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**A Neural Network Based Window Filter
and its Training
for Image Processing Tasks**

A thesis presented in partial fulfilment of the requirements for
the degree of Doctor of Philosophy in Technology at
Massey University, Palmerston North, New Zealand.

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1995

ABSTRACT

The design and implementation of a neural network based universal window filter (NNWF) is described. Experiments are reported which demonstrate that such a network filter can learn to perform filtering operations from input-target image pairs. Difficulties with training such a filter for more complex tasks are then described. Standard methods of improving the learning performance of neural networks are reviewed. Speculation on development of intelligent systems is presented with particular reference to the purpose and use of logical sequential thought and rules. The importance of an educational environment is outlined and a series of four heuristics for improving the training of neural networks is suggested. Initial experiments with these heuristics are described. The analogy to instructional design theory for humans is proposed and a formal basis for the design of an educational environment for the neural network based window filter is developed. Finally, a series of experiments are reported which test the validity of the use of the educational environment and demonstrate the effectiveness of the methods developed for implementing such an environment for the NNWF.

PREFACE

My father is a psychiatrist, my eldest sister a psychologist, with other brothers and sisters working in medicine and psychiatric nursing it is perhaps natural that I should have an interest in how people think. My undergraduate degree was in Physics and I have worked in various aspects of computing during the last fifteen years. Thus it was with something of a feeling of completing a circle that I discussed the idea of working on neural networks with my supervisor Prof. Bob Hodgson. To combine my interest in the human brain and biological systems with computer science and attempts to make computers more intelligent had great appeal.

The particular avenue for exploring this interaction was that of image processing or computer vision. This I think is a particularly appropriate area for attempting to make use of biological analogies for two reasons; Firstly, animals do it very easily whereas computers find it very difficult. Secondly, computer vision has been dominated by the hard algorithmic approach and by very limited success. What was expected to be easy was found to be very difficult.

"Just determine which is the chair and which is the table, it should be quite straight forward, then ...

If someone could define what is meant by an edge then I might be able to find them, having found them I might be able to find the objects, having found them I might be able to identify them, having ... but so far we cannot adequately define an edge"

So by combining the area of Image Processing, an area in which my supervisors had considerable research experience, with the new and exciting field of Neural Networks we could embark on some interesting work which was based on firm foundations.

ACKNOWLEDGMENTS

I would like to thank my two supervisors, Prof. Bob Hodgson and Dr. Bob Chaplin for their considerable help and encouragement during this process which has been so aptly described as a "research apprenticeship." I have been extremely fortunate in having supervisors, who have encouraged high professional standards in research and writing at the same time as engendering enthusiasm and providing many important insights in the fascinating area we have been studying. They have also allowed me considerable freedom to develop the research in my own way.

I want to acknowledge the considerable amount of "family time" that my wife Sue and my four daughters have sacrificed to enable me to complete this thesis. Without their support I could never have completed this work. Sue has had to act a single parent at times in addition to editing and discussing many drafts and re-drafts of sections of this work. Other members of my extended family have also provided considerable support; my mother with careful proof reading of all of the chapters, my father with insightful discussion on intelligence and other aspects of biological systems, my elder sister Olin with proof reading and encouragement to continue with some of the more speculative aspects of the work. To these and the others who have helped me along the way; thank you.

CONTENTS

Abstract.....	i
Preface	ii
Acknowledgements.....	iii
List of Figures.....	viii
Publications	x
1. Introduction.....	1.1
1.1 Scope of Research.....	1.2
1.2 Thesis Overview	1.3
1.3 Content by Chapter	1.4
1.4 References.....	1.6
2. Background.....	2.1
2.1 Image Processing and Window Filters	2.2
2.1.1 Linear Filters	2.4
2.1.2 Sobel Filter	2.4
2.1.3 Marr Hildreth Filter.....	2.5
2.2 Neural Networks and Back-Propagation	2.9
2.2.1 Back Propagation.....	2.12
2.2.2 Derivation of Back Propagation Equations	2.14
2.3 Instructional Design.....	2.19
2.4 Discussion	2.21
2.5 References.....	2.23
3. A Universal, Neural Network Based, Window Filter	3.1
3.1 Structure & Implementation of the NNWF.....	3.2
3.1.1 Structure of the NNWF	3.2
3.1.2 Implementation of the NNWF	3.4
3.2 Window Filter Emulation with the NNWF.....	3.6
3.2.1 Vertical Edge Filter	3.8
3.2.2 Sobel Filter.....	3.11
3.2.3 Marr-Hildreth Filter	3.14

