

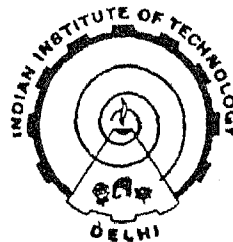
NEURAL NETWORKS FOR NATURAL LANGUAGE PROCESSING

A Thesis submitted
for the award of the Degree of

Doctor of Philosophy

By

B. Krishna Murthy



to the

**Department of Mathematics
Indian Institute of Technology, Delhi**

August 1996

CERTIFICATE

This is to certify that the thesis entitled **Neural Networks for Natural Language Processing** which is being submitted by **Mr. B. Krishna Murthy** for the award of **Doctor of Philosophy** to the **Indian Institute of Technology, Delhi** is a bonafide record of research work under my guidance and supervision

The thesis has reached the standard of fulfilling the requirements of the regulations relating to the degree. The results obtained in this thesis have not been submitted to any university or Institute for the award of any degree or diploma.

B. Chandra

Dr.(Mrs.) B.Chandra

Associate Professor

Computer Applications Group

Department of Mathematics

Indian Institute of Technology

New Delhi

Acknowledgements

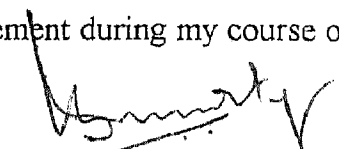
With great pleasure and deep sense of gratitude, I acknowledge the invaluable guidance of Dr. (Mrs.) B. Chandra, my thesis supervisor. It was she who introduced me to the area of "Neural Networks for Natural Language Processing". In spite of her busy schedule, she could find time to provide precious guidance. She was always kind, cooperative and helped me whenever I needed. Her never ending patience and hard work inspired me to work. I am extremely grateful to her for fulfilling my dream. She was always friendly, cooperative and inspired me to cultivate new research ideas. I express my profound gratitude to her. I am deeply indebted to her.

I express my sense of indebtedness to the Dean, P. G. Studies; Head, and other Faculty members of Department of Mathematics for the support they have provided for pursuing my research.

I express my sincere thanks to Sh.S.S.Oberoi, Adviser; Sh.R.K.Arora, Senior Director; Sh. Deshpande, Sh. A.B. Patki, Dr. Om Vikas, Directors; Sh. G.V. Raghunathan, Sh. R.G. Gupta, Addl. Directors and other friends of DoE for their support and cooperation.

I acknowledge the moral support given by my friends Mr. BVC Rao, Mr. A Duraga Prasad, Mr. Sumeer Goyal, Mr. NSC Babu, Mr. DVL Somayajulu and others.

Last but not the least, I would thank my wife (Padmasri), my brothers, sisters, in-laws and relatives for their emotional support and constant encouragement during my course of work.



(B.Krishna Murthy)

Abstract

The thesis aims at development of Neural Network models for Natural Language Processing (NLP). NLP involves development of computer models for syntactic and semantic analyses. Through this research it has been shown that Neural Network models are a promising tool for NLP. Parsing is an essential part of any NLP system.

This research work introduces Neural Networks for Indian language processing. Indian languages are inflectional and relatively free word ordered. An efficient technique is lacking for parsing of Indian languages. So far parsers based on only conventional techniques have been developed. The advantage of using Neural Networks for NLP is that it is a one time processing effort.

Cascading of Backpropagation (BP) networks has been introduced in this thesis. Based on this, models have been designed and implemented for processing of two Indian languages namely, Tamil and Telugu. Highly successful results have been achieved. Concepts of Genetic Algorithms have been employed in training Multilayered Neural Networks for Indian language processing. The genetic operators have been transformed to Neural Network parameters. The advantages of both Genetic Algorithms and Neural Networks have been best utilised. The models have been designed in such a way that they can be used for processing any language.

In order to eliminate the hidden layer in a Multilayered Neural Network, Radial Basis Function (RBF) networks have also been designed for parsing. A new distance measure viz. lexical distance, suited for natural language processing has been introduced. A model for syntactic analysis using multistage heterogeneous networks namely, a mixture of RBF and Backpropagation

networks has been designed. Evolutionary learning algorithm has been designed for RBF networks which allow classification of patterns belonging to more than one class.

In order to speed up the computational time for training, models have also been designed using Functional Link Networks (FLN) for category prediction. It has been observed that FLN takes around 1/10th of the computational time taken for training using Backpropagation network. It has been shown that FLN is useful for Example Based Machine Translation, by designing of a system for translation of simple sentences from one Indian language to another.

