

Contents

1	Introduction	1
1.1	Motivation	1
1.2	Hypothesis	3
1.3	Objective	3
1.3.1	General Objective	3
1.3.2	Specific Objectives	4
1.4	Methodology	4
1.5	Thesis Structure	5
2	Related Work	7
2.1	Supervised Learning	7
2.2	Interpretable methods	8
2.2.1	Decision Trees and Random Forest	9
2.2.2	Bayesian derived methods	10
2.3	Interpretability indicators in Fuzzy Rule-Based Systems	11
2.4	Interpretability in other methods	12
2.5	Dempster Shafer Theory	14
2.5.1	Mass assignment functions	14
2.5.2	Belief and Plausibility	15
2.5.3	Probability estimation	17
2.5.4	Dempster Rule	17
2.5.5	Commonality functions	19
2.6	Dempster Shafer Theory applications in supervised learning	20
2.7	Mathematical methods	22
2.7.1	Optimization Methods	22
2.7.2	Automatic differentiation	27
3	Proposed Model	33
3.1	Classification	33
3.1.1	Dempster Shafer Implementation	33
3.1.2	Rules	36
3.1.3	Support	36
3.1.4	One-attribute Rule Generators	38
3.1.5	Two-attribute Rule Generators	40
3.1.6	Prediction	40
3.2	Optimization	42

3.2.1	Loss Functions	43
3.2.2	Gradient Descent	43
3.2.3	Projection	45
3.2.4	Convergence Conditions	47
3.2.5	Batching	47
3.2.6	Pseudo-code for the optimization process	48
3.3	Interpretability	48
3.4	Improvements and Implementation notes	50
3.4.1	Rule predicate precomputation	50
3.4.2	Dempster Rule vectorization	50
3.4.3	Commonality transformation	51
3.4.4	Commonality and normalization	52
3.4.5	Plausibility probability estimation and commonality	53
3.5	Model Complexity	53
3.5.1	Prediction	54
3.5.2	Training	54
3.5.3	Interpretability	54
4	Results	55
4.1	Controlled Scenarios	55
4.1.1	1-D distribution	55
4.1.2	Full random classification	57
4.1.3	Imperfect classification	60
4.1.4	2D distribution	62
4.1.5	2D Gaussian distributions	66
4.1.6	Multi-class classification	67
4.1.7	Commonality transformation	70
4.1.8	Multiple kinds of attributes	72
4.1.9	Scikit learn classifier comparison datasets	73
4.2	Traditional Datasets	75
4.2.1	Iris Dataset	77
4.2.2	Wine quality dataset	77
4.2.3	Heart Disease Dataset	77
4.2.4	Breast Cancer Dataset	78
4.2.5	Handwritten Digits Dataset	80
4.2.6	Gas sensor array drift	82
4.2.7	Summary	82
5	Application to Stroke risk prediction	83
5.1	Motivation	83
5.2	Data Description	84
5.3	Data Exploration	85
5.4	Embedding	88
5.5	Rules and Configuration	89
5.6	Model Results	91
5.6.1	Comparison with other Machine Learning Models	92
5.6.2	Comparison with Deep Learning methods	95

5.6.3	Comparison with other Stroke risk assessment methods	97
6	Validation	99
6.1	Interpretability Results	99
6.2	Explanation models	101
6.2.1	Decision Trees	101
6.2.2	Partial dependency plots	104
6.2.3	LIME	106
6.3	Contrasting the Model with Medical Literature	109
6.3.1	Cerebrovascular disease in the past	110
6.3.2	Low values of platelets	110
6.3.3	High values of Hemoglobin concentration	110
6.3.4	Diabetes condition	111
6.3.5	High level of body fat	111
6.3.6	High rates of HDL-C	111
6.3.7	High values of waist measurements	112
6.4	Expert Survey	112
7	Conclusion	115
7.1	Future Work	116
7.2	Contributions	117
	Bibliography	118
	Appendix	126