3.2.4 Effects of Network Parameters	3.17
3.3 Further Experiments with the NNWF	3.21
3.3.1 Using the NNWF to remove noise.....	3.21
3.4 Improving the performance of the Neural Network Window	
Filter.....	3.26
3.4.1 Improvements to the NNWF for Image Processing.....	3.26
3.4.2 Machine Learning and the NNWF	3.28
3.4.3 Other Neural Network Techniques and the NNWF	3.29
3.5 Discussion	3.37
3.6 References.....	3.41
4. Neural Networks and Intelligent Systems.....	4.1
4.1 Introduction	4.2
4.2 Background.....	4.3
4.3 An Alternative Approach to Intelligence	4.4
4.3.1 Creatures of a fixed design.....	4.4
4.3.2 Creatures with genetic inheritance.....	4.5
4.3.3 Creatures that respond to conditioning.....	4.5
4.3.4 Creatures with logical sequential thought.....	4.6
4.4 The Frame Problem.....	4.8
4.5 Expert Systems	4.11
4.6 Summary	4.13
4.7 Final Afterthoughts	4.14
4.8 Conclusion.....	4.16
4.9 References.....	4.17
5. An Educational Environment	5.1
5.1 Introduction	5.2
5.2 Rationale for the four Heuristics.....	5.3
5.2.1 Learning simpler similar tasks first.....	5.3
5.2.2 Learning to perform useful sub-tasks first.	5.3
5.2.3 Using rules provided by a teacher during training.....	5.3
5.2.4 Structuring the learning experience.	5.4
5.3 Fuzzy Targets For Training.....	5.6
5.4 Experiments Using The Four Heuristics.....	5.7
5.4.1 Task 1: Improving the Marr-Hildreth emulation.....	5.8
5.4.2 Task 2: Finding E's in images of printed text.....	5.11
5.4.3 Task 3: Identification of valve parts	5.15
5.5 Discussion	5.18
5.6 References.....	5.19

6. Instructional Design and Training Artificial Neural Networks	6.1
6.1 What is Instructional Design.....	6.3
6.2 Differences between ID for people and ID for ANNs.....	6.6
6.3 Theories of ID and their relevance to ANNs	6.9
6.3.1 Early Theories of ID (Gagné & Briggs)	6.9
6.3.2 A Behavioural Approach (Groppe)	6.13
6.3.3 Component Display Theory (Merrill)	6.24
6.3.4 Elaboration Theory (Reigeluth & Stein).....	6.32
6.4 Discussion of ID theories	6.36
6.5 A theory of ID for ANNs.....	6.37
6.6 References.....	6.40
7. Training Heuristics and their Implementation.....	7.1
7.1 Introduction	7.2
7.2 Consideration of Stimulus / Response Characteristics	7.5
7.3 Internal Heuristics	7.9
7.3.1 Learning Useful Sub-Tasks First.....	7.9
7.3.2 Learning Simpler, Similar Tasks First.....	7.10
7.3.3 Use of Rules To Assist Learning	7.11
7.4 Implementation Methods for Internal Heuristics.....	7.15
7.4.1 Eight Methods for Implementing Internal Heuristics	7.16
7.4.2 Methods for implementing sub-tasks	7.24
7.4.3 Methods for Simpler Similar Tasks.....	7.25
7.4.4 Methods for using Rules.....	7.26
7.5 Structured Training.....	7.27
7.6 Summary & Discussion.....	7.28
7.7 References.....	7.29

