## Contents

Declaration of Authorship									
A	Abstract ii Acknowledgements iii								
A									
Contents									
A	bbre	viations	ii						
1	Inti	roduction	1						
	1.1	How do Artifical Neural Networks compare to the human brain?	1						
	1.2	Motivation	1						
2	Rac	ckground	2						
_	2.1	Introduction	2						
	2.2	What are Artifical Neural Networks good at?	2						
	2.2	2.2.1 Classification	3						
		2.2.1 Classification	3						
		2.2.3 Reinforcement Learning	3						
	2.3	What are Artificial Neural Networks bad at?	3						
	2.0	2.3.1 data ineffciency	3						
	2.4	How to Get Off the Symbol Grounding Merry-Go-Round	3						
	2.1	2.4.1 What is symbol grounding?	3						
		2.4.2 How do humans do it?	3						
		2.4.3 How do machines do it?	4						
	2.5	Why brains are better	4						
	2.0	2.5.1 Embodiment	4						
		2.5.1.1 Sensory Redundancy	4						
		2.5.1.2 Biological Filters	4						
		2.5.2 Development	4						
		2.5.2.1 Biological Filters, again	4						
		2.5.3 Pulling yourself up by the bootstraps	4						
		2.5.4 Machine Equivelancy	4						
		2.5.4.1 How do we simulate Embodiment for ANNs?	4						
		2.5.4.2 How do we simulate Development for ANNs?	4						
		2.5.1.2 How do no simulate Development for Hittis	•						

Contents

	2.6	Where 2.6.1 2.6.2	Robot bodies				
		2.6.3	transfer learning				
3	A F	Primer	on Artifical Neural Networks				
	3.1	Percep	otrons				
		3.1.1	Multi Layer Perceptron				
		3.1.2	Activation Functions				
	3.2	Convo	lutional Neural Networks				
		3.2.1	What is Convolution?				
			3.2.1.1 Kernels				
			3.2.1.2 Strides				
			3.2.1.3 Dilations				
		$\frac{3.2.2}{-}$	Transposed Convolutions				
	3.3		rent Neural Networks				
		3.3.1	Vanilla RNN				
	0.4	3.3.2	Gated RNN				
	3.4		ng Algorithms				
		3.4.1	Gradient Decent				
		3.4.2	Backpropagation				
		3.4.3	Extensions and Improvements				
			3.4.3.1 Learning Rate Schedule				
	3.5	Cumm	3.4.3.2 Momentum				
	0.0	Summ	ary				
4	Sensory Redundancy: Are two heads better than one?						
	4.1	Why h	have one sensor when two are better?				
		4.1.1	Aims				
	4.2	Flikr2	5K				
		4.2.1	dataset description				
		4.2.2	problem description				
		4.2.3	network description				
		4.2.4	results				
		4.2.5	discussion				
	4.3						
	4.4		Arabic Spoken Digits and MNIST				
		4.4.1	Dataset Description				
			4.4.1.1 UCU Arabic Spoken Digits				
		4.4.0	4.4.1.2 MNIST Handwritten Digits				
		4.4.2	Problem Description				
			4.4.2.1 Classification				
	4 =	TD	4.4.2.2 Bidirectional Symbol Grounding				
	4.5	-	ment Details				
		4.5.1	dataplumbing				
		4.5.2	4.5.1.1 Combining Datasets				
		/I / /	MICHALIN MODULINES				

*Contents* vi

		4.5.3	Network Description							
		4.5.4	Results							
		4.5.5	Discussion							
	4.6 Conclusion									
5	Mag	Magical Vectors and Where to Find Them 14								
•	5.1	_	Latent space: the Final Frontier							
	0.1	5.1.1	Vector Arithematic Explained							
	5.2		cal Shapes Dataset							
	-	5.2.1	dataset description							
		5.2.2	problem description							
		5.2.3	network description							
		5.2.4	results							
			5.2.4.1 Image Generation							
			5.2.4.2 Multilabel classification							
			5.2.4.3 Vector Arithematic							
		5.2.5	discussion							
	5.3	Real S	Shapes Dataset							
		5.3.1	dataset description							
		5.3.2	problem description							
		5.3.3	network description							
		5.3.4	results							
			5.3.4.1 Image Generation							
			5.3.4.2 Multilabel classification							
			5.3.4.3 Vector Arithematic							
		5.3.5	discussion							
6	Transfer Learning: kick-starting the learning process 17									
	6.1	What	is transfer learning							
		6.1.1	A biological analogue							
	6.2	The in	mportance of transfer learning							
	6.3	Multis	Sense 1 dataset							
		6.3.1	dataset description							
		6.3.2	problem description: image generation from raw speech audio 17							
		6.3.3	network description							
		6.3.4	results							
		6.3.5	discussion							
7	Wh	at hav	e we learnt and more importantly, what have our neural nets							
	lear	learnt?								
	7.1	Summ	nary of important points							
	7.2	2 Conclusion								
8	Fut	ure W	ork 19							
	8.1	Where	e do we go now?							
		8.1.1	More Sensors							
		8.1.2	Better Sensors							
		8.1.3	Swarm Robots and the Cloud							