

List of Acronyms

CWT	: Continuous-time Wavelet Transform
DCT	: Discrete-time Cosine Transform
DFT	: Discrete-time Fourier Transform
DWT	: Discrete-time Wavelet Transform
EZW	: Embedded Zerotree Wavelet
FOII	: First-order Interchannel Interaction
FIR	: Finite Impulse Response (filter)
GD	: Gibbs Distribution
KL	: Karhunen-Lóve
LIP	: List of Insignificant Pixels
LIS	: List of Insignificant Set
LSP	: List of Significant Pixels
MAP	: Maximum <i>a posteriori</i>
MMSE	: Minimum Mean Square Estimation
MRA	: Multi-Resolution Analysis
MRF	: Markov Random Field
MRME	: Multi-Resolution Motion Estimation
MSAD	: Multiresolution Sum of Absolute Differences
NI	: Non-Interaction
PR-QMF	: Perfect Reconstruction Quadrature Mirror Filter
PSF	: Point Spread Function
PSNR	: Peak Signal to Noise Ratio
QMF	: Quadrature Mirror Filter
RGB	: Red-Green-Blue (color/color coordinate)
RLC	: Run Length Coding
SA	: Simulated Annealing
SAD	: Sum of Absolute Difference
SAQ	: Successive Approximation Quantization
SNR	: Signal to Noise Ratio
SPIHT	: Set Partition in Hierarchical Trees
STFT	: Short Time Fourier Transform
SVD	: Singular Value decomposition

List of Symbols

$y(.,.)$:	observed -degraded image pixel at location $(,)$
$x(.,.)$:	original image pixel at location $(,)$
$h(.,.)$:	Point Spread Function
$n(.,.)$:	noise value at location $(,)$
X, Y	:	Lexicographically ordered vectors of x and y respectively
\mathbf{H}	:	PSF matrix formed from $h(,)$
L	:	A square lattice
η	:	neighborhood system
M	:	Size of a lattice
S	:	Subset
c	:	clique
\mathcal{C}	:	set of all cliques
$P[X = x]$:	Probability
$P[. .]$:	Conditional Probability
Z	:	Normalizing function
T	:	Temperature
$U()$:	<i>a priori</i> energy function
$U_p()$:	<i>a posteriori</i> energy function
\mathbf{R}	:	Auto-correlation matrix
$\psi()$:	prototype mother wavelet function
$L^2(\mathbb{R})$:	space of square integrable functions
$\Psi()$:	Fourier Transform of $\psi()$
\mathbf{Z}	:	Set of integers
$f()$:	function
$\phi()$:	Scaling function
V_j	:	j^{th} subspace in MRA
W_m	:	orthogonal complement of V_j in V_{j-1}
\oplus	:	Direct sum
V_{j-1}	=	$V_j \oplus W_m$
E	:	Expectation operator
\mathbf{D}	:	Decimation matrix
$\lfloor . \rfloor$:	floor operator
$D_{(.)}(,)$:	Decay parameter
Φ	:	KLT matrix
Ω	:	Search area

${}^k b_p^g$:	k^{th} macro block of p^{th} video frame of size $g \times g$
${}^k B_p^g$:	Discrete orthogonal Transform of ${}^k b_p^g$
$\mathcal{O}(,)$:	set of offspring nodes
$\mathcal{D}(,)$:	set of all descendants
$\mathcal{L}(i, j)$	=	$\mathcal{O}(i, j) - \mathcal{D}(i, j)$
\mathcal{H}	:	coordinates of all spatial orientation tree roots
$S_n(,)$:	Function indicating presence of non-zero motion vector in a set of coordinates $(,)$
θ	:	Threshold
v, h	:	Vertical and horizontal line fields
V_c	:	Clique potential
κ	:	Sample space
μ	:	Smoothness in MRF energy function
γ	:	Penalty term in MRF energy function
w	:	Motion vector
$\mathbf{0}$:	null matrix

Contents

1	Introduction	1
1.1	Image Restoration	2
1.2	Image Zooming	3
1.3	Video Zooming	4
1.4	Contributions	5
1.5	Organization of The Thesis	6
2	Mathematical Background	8
2.1	Markov Random Field	8
2.1.1	Basic Framework	9
2.1.2	Clique	10
2.1.3	Incorporating Discontinuities	12
2.1.4	Simulated Annealing	13
2.2	Hotelling (K-L) Transform	14
2.3	Wavelets	15
2.3.1	Continuous Wavelet Transform	15
2.3.2	Discrete Wavelet Transform	17
2.3.3	2-Dimensional DWT	21
2.4	Summary	23
3	Robust Color Image Restoration	24
3.1	The Optimality Criterion	24
3.2	Constrained Optimal Methods	25
3.2.1	Constrained l_2 Approach	25
3.2.2	Maximum Entropy Method	26
3.2.3	Bayesian Approach	27
3.2.4	Minimum Mean Square Error(MMSE)	27

3.3	Feasibility Criterion Approach	28
3.4	The Proposed Method: Restoration of Multichannel Images	29
3.4.1	Image Model	30
3.4.2	Results	34
3.4.3	Discussion and Conclusions	36
3.5	Summary	40
4	Still Image Zooming	41
4.1	Introduction	41
4.2	Background	42
4.2.1	Wavelets	42
4.2.2	The KL Transform	44
4.3	Some Existing Methods for Image Zooming	45
4.3.1	Spatial domain Methods	45
4.3.2	Transform Domain Methods	46
4.3.3	Wavelet Techniques	46
4.3.4	Scaling Function Based Zooming	47
4.4	Proposed Method - 1 : MRF Based Approach	48
4.5	Proposed Method - 2 : MRA Based Approach	51
4.5.1	MRA method	51
4.5.2	Joint MRA and MRF method	56
4.6	Color Images	59
4.6.1	K-L Transform	63
4.7	Results and Discussion	64
4.8	Conclusion	66
5	An Overview of Wavelet Based Image Compression Schemes	69
5.1	Introduction	69
5.2	Zerotree	70
5.2.1	The EZW Algorithm	73
5.3	The SPIHT Algorithm	75
5.4	Summary	77
6	Zooming of Compressed Video	79
6.1	Introduction	80
6.2	Video Compression Techniques	82

6.2.1	Block Matching Motion Estimation	83
6.2.2	DWT based Techniques	85
6.3	Multiresolution Motion Vector Estimation Techniques	86
6.4	Motion Vector Interpolated Zooming of Compressed Video	89
6.4.1	Performance Measure	92
6.5	Zooming of Video Stream Compressed by MRME Method	97
6.5.1	Coding of Motion Vectors using Zerotree	97
6.5.2	Video Encoder - Decoder	99
6.6	Temporal Video Frame Interpolation using Motion Vectors	101
6.7	Discussion	102
6.8	Summary	102
7	Conclusions and Future Directions	112
7.1	Specific Contribution	112
7.2	Future Directions	113
7.3	Postscript	115
A	Color Images	116
A.1	Color Coordinate Systems	117
A.2	H.263 and QCIF	117
B	MRF	119