8. Experiments with an Educational Environment for the NNWF	8.1
8.1 Introduction	8.2
8.2 Experiments	8.4
8.2.1 Sub-task Experiments	8.4
8.2.1.1 Experiment 1.1 Texture as a sub-task.....	8.7
8.2.1.2 Experiment 1.2 Edges as a sub-task.....	8.18
8.2.1.3 Discussion of Sub-task experiments	8.20
8.2.2 Finding Tree edges.....	8.21
8.2.2.1 Consideration of S-R Characteristics.....	8.29
8.2.2.2 Sub-tasks	8.31
8.2.2.3 Simpler-Similar Tasks.....	8.35
8.2.2.4 Use of Rules	8.36
8.2.2.5 Structured Training	8.37
8.2.2.6 Discussion of Tree edge experiments	8.44
8.3 Discussion	8.46
8.4 References.....	8.47
9. Summary & Conclusions	9.1
9.1 Summary	9.2
9.2 Conclusions	9.4
 Appendix A: Marr-Hildreth Operator Examples.....	A1
Appendix B: Aspirin/Migraines Additions and Unix Control Files.....	B1
Initialisation File.....	B2
Learn Control File.....	B6
Run Control File	B7
Dump Weights Control File	B8
Appendix C: NIH Image "Plug-ins" and User Routines	C1
Marr-Hildreth Plugin	C2
Utility Routines	C13
User.p From NIH Image.....	C17

