is only a start of a life-long learning experience. I am truly grateful for his progressive vision about my training in science, his tolerance of my naïve mistakes, and his commitment to my future career. I also would like to express very special thanks for their suggestions and co-operation throughout the study. I also sincerely thanks for the time spent proofreading and correcting my many mistakes.

My sincere thanks go to all my labmates and members of the staff of the Mechanical Engineering Department, UMP, who helped me in many ways and made my stay at UMP pleasant and unforgettable. Many special thanks go to member engine research group for their excellent co-operation, inspirations and supports during this study.

I acknowledge my sincere indebtedness and gratitude to my parents for their love, dream and sacrifice throughout my life. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to attain my goals. Special thanks should be given to my committee members. I would like to acknowledge their comments and suggestions, which was crucial for the successful completion of this study.

## ABSTRACT

This thesis is to investigate the uncertainty analysis using numerical sequential perturbation method and analytical Newton approximation method. The objective of this project to propose the a new technique using numerical sequential perturbation in calculating uncertainty propagation compare to the use of analytical Newton approximation method in application where the unknown function is approximated using artificial neural network ANN. The process to determine uncertainty have five step including begin from selected function, randomize the data, function approximation and applied the numerical method in ANN and lastly determine percent of error between numerical with ANN and compare with the analytical method. The ANN was applied in MATLAB software. From the uncertainty analysis, was define that three major figure the end of this project. First figure shown the average error between numerical and analytical method without ANN are **0.03%**. Second figure average error of function approximate the mass flow rate compare the actual value is **0.03%**. The application with numerical method with ANN gives small uncertainty propagation error compare with analytical method where the error is **1.2%** is the last graph of this project. The new technique will be approving to determine the uncertainty analysis using artificial neural network (ANN). This technique also can be applied for application in laboratory or industrial field.

## ABSTRAK

Tesis ini adalah untuk menyiasat analisis ketidakpastian menggunakan kaedah berangka Usikan bersiri dan kaedah analisis pendekatan Newton. Objektif projek ini adalah mencadangkan teknik baru menggunakan kaedah berangka Usikan bersiri dalam menghitung ketidakpastian dibandingkan dengan penggunaan kaedah analisis pendekatan Newton dalam aplikasi di mana fungsi yang tidak diketahui dianggarkan menggunakan rangkaian neural tiruan. Proses untuk menentukan ketidakpastian mempunyai lima langkah, termasuk mulai dari fungsi yang dipilih, merawakkan data, penghampiran fungsi dan menerapkan pendekatan kaedah berangka dalam rangkaian neural tiruan dan terkini menentukan peratus kesalahan antara berangka dengan rangkaian neural tiruan dan bandingkan dengan kaedah analisis. The rangkaian neural tiruan itu diterapkan dalam perisian MATLAB. Dari analisis ketidakpastian, adalah menetapkan bahawa tiga graf utama pada akhir projek ini. Graf pertama menunjukkan purata ralat diantara kaedah berangka dan kaedah analisis tanpa rangkaian neural tiruan adalah 0,03%. Graf Kedua angka purata ralat fungsi laju aliran masa dibandingkan dengan nilai sebenar adalah 0,03%. Aplikasi dengan kaedah berangka dengan rangkaian neural tiruan memberikan nilai ralat ketidakpastian kecil dibandingkan dengan kaedah analisis di mana kesalahan adalah 1,2% adalah graf terakhir daripada projek ini. Teknik baru akan dipersetujui untuk menentukan ketidakpastian analisis menggunakan rangkaian neural tiruan. Teknik ini juga boleh digunakan untuk aplikasi di makmal atau bidang industri.

## TABLE OF CONTENTS

	<b>Page</b>
<b>SUPERVISOR’S DECLARATION</b>	ii
<b>STUDENT’S DECLARATION</b>	iii
<b>ACKNOWLEDGEMENTS</b>	v
<b>ABSTRACT</b>	vi
<b>ABSTRAK</b>	vii
<b>TABLE OF CONTENTS</b>	viii
<b>LIST OF TABLES</b>	xi
<b>LIST OF FIGURES</b>	xii
<b>LIST OF SYMBOLS</b>	xiv
<b>LIST OF ABBREVIATIONS</b>	xv
<b>CHAPTER 1     INTRODUCTION</b>	
1.1     Project Background	1
1.2     Problem statement	2
1.3     Objective of the Research	2
1.4     Scope of Work	3
<b>CHAPTER 2     LITERATURE REVIEW</b>	
2.1     Introduction	4
2.2     Brief History of Neural Network	5
2.2.1     Neurons 101	8
2.2.2     ANNs 101	8
2.2.3     Possible Futures of ANNs	9
2.3     Neural Network	9
2.3.1     Layers	13
2.3.2     Feed Forward Neural Network	15
2.4     The biological Model	17



