

Contents

1	Introduction	1
1.1	Motivation	2
1.2	Overview of this Document	3
2	Automated Lecture Recording	5
2.1	Distance Education	5
2.2	Technology-Augmented Classroom Teaching	5
2.3	Lecture Recording Without Automation	6
2.4	Classroom 2000/eClass	9
2.5	LecCorder	10
2.6	Authoring on the Fly	11
2.7	Lecturnity	12
2.8	Lectopia/iLecture	13
2.9	Camtasia	14
2.10	tele-TASK	15
2.11	Classroom Presenter	16
2.12	A Minimalistic Automated Lecture Recording System	17
2.13	Other Systems	19
2.14	Conclusion	19
3	The E-Chalk System	21
3.1	E-Chalk's Philosophy	21
3.2	The Software System	23
3.3	Usage Scenarios	25
3.4	Distance Teaching	27
3.5	Editing Lectures	28
4	Server Architecture	29
4.1	Preliminary Considerations	29
4.2	Existing Multimedia Architectures	31
4.3	Architecture Overview	32
4.4	Java as Execution Platform	33
4.5	The Component Framework	34
4.6	Component Discovery	37
4.7	Component Assembly	38
4.7.1	Processing Nodes	38
4.7.2	The Processing Graph	40
4.7.3	Resolving the Media Graph	42

4.7.4	Identifying Media Formats	43
4.7.5	Synchronization	43
4.7.6	Top-Level Application	45
4.8	Limits of the Approach	45
4.9	Practical Usage Examples	46
4.10	Conclusion	49
5	Client Architecture	51
5.1	Preliminary Considerations	51
5.2	The Java Client	51
5.2.1	Board Client	53
5.2.2	Audio Client	54
5.2.3	Video Client	55
5.2.4	Slide-show Client	56
5.2.5	Console	57
5.3	Playback as Video	57
5.4	MPEG-4 Replay	60
5.4.1	Encoding E-Chalk Lectures in MPEG-4	61
5.4.2	Practical Experiences	62
5.5	A Note on Bandwidth Requirements	63
5.6	Conclusion	65
6	Audio Storage and Transmission	67
6.1	Evolution of E-Chalk's Audio System	67
6.1.1	The World Wide Radio System	67
6.1.2	World Wide Radio 2	69
6.1.3	The E-Chalk Audio System	70
6.2	E-Chalk's Default Audio System	72
6.2.1	Encoding	72
6.2.2	Live Transmission and Archiving	72
6.3	Tools	73
6.3.1	Lecture Repair Tool	74
6.3.2	Audio Format Converter	74
6.3.3	E-Chalk Broadcaster	75
7	Active Audio Recording	77
7.1	Audio Recording in Classrooms	77
7.1.1	Usability Problems	77
7.1.2	Distortion Sources	78
7.1.3	Other Issues	79
7.1.4	Ideal Audio-Recording Conditions	79
7.2	Improving Audio-Recording Quality	80
7.3	Before the First Lecture	82
7.3.1	Detection of Sound Equipment	83
7.3.2	Recording of Floor Noise	83
7.3.3	Dynamic-Range Adjustment	84
7.3.4	Measuring Signal-to-Noise Ratio	84
7.3.5	Fine-Tuning and Simulation	85
7.3.6	Summary and Report	85
7.4	During Lecture Recording	86

7.4.1	Mixer Monitor	86
7.4.2	Mixer Control	87
7.4.3	Filtering	88
7.4.4	Final Processing	88
7.5	Practical Experiences	89
7.6	Limits of the Approach	90
7.7	Conclusion	90
8	Video Storage and Transmission	91
8.1	Preliminary Considerations	91
8.2	Overview	93
8.3	Configuring the Video Server	94
8.4	Video Encoding	94
9	Merging Video and Blackboard	97
9.1	Split Attention	97
9.2	Related Approaches	100
9.2.1	Transmission of Gestures and Facial Expressions	100
9.2.2	Segmentation	100
9.3	Setup	103
9.4	Initial Experiments	104
9.4.1	Simple Approaches	104
9.4.2	Motion-Based Segmentation	106
9.4.3	A Combined Approach	107
9.4.4	Conclusion	109
9.5	Robust Real-Time Instructor Extraction	110
9.5.1	Conversion to CIELAB	110
9.5.2	Gathering Background Samples	111
9.5.3	Building a Model of the Background	113
9.5.4	Postprocessing	114
9.5.5	Board Stroke Suppression	115
9.6	Example Results	115
9.7	Limits of the Approach	116
9.8	Conclusion	117
10	Generalizing the Instructor Extraction	119
10.1	The State of the Art	119
10.2	Algorithm Description	121
10.2.1	Construction of Color Signatures	122
10.2.2	Classification of Unknown Pixels	124
10.2.3	Post-processing	125
10.3	Segmentation of Still Images	125
10.4	Sub-pixel Refinement	127
10.5	Extraction of Multiple Objects	129
10.6	Video Segmentation	130
10.7	Evaluation	132
10.7.1	Benchmarking and Tuning of Thresholds	133
10.7.2	Testing Assumptions	135
10.7.3	Other Means of Evaluation	136
10.8	Limits of the Approach	138

10.9 Conclusion	141
11 Hardware-Supported Instructor Extraction	143
11.1 The Time-of-Flight Principle	143
11.2 Setup	144
11.3 Technical Issues	145
11.4 Segmentation Approach	147
11.5 Conclusion	148
12 Conclusion	151
12.1 Summary	151
12.2 Future Work	152
12.3 Final Note	153
A E-Chalk: Project Overview	155
B SOPA: Technical Details	161
B.1 DTD of SOPA Graph Serialization	161
B.2 LDAP Query Syntax	161
B.3 SOPA Command Line Commands	162
B.4 A Minimal PipeNode	163
C Board-Event Encoding	165
C.1 The E-Chalk Board Format	165
C.2 Mapping E-Chalk Events to MPEG-4 BIFS	166
D E-Chalk's Audio Format	169
D.1 Events	169
D.2 Zipped packets	170
D.3 Codecs	170
E Audio Recording Tools	171
E.1 VU Meter	171
E.2 Graphic Equalizer	172
E.3 Assessment of the Audibility of Noise	172
E.4 Equipment Grading	173
F E-Chalk's Video Format	175
F.1 Header	175
F.2 Packet	176
G SIOX Benchmark Results	179
G.1 Input and Output Images	179
G.2 Detailed Results	188
Bibliography	189
Web References	207
List of Figures	213
Anhang gemäß Promotionsordnung	217