

Contents

Acknowledgments — XIII

1 Introduction — 1

- 1.1 The Introduction of Information Hiding Technology — 1
 - 1.1.1 The Basic Terminology of Information Hiding Technology — 1
 - 1.1.2 The Classification of Information Hiding Technology — 3
 - 1.1.3 The Development of Information Hiding Technology — 4
- 1.2 Digital Watermarking Technology — 5
 - 1.2.1 The Background of the Digital Watermarking Technology — 5
 - 1.2.2 The Basic Concept of Digital Watermarking — 7
 - 1.2.3 The Basic Framework of Digital Watermarking — 12
 - 1.2.4 The Attack Methods of Digital Watermarking — 13
 - 1.2.5 Quality Evaluation of Digital Watermarking — 16
- 1.3 The Research Status of Color Image Digital Watermarking Technology — 19
 - 1.3.1 Research Status of Color Image Watermarking Technology Based on Spatial Domain — 20
 - 1.3.2 Research Status of Color Image Watermark Technology Based on Frequency Domain — 22
 - 1.3.3 Research Status of Color Image Watermarking Technology Based on Color Quantization — 25
- 1.4 Conclusion — 26

2 Common Mathematical Knowledge Used in Digital Watermarking — 27

- 2.1 The Common Transforms of Image — 27
 - 2.1.1 The Discrete Fourier Transform — 27
 - 2.1.2 The Discrete Cosine Transform — 29
 - 2.1.3 The Discrete Wavelet Transform — 32
- 2.2 Common Matrix Decomposition — 37
 - 2.2.1 Singular Value Decomposition — 37
 - 2.2.2 Schur Decomposition — 47
 - 2.2.3 QR Decomposition — 48
 - 2.2.4 Hessenberg Decomposition — 49
- 2.3 Conclusion — 52

3 Color Image — 53

- 3.1 Introduction — 53
- 3.2 The Basic Types of Image — 53
 - 3.2.1 Binary Image — 54
 - 3.2.2 Gray-Level Image — 55

3.2.3	Color Image — 56
3.3	The Basic Terminology of Color Images — 56
3.3.1	Color Edge — 57
3.3.2	Derivative of Color Image — 58
3.3.3	Contrast of Color Image — 58
3.3.4	Color Constancy — 60
3.3.5	Noise in Color Image — 61
3.3.6	Luminance, Illuminance, and Brightness of Color Image — 61
3.4	Common Color Space of Color Image — 62
3.4.1	RGB Color Space — 62
3.4.2	YIQ Color Space — 65
3.4.3	YUV Color Space — 65
3.4.4	YCbCr Color Space — 67
3.5	Perception-Based Color Spaces — 67
3.5.1	HSI Color Space — 67
3.5.2	HSV Color Space — 70
3.6	Conclusion — 73
4	The Color Image Watermarking Algorithm Based on DC Component — 74
4.1	Introduction — 74
4.2	The Technique of Modifying DC Coefficient in Spatial Domain — 75
4.2.1	Obtaining DC Coefficient in the Spatial Domain — 75
4.2.2	The Feasibility of Embedding Watermark with DC Coefficient in Spatial Domain — 76
4.2.3	Modifying DC Coefficient in Spatial Domain — 77
4.3	The Spatial Watermarking Algorithm Based on DC Coefficient — 79
4.3.1	Watermark Generation — 79
4.3.2	Watermark Embedding — 79
4.3.3	Watermark Extraction — 81
4.4	Algorithm Test and Result Analysis — 81
4.4.1	Watermark Invisibility Test — 82
4.4.2	Watermark Robustness Test — 83
4.5	Conclusion — 85
5	The Color Image Watermarking Algorithm Based on Integer Wavelet Transform — 87
5.1	Introduction — 87
5.2	State Coding and IWT — 88
5.2.1	State Coding Technique — 88
5.2.2	Integer Wavelet Transform — 89

5.3	The Color Image Watermarking Algorithm Based on State Coding and IWT — 90
5.3.1	Watermark Embedding — 90
5.3.2	Watermark Extraction — 92
5.4	Experimental Results and Discussion — 93
5.4.1	Watermark Invisibility Test — 93
5.4.2	Watermark Robustness Test — 93
5.4.3	Comparison with Some Related Color Watermarking Algorithms — 96
5.5	Conclusion — 97
6	The Color Image Watermarking Algorithm Based on Singular Value Decomposition — 98
6.1	Introduction — 98
6.2	The SVD of Image Block and the Compensation Optimization Method — 100
6.2.1	The SVD of Image Block — 100
6.2.2	The Proposed Optimization Compensation Method of SVD — 103
6.3	The Proposed Color Image Watermarking Algorithm — 106
6.3.1	Watermark Embedding — 106
6.3.2	Watermark Extraction — 107
6.4	Experimental Results and Analysis — 108
6.4.1	Test of the Watermark Invisibility — 109
6.4.2	Test of the Watermark Robustness — 109
6.4.3	The Analysis of False-Positive Detection Problem — 118
6.5	Conclusion — 118
7	The Color Image Watermarking Algorithm Based on Schur Decomposition — 119
7.1	Introduction — 119
7.2	The Schur Decomposition of Image Blocks — 120
7.3	The Color Image Watermarking Algorithm Based on Schur Decomposition — 122
7.3.1	Watermark Embedding — 122
7.3.2	Watermark Extraction — 123
7.4	Algorithm Test and Result Analysis — 124
7.4.1	Test of the Watermark Invisibility — 125
7.4.2	Test of the Watermark Robustness — 125
7.4.3	Comparison with the Spatial Domain Algorithm — 132
7.5	Conclusion — 134

8	The Color Image Watermarking Algorithm Based on QR Decomposition — 135
8.1	Introduction — 135
8.2	The QR Decomposition of Image Block — 136
8.2.1	Condition Analysis — 136
8.2.2	The Analysis of the Probability — 138
8.3	Color Image Watermark Algorithm Based on QR Decomposition — 141
8.3.1	Watermark Embedding — 141
8.3.2	Watermark Extraction — 143
8.4	Experimental Results and Discussion — 144
8.4.1	The Selection of Quantization Step — 144
8.4.2	Test of the Watermark Invisibility — 145
8.4.3	Test of the Watermark Robustness — 145
8.4.4	Comparison with the Spatial Domain Algorithm — 152
8.4.5	The Execution Time Comparison of Different Algorithms — 152
8.5	Conclusion — 154
9	The Color Image Watermarking Algorithm Based on Hessenberg Decomposition — 155
9.1	Introduction — 155
9.2	Hessenberg Transform on Image Block — 157
9.3	Proposed Method — 158
9.3.1	Watermark Embedding — 158
9.3.2	Watermark Extraction — 160
9.4	Algorithm Testing and Result Analysis — 161
9.4.1	Test of the Watermark Invisibility — 162
9.4.2	Test of the Watermark Robustness — 165
9.4.3	The Analysis of Watermark Capacity — 166
9.4.4	The Analysis of Execution Time — 166
9.5	Conclusion — 167
10	Summary and Prospect — 168
10.1	Summary — 168
10.2	Prospect — 170
References — 171	
Index — 181	