2.5	The Mathematical Model	20
2.6	Neural Network VS human Brain	23
2.7	Comparison between Artificial VS Biological Neuro	27
2.8	Application of ANN	31
2.8.1	Real Life Application	31
2.8.2	Use in Teaching Strategy	33
2.9	Uncertainty Analysis	33
2.9.1	Analytical (Newton Approximation) Method	34
2.9.2	Numerical (Sequential Perturbation) Method	37

### **CHAPTER 3      METHODOLOGY**

3.1	Flowchart	40
3.2	Selected Function	41
3.3	Random Data	43
3.4	Function Approximation	43
3.5	Created Neural Network	44
3.5.1	Neuron Model (tansig, purelin, trainlim)	45
3.5.2	Back Propagation Algorithm	47
3.6	Training, Test and Validation Data	48
3.7	Numerical (Sequential Perturbation) Method with Artificial Neural Network (ANN)	53

### **CHAPTER 4      RESULT AND DISCUSSION**

4.1	Introduction	54
4.2	Input and Output Data	55
4.3	Neural Network Approximation	56
4.3.1	Training the Data	57
4.4	Uncertainty Estimation Analysis	59

4.5	Results for Uncertainty Analysis Numerical (Sequential Perturbation) and Analytical (Newton approximation method) without ANN	60
4.6	Results for Function Approximation using Artificial Neural network (ANN)	62
4.7	Results for Uncertainty Analysis Numerical Sequential Perturbation with (ANN)	65
4.8	Conclusion	70

## **CHAPTER 5 CONCLUSION AND RECOMMENDATIONS**

5.1	Conclusion	71
5.2	Recommendation	72

<b>REFERENCES</b>	73
-------------------	----

## **APPENDIX**

<b>A</b>	MATLAB Command	75
<b>B</b>	Gantt chart Final Year Project 1	78
<b>C</b>	Gantt chart Final Year Project 2	79

]

**LIST OF TABLES**

<b>Table No.</b>	<b>Title</b>	<b>Page</b>
2.1	There are Several Types of Inter-Layer Connections	14
2.2	Comparison with human brain and computer As a discipline of Artificial Intelligence	24
3.1	Mass Flow Rate Description	41
3.2	The Component Uncertainties	42
3.3	The Range of Each Input	42
3.4	ANN Network Configurations Parameter Result	53
4.1	Mass Flow Rate Description	55
4.2	The component uncertainties	56
4.3	The range of each input	56

## LIST OF FIGURES

<b>Figure No.</b>	<b>Title</b>	<b>Page</b>
2.1	Natural Neurons	10
2.2	An Artificial Neuron	11
2.3	Backpropagation Network	13
2.4	Artificial Neural Network Diagram	15
2.5	Feed-forward Network Layers	17
2.6	The Biological Model	18
2.7	A Model Neuron	19
2.8	The Mathematical Model	21
2.9	Common non-linear Function Used For Synaptic Inhibition	22
2.10	Simplified Biological Neuron	26
2.11	A schematic Representation of an Artificial Neuron	27
2.12	Provides the Data used by the Neuron in order to Generate an Output Between Artificial VS Biological Neuron	28
2.13	Weight Increase or Decrease the Value of the Input Signal Between Artificial VS Biological Neuron	28
2.14	The Summation Function Allow the neuron to Evaluate The Total Input between Artificial VS Biological Neuron	29
2.15	The Bias value is very similar to the Weights, in that it Adjusts the Total Value Between Artificial VS Biological Neuron	29
2.16	Processing to Generated Outputs of Artificial VS Biological Neuron Between Artificial VS Biological Neuron	30
2.17	Output Between Artificial VS Biological Neuron	30
3.1	An Elementary Neuron with R	45
3.2	Tan-Sigmoid Transfer Function	46

3.3	Linear Transfer Function	46
3.4	Neural Network Training	50
3.5	Best Performance Training	51
3.6	Regression of Training, Testing and Validation	52
4.1	Neural Network Training Process	58
4.2	Numerical and Analytical Uncertainty Value	60
4.3	Enlargement of Numerical and Analytical Uncertainty Value	60
4.4	Numerical and Analytical Uncertainty Error	61
4.5	Function Approximation using ANN	62
4.6	Enlargement of Function Approximation using ANN	63
4.7	Function Approximation Error	63
4.8	Uncertainty Value for Numerical with ANN	65
4.9	Uncertainty of Analytical Method	66
4.10	Uncertainty Value for both Method	66
4.11	Enlargement of Uncertainty Value for both Method	67
4.12	Numerical Sequential Perturbation Approximate Error	68
4.13	Enlargement for Sequential Perturbation Approximate Error	68

**LIST OF SYMBOLS**

%	percent
M	Mass flow
C	Empirical discharge coefficient.
P	Nozzle inlet pressure
A	Nozzle throat area
$\Delta P$	Upstream and Downstream Pressure Different
gc	Gravitational
R	Gas constant for air and humidity
T	Temperature of air at inlet to nozzle

**LIST OF ABBREVIATIONS**

ANN	Artificial Neural Network
SP	Sequential Perturbation
U%	Percent of uncertainty