

Contents

Statement of authorship	iii
Abstract	v
List of Figures	vii
List of Tables	xi
Acronyms	xiii
1. Introduction	1
1.1. The concept of a Silent-Speech Interface	4
1.2. Structure of this work	4
2. Fundamentals of phonetics	7
2.1. Components of the human speech production system	7
2.2. Vowel sounds	9
2.3. Consonantal sounds	10
2.4. Acoustic properties of speech sounds	15
2.5. Coarticulation	18
2.6. Phonotactics	19
2.7. Summary and implications for the design of a Silent-Speech Interface (SSI)	21
3. Articulatory data acquisition techniques in Silent-Speech Interfaces	25
3.1. Introduction	25
3.2. Scope of the literature review	27
3.3. Video Recordings	27
3.4. Ultrasonography	30
3.5. Electromyography	34
3.6. Permanent-Magnetic Articulography	41
3.7. Electromagnetic Articulography	44
3.8. Radio waves	47
3.9. Palatography	49
3.10. Conclusion and Discussion	52
4. Electro-Optical Stomatography	55
4.1. Contact sensors	55
4.2. Optical distance sensors	57
4.3. Lip sensor	81
	v

4.4. Sensor Unit	84
4.5. Control Unit	89
4.6. Software	93
5. Articulation-to-Text	99
5.1. Introduction	99
5.2. Command word recognition pilot study	99
5.3. Command word recognition small-scale study	102
6. Articulation-to-Speech	109
6.1. Introduction	109
6.2. Articulatory synthesis	109
6.3. The six point vocal tract model	113
6.4. Objective evaluation of the vocal tract model	116
6.5. Perceptual evaluation of the vocal tract model	120
6.6. Direct synthesis using EOS to control the vocal tract model	125
6.7. Pitch and voicing	132
7. Summary and outlook	145
7.1. Summary of the contributions	145
7.2. Outlook	146
A. Overview of the International Phonetic Alphabet	151
B. Mathematical proofs and derivations	153
B.1. Combinatoric calculations illustrating the reduction of possible syllables using phonotactics	153
B.2. Signal Averaging	155
B.3. Effect of the contact sensor area on the conductance	155
B.4. Calculation of the forward current for the OP280V diode	155
C. Schematics and layouts	157
C.1. Schematics of the control unit.	158
C.2. Layout of the control unit	163
C.3. Bill of materials of the control unit	164
C.4. Schematics of the sensor unit	165
C.5. Layout of the sensor unit	166
C.6. Bill of materials of the sensor unit	167
D. Sensor unit assembly	169
E. Firmware flow and data protocol	177
F. Palate file format	181
G. Supplemental material regarding the vocal tract model	183
H. Articulation-to-Speech: Optimal hyperparameters	189
Bibliography	191