

Table of Contents

CHAPTER 1 Introduction	1
1.1 The avatar	1
1.1.1 Representation and embodiment	2
1.1.2 Value of avatar worlds	2
1.1.3 Limitations to expression through avatars	3
1.1.4 Designing avatar controls	4
1.2 Nonverbal communication	4
1.2.1 Range of nonverbal behavior	5
1.2.2 Gesture	6
1.3 Desktop virtual reality	12
1.3.1 Typical virtual world application interface	12
1.3.2 Nonverbal communication and personal expression	13
1.3.3 Psychology of Avatar Communication	15
1.3.4 Applications for drivable avatars	16
1.4 The problem of interactive control of avatar gesture	17
1.5 Goals	18
1.6 A solution using pen gestures	19
1.7 Contributions	20
1.8 Dissertation overview	21
CHAPTER 2 Literature review	22
2.1 Avatars in virtual worlds	22
2.1.1 Controlling NVC	23
2.1.2 Palettes of discrete expressions	24
2.2 Desktop virtual environments and nonverbal communication	27
2.2.1 Selection and modulation	27
2.2.2 Avatar as communication agent	32
2.2.3 Summary of avatar world controls	33
2.3 Synthetic actors and scripted animation	34
2.4 Visualizing Computer-Mediated Communication	38
2.4.1 Chat conversation visualization	38
2.4.2 Expressive abstract communication	39
2.5 Summary	40
CHAPTER 3 Interaction technique	43
3.1 Expressive movement in gesture	43
3.2 Limitations of existing techniques	44

3.2.1	Narrow range of behaviors	44
3.2.2	Minimal movement modulation	45
3.2.3	Restriction to standard UI elements	46
3.2.4	Consequences	47
3.3	Description of interaction	48
3.3.1	Avatar model	48
3.3.2	Avatar gestures	49
3.3.3	Avatar gesture library	49
3.3.4	User input	50
3.3.5	Selection and modulation of gesture	51
3.3.6	Auxiliary features	52
3.4	Design issues	52
3.4.1	Choice of pen gesture set	53
3.4.2	Avatar gesture vocabulary	53
3.5	Discussion	54
3.5.1	Pen gesture as affective input	54
3.5.2	Personality	54
3.5.3	Continuous interfaces and transparency	55
3.5.4	Limitations	58
3.6	Contributions	59
3.7	Summary	59
CHAPTER 4 From pen gesture to expressive avatar gesture		61
4.1	Mapping handwriting to animation modulation	61
4.1.1	Style feature selection	62
4.1.2	Avatar gesture modulation parameters	63
4.1.3	Finding the map	63
4.2	A design using physical features	64
4.2.1	Calibration issues	64
4.2.2	Writing features	64
4.2.3	Motion parameters	65
4.2.4	Direct physical map	65
4.3	Synthesizing expressive gesture motion	65
4.3.1	Motion samples	66
4.3.2	Motion data	67
4.3.3	Multilinear interpolation	67
4.3.4	Gesture speed	70
4.4	Evaluation	71
4.5	Discussion	72
CHAPTER 5 Emotion parameterization of gesture		74

5.1	Parameterization of movement by emotion	74
5.2	Handwriting and nonverbal expression	76
5.3	Handwriting style features	78
5.3.1	Graphological features	78
5.3.2	Experimental method to find map	79
5.4	Synthesis	80
5.4.1	Avatar gesture samples	80
5.4.2	Interpolation	80
5.5	Towards affective input	82
CHAPTER 6 System architecture		84
6.1	Cursive	84
6.1.1	Portability	85
6.1.2	Interest	86
6.2	Virtual world application model	86
6.2.1	Virtual world manager	87
6.2.2	Virtual world client	88
6.2.3	VRML browser	88
6.3	Cursive communication	89
6.3.1	Updating virtual world state	90
6.3.2	Gesture command communication	92
6.4	Cursive functional modules	93
6.4.1	Pen UI and pen gesture feature analyzer	93
6.4.2	Gesture generation	94
6.4.3	Gesture command server	95
6.4.4	Gesture animation	96
6.5	Summary	97
CHAPTER 7 Conclusions and Future work		98
7.1	Summary of work	98
7.2	Contributions	101
7.3	Future work	102
7.3.1	Evaluations	103
7.3.2	Additional features	104
7.3.3	Design alternatives	105
7.3.4	Interdisciplinary work	106
7.3.5	Alternative applications	106
7.4	Conclusions	107
Bibliography		108

APPENDIX A Online references and virtual world resources 118
APPENDIX B Avatar gesture library details 119