

Contents

Preface	1
1 Preliminaries and Goals	7
1.1 Research scope	8
1.2 Classification of MT Systems	10
1.2.1 By Type of Input	10
1.2.2 By Application	10
1.2.3 By Level of Analysis	11
1.2.4 By Core Technology	12
1.3 Statistical Machine Translation	14
1.3.1 Decision Theory	14
1.3.2 Source-channel Model	16
1.3.3 Maximum Entropy Model	17
1.4 Estimating the Quality of MT Outputs	18
1.5 Interactive Machine Translation	20
1.6 Assessment Criteria	24
1.6.1 Translation Quality	25
1.6.2 Supervision Effort	27
1.6.3 Statistical Significance of Results	29
1.7 Scientific Goals	30
1.7.1 Combination of Machine Translation Systems	31
1.7.2 Machine Translation Quality Estimation	32
1.7.3 Active Protocols for Interactive Machine Translation	33
1.8 Summary	34
2 Minimum Bayes' Risk System Combination	35
2.1 Introduction	36
2.2 MBRSC Model	38
2.3 MBRSC Risk Computation	40
2.3.1 Linear BLEU	41

2.3.2	BLEU over n -gram Count Expectations	42
2.3.3	Computing Feature Expectations	43
2.4	MBRSC Search	44
2.4.1	Sentence Selection Search Algorithm	46
2.4.2	Greedy Gradient Ascent Search Algorithm	47
2.4.3	Dynamic-Programming-Based Search Algorithms	49
2.5	Experiments	55
2.5.1	Comparative Experiments	55
2.5.2	Comparison to State-of-the-art Methods	66
2.6	Summary	68
3	Machine Translation Quality Estimation	71
3.1	Introduction	72
3.2	Proposed Training Methodology for QE	74
3.3	Dimensionality Reduction	76
3.3.1	Motivation	76
3.3.2	Dimensionality Reduction Problem and Approaches	76
3.3.3	Heuristic Feature Selection Methods	77
3.3.4	DR Methods Based on Statistical Multivariate Analysis	78
3.4	Machine Learning Models	83
3.4.1	Linear Regression	83
3.4.2	Support Vector Machines	84
3.4.3	Regression Trees	85
3.5	Features	86
3.5.1	Data	86
3.5.2	Sentence-Based Features	87
3.5.3	Subsequence-Based Features	89
3.6	Experiments	96
3.6.1	Evaluation Criteria	96
3.6.2	Experiments to Determine the Best Configuration of the Proposed Training Methodology	97
3.6.3	Exhaustive Experiments with Several Feature Sets	104
3.7	Summary	114
4	Active Interaction for Interactive MT	117
4.1	Introduction	118
4.2	Implementation of Active Interaction for IMT	120
4.2.1	Word-Level Active Interaction	121
4.2.2	Sentence-Level Active Interaction	123
4.3	Experimental Setup	124

4.3.1	Corpus and Methodology	124
4.3.2	User Simulations	126
4.3.3	Assessment Measures	127
4.4	Experiments	128
4.4.1	In-Laboratory Experiments for Word-Level Active Interaction	128
4.4.2	In-Laboratory Experiments for Sentence-Level Active Interaction	132
4.4.3	Experiments with Actual Human Translators	134
4.5	Summary	139
5	Active Learning for Interactive MT	141
5.1	Introduction	142
5.2	Active Learning for IMT	144
5.2.1	Translation Work-Flow and Supervision Protocol	145
5.2.2	Sentence Sampling Strategies	149
5.2.3	On-line Training for SMT	156
5.3	Experiments	157
5.3.1	Methodology and Data	157
5.3.2	Evaluation Measures	158
5.3.3	Conventional Active Learning Results	158
5.3.4	Cost-Sensitive Active Learning Results	160
5.4	Summary	164
6	Conclusions	167
6.1	Scientific Contributions	168
6.1.1	Combination of Machine Translation Systems	168
6.1.2	Machine Translation Quality Estimation	169
6.1.3	Active Protocols for Interactive Machine Translation	170
6.2	Publications	173
6.2.1	Combination of Machine Translation Systems	173
6.2.2	Machine Translation Quality Estimation	173
6.2.3	Active protocols for IMT	174
6.2.4	Additional Research Directions	176
6.3	Future Work	177
6.3.1	Machine Translation System Combination	178
6.3.2	Machine Translation Quality Estimation	178
6.3.3	Active Protocols for IMT	178
A	IMT Implementation with Word-Graphs	183

B Linear BLEU derivation	185
C Computation of N-Gram Feature Expectations	187
D On-Line Learning for SMT	189
E Symbols and Acronyms	193
E.1 Mathematical symbols	193
E.2 Acronyms	194
List of Figures	195
List of Tables	197
List of Algorithms	199