

Contents

1	Introduction	1
1.1	What is a Speaker Verification System?	1
1.2	What is Machine Learning?	2
1.3	Road Map of the Thesis	2
2	Text-Independent Speaker Verification Systems	5
2.1	Machine Learning Tools	6
2.1.1	Diagonal Covariance Gaussian Mixture Models	6
2.1.2	Support Vector Machines	8
2.2	GMM Based System	10
2.3	Feature Extraction	11
2.3.1	Cepstral Parameters	12
2.3.2	Additional Transformations	14
2.3.3	Silence/Speech Detector	14
2.4	Score Normalization	15
2.4.1	T-norm	16
2.4.2	Z-norm	16
2.5	SVM and GLDS Kernel	17
2.6	Conclusion	19
3	Performance Measures for Speaker Verification	21
3.1	Common Measures	22
3.2	Expected Performance Curve	25
3.2.1	Cautious Interpretation of ROC and BEP	28
3.2.2	Expected Performance Curve: an “a priori” Performance Curve	30

3.3	Statistical Tests	34
3.3.1	The Z-Test on Proportions	34
3.3.2	Z_{HTER} -Test: a Statistical Test for HTERs	37
3.3.3	Other Statistical Tests	40
3.3.4	Analysis	42
3.4	Methodology and Presentation of Results	48
3.5	Conclusion	49
4	Experimental Methodology	53
4.1	Methodology	53
4.2	Databases	54
4.2.1	Banca	54
4.2.2	Polyvar	57
4.2.3	NIST	58
4.3	Conclusion	60
5	Text-Independent Speaker Verification: a Machine Learning Perspective	63
5.1	Framework	64
5.1.1	Statistical Framework	65
5.1.2	A Score Based Framework	68
5.2	Are GMMs Discriminant?	69
5.2.1	GMMs: a Mixture of Linear Classifiers	69
5.2.2	Experimental Results	72
5.2.3	Discussion	74
5.3	Score Normalization	74
5.3.1	Unified Framework for Score Normalization	75
5.3.2	Relation to Existing Normalization Techniques	76
5.3.3	Comparison Between New and Classical Z- and T-norm	79
5.3.4	Experiments	79
5.3.5	T-norm for SVM	80
5.4	Conclusion	83
6	GMMs and Discriminant Models	87
6.1	Learning the Decision Function	88
6.2	HTER Cost Function	89
6.3	GMM LLR	90
6.4	GMM Gaussian LLR	91
6.5	Posterior Based Approach	92

6.6	Conclusion	96
7	Sequence Kernel Based Speaker Verification	97
7.1	Mean Operator Kernel	98
7.2	Max Operator Kernel	102
7.3	Non-Mercer Kernels	104
7.4	Experimental Results on Polyvar and Banca Databases	105
7.4.1	Polyvar	106
7.4.2	Banca	107
7.5	Smoothing the Max Kernel	109
7.6	Clustering Techniques	110
7.7	Experimental Results on the NIST Database	114
7.8	Conclusion	117
8	A New Perspective: Working on the Distance Measure	119
8.1	Unbalanced SVM Criteria	120
8.2	Class Dependent RBF Kernel	121
8.3	Conclusion	125
9	Conclusion	127
9.1	Contribution of the Thesis	127
9.2	Other contributions	133