Contents

Abstract	vii
1. Introduction	1
1.1 Artificial Neural Networks	1
1.1.1 Introduction	1
1.1.2 Biological and Artificial Neural Systems	1
1.1.3 Learning, Recall and memory	8
1.2 Overview of Neural networks	9
1.2.1 Backpropagation Networks	10
1.2.2 Counterpropagation Network	11
1.2.3 Hopfield Network	12
1.2.4 Hamming Network	14
1.2.5 Kohonen's Self Organising Feature Map	15
1.2.6 Carpenter Grossberg Network	16
1.2.7 Radial Basis Function (RBF) Networks	17
1.2.8 Functional Link Networks	19
1.3 Natural Language Understanding	20
1.3.1. Natural Language Processing (NLP)	21
1.3.2 Natural Language Parsing	22
1.3.3 Various Parsing Techniques	23
1.4 NLP for Indian Languages	24
1.4.1 Parsing Based on Paninian Grammar	25
1.4.2 NLP of Bengali based on LFG	25

1.4.3	Parsing of Hindi Sentences using Tree Adjoining Grammar	26
1.5	Natural Language Processing using Neural Networks	26
1.6	Organisation of the Thesis	28
2.	Natural Language Parsing Using Multilayered Neural Networks	32
2.1	Introduction	32
2.2	Multilayered Feedforward Neural Networks	35
2.2.1	Backpropagation Algorithm	37
2.2.2	Pattern Update	38
2.2.3	Session Update	42
2.2.4	Improvements in Backpropagation Algorithm	44
2.3	Verbphrase Analysis Using Multilayered Neural Networks	45
2.3.1	Some Features of an Indian Language (Tamil)	46
2.3.2	Design and Implementation of MNNs for VerbPhrase Analysis	49
2.4	Multilayered Neural Networks for Parsing	50
2.4.1	Some Linguistic Features of Telugu	52
2.4.2	Design Issues	58
2.4.3	Illustrations	59
2.4.4	Implementation and Results	60
2.5	Conclusions	67
3.	Genetic Algorithms and Neural Networks for Processing of Indian Languages	68
3.1	Introduction	68
3.2	Genetic Algorithms for Neural Networks	70
3.2.1	Preliminaries of Genetic Algorithms	71

3.2.2 Applications of Genetic Algorithms	74
3.2.3 Genetic Algorithms for Training of Multilayered Neural Networks	75
3.3 Genetic Algorithms and Neural Networks for Language Processing	81
3.3.1 Model Design	81
3.3.2 Some Linguistic Features of an Indian Language (Telugu)	86
3.3.3 Implementation and Illustration	90
3.4 Discussions and Conclusions	104
4. Syntactic Analysis using Hetrogenous Neural Networks	106
4.1 Introduction	106
4.2 Preliminaries of RBF Networks	109
4.2.1 Radial Basis Function (RBF) Networks	109
4.3 Syntactic Analysis Using Hetrogenous Networks	117
4.3.1 Category Stage	118
4.3.2 Morphological Stage	119
4.3.3 Phrase Stage	121
4.3.4 Syntactic Net	122
4.4 Implementation and Illustrations	122
4.5 Evolutionary Learning Algorithm for RBF Networks	127
4.5.1 Problem Definition	129
4.5.2 Design of Evolutionary RBF Network	130
4.6 Conclusions	133
5. Parsing using Functional Link Networks	135
5.1 Introduction	135
5.2 Overview of Functional Link Networks	137

5.2.1 Training of Functional Link Network	140
5.3 Design of Functional Link Network for NLP	142
5.3.1 Implementation and Results	143
5.4 Application of FLN for Example Based Machine Translation	154
5.4.1 Illustration	158
5.5 Conclusions	160
 6. Comparison with Traditional Parsers, Conclusions and Future Work.	 163
6.1 Comparison with Traditional Parsers	163
6.1.1 Parsers Based on Augmented Transition Network (ATN)	165
6.1.2 Parsers Based on Lexical Functional Grammar	166
6.1.3 Parsers Based on Tree Adjoining Grammar	170
6.1.4 Parser Based on Paninian Grammar	172
6.2 Discussions and Conclusions	173
6.3 Futurework	179
 Bibliography	 180
 List of Papers Published/Communicated	 194