LIST OF FIGURES

Figure 2.1: Operation of a window filter..... 2.3

Figure 2.2: Commonly used linear filter masks 2.3

Figure 2.3: Marr-Hildreth Edge Filter..... 2.7

Figure 2.4: Marr-Hildreth Edge Filter Option Effects 2.8

Figure 2.5: Back propagation network 2.13

Figure 3.1: Topology of Neural Network Window Filter 3.3

Figure 3.2: Microscope Test Image 3.7

Figure 3.3: Einstein Test Image 3.8

Figure 3.4: Convergence for Linear Filter Emulation..... 3.9

Figure 3.5: Emulation of Linear Vertical Edge Filter..... 3.10

Figure 3.6: Convergence for Sobel Emulation 3.11

Figure 3.7: Emulation of Sobel Edge Filter 3.13

Figure 3.8: Convergence for Marr-Hildreth Emulation..... 3.16

Figure 3.9: Emulation of Marr-Hildreth Operator..... 3.17

Figure 3.10: Convergence of NNWF for Large number of training epochs... 3.18

Figure 3.11: Effect of Gain and Momentum terms on convergence..... 3.19

Figure 3.12: Effect of the number of hidden units on convergence..... 3.20

Figure 3.13: Image degradation with different types of noise..... 3.22

Figure 3.14: Noise removal with NNWF and median filter..... 3.25

Figure 5.1: Weight values for sub networks 5.9

Figure 5.2: Combined network structure 5.9

Figure 5.3: Output of combined NNWF 5.10

Figure 5.4: Image of a section of a newsletter 5.12

Figure 5.5: Single word enlarged to show effects of digitisation 5.13

Figure 5.6: Identification of machined parts 5.15

Figure 5.7: Rule generated input and target data 5.16

Figure 6.1: Merrill's Performance - Content Matrix..... 6.24

Figure 6.2: CDT Content categories 6.26

Figure 6.3: Primary Presentation Forms (PPFs)..... 6.27

Figure 6.4: Secondary Presentation Forms (SPFs)	6.28
Figure 6.5: Secondary presentations.....	6.29
Figure 6.6: PPF principles for FIND and USE.....	6.30
Figure 6.7: Secondary presentation form principles	6.31
Figure 7.1: Solution Graph.....	7.10
Figure 7.2: Implementation of Internal Heuristics	7.15
Figure 7.3: Use of an embedded function	7.22
Figure 8.1: Images from textured shapes experiments.....	8.6
Figure 8.2: Texture as a sub-task.....	8.7
Figure 8.3: H0M0 Standard Training Using Examples.....	8.8
Figure 8.4: H2M1 Sub-Task Implemented as a Sequence.....	8.9
Figure 8.5: H2M2 Sub-Task Implemented as Pre-training.....	8.10
Figure 8.6: H2M3 Sub-Task Implemented as Dual Inputs.....	8.11
Figure 8.7: H2M4 Sub-Task Implemented using Dual Outputs.....	8.12
Figure 8.8: H2M5 Sub-Task Implemented as an Embedded Sub-network....	8.13
Figure 8.9: Embedded sub-network.....	8.13
Figure 8.10: H2M6 Sub-Task Implemented as an Embedded Sub-algorithm	8.15
Figure 8.11: Smoothed Target and Best result from NNWF.....	8.16
Figure 8.12: Target image for edges sub-task	8.19
Figure 8.13: Target image for edges sub-task	8.19
Figure 8.14: Image from Pine Forest.....	8.22
Figure 8.15: Alternative edge filters	8.24
Figure 8.16: Output from trained NNWF	8.25
Figure 8.17: Training sub-image and target.....	8.26
Figure 8.18: Intensity profile through training sub-image	8.27
Figure 8.19: NNWF Result from standard training.....	8.28
Figure 8.20: Separate left right training.....	8.30
Figure 8.21: Output from "find bark" sub-network.....	8.31
Figure 8.22: Output from network pre-trained on "find bark"	8.32
Figure 8.23: A gap-filling network.....	8.33
Figure 8.24: Post processing with gap-filling network	8.34
Figure 8.25: A simpler similar task	8.35
Figure 8.26: Training set extended by use of a rule.....	8.36
Figure 8.27: Structured training 1	8.38
Figure 8.28: Combined result.....	8.39
Figure 8.29: A different forest scene.....	8.40
Figure 8.30: Edges found by NNWFs.....	8.41
Figure 8.31: Results from post processing network.....	8.42
Figure 8.32: Post processing of rule extended result.....	8.43

PUBLICATIONS

Publications and presentations prepared during the course of the research for this thesis include;

- R.H. Pugmire, R.M. Hodgson, *Why you should know about Neural Networks*, in proceedings of the 27th New Zealand National Electronics Conference NELCON'90, Wellington, 1990
- R.H. Pugmire & R.M. Hodgson, *Alternative Approaches to Cervical Smear Screening*, in proceedings of 5th New Zealand Image Processing Workshop, Palmerston North, August 1990, pp29-33
- R.H. Pugmire, R.M. Hodgson, *Experiments with a Neural Network Based Window Filter*, in proceedings of 5th New Zealand Image Processing Workshop, August 1990, pp48-55
- R.H. Pugmire & R.M. Hodgson, *Watching a Neural Network Learn*, in proceedings of 6th New Zealand Image Processing Workshop, Lower Hutt , 1991, pp27-33
- R.H. Pugmire, *The Purpose of Logical Sequential Thought*, in proceedings of New Zealand Transputer Users Group Meeting , Auckland, 1992, pp53-58
- R.H. Pugmire, *Experiments with a Neural Network Based Window Filter; Hierarchical Neural Networks*, The Fourth Australian Conference on Neural Networks ACNN'93, Melbourne, 1993
- R.H. Pugmire, R.M. Hodgson, R.I. Chaplin, *Rules and Neural Networks*, First Australian and New Zealand Conference on Intelligent Information Systems ANZIIS'93, Perth Australia, 1993
- R.H. Pugmire, R.M. Hodgson, R.I. Chaplin, *Teaching a Neural Network based Window Filter to Perform Difficult Tasks*, in proceedings of the first New Zealand conference on Image and Vision Computing IVCNZ'93, Auckland, 1993, pp
- R.H. Pugmire, R.M. Hodgson, R.I. Chaplin, *Educating a Neural Network for Image Processing*, in proceedings of the first New Zealand conference on Artificial Neural Networks and Expert Systems ANNES'93, Dunedin, November 1993, pp86-91
- R.H. Pugmire, R.M. Hodgson, R.I. Chaplin, *The properties and training of a neural network based universal window filter*, The fifth IEE International Conference on Image Processing and its Applications IPA'95, Edinburgh, July 1995