## Contents

	or	ΧV
Acknowledgen	nents x	(Vii
CHAPTER 1	Introduction	1
1.1	HDR and WCG	1
1.2	Improved image appearance with HDR/WCG	1
1.3	The need for an HDR ecosystem	2
1.4	Problems to solve to enable an HDR ecosystem	3
	1.4.1 New colour management and grading tools	3
	1.4.2 New projection systems for movie theatres	4
	1.4.3 Tools for conversion between HDR and SDR	4
	1.4.4 Tools for colour gamut conversions	5
	1.4.5 Production and editing guidelines for HDR material	6
	1.4.6 Tools for personalisation	6
1.5	Overview of the book	7
110	References	9
CHAPTER 2	The biological basis of vision: the retina	11
2.1	How the retinal image is created	11
2.2	Retinal structure	15
2.3	Photoreceptors	21
	2.3.1 How photoreceptors operate	21
	2.3.2 Photoreceptor sensitivity and spatial distribution	22
	2.3.3 Visual pigments and colour perception	24
	2.3.4 Photoreceptor evolution and the cone mosaic	25
2.4	Receptive fields and lateral inhibition	28
2.5	Horizontal cells	29
2.6	Bipolar cells: the beginning of parallel processing in the visual	
	system	32
	2.6.1 ON/OFF	33
	2.6.2 Transient/sustained	35
	2.6.3 Diffuse/midget/S-cone BC	35
2.7	Amacrine cells	36
2.8	Retinal ganglion cells	36
	2.8.1 Impulse generation	36
	2.8.2 Mosaics, stratification, receptive fields	38
	2.8.3 Midget, parasol and bistratified retinal ganglion cells	40
	2.8.4 Intrinsically photosensitive retinal ganglion cells	43
	2.8.5 Retinal ganglion cells sensitive to orientation and	
	motion	44

	References	44
CHAPTER 3	The biological basis of vision: LGN, visual cortex	
	and L+NL models	47
3.1	Lateral geniculate nucleus	47
-	3.1.1 General structure of the LGN	47
	3.1.2 Layers of the LGN	49
	3.1.3 Colour representation in the LGN	50
	3.1.4 Visual processing in the LGN	51
3.2	Cortex	52
O.L	3.2.1 Layers of V1	53
	3.2.2 Simple and complex cells	54
	3.2.3 Ocular dominance columns and orientation columns	55
	3.2.4 Maps of V1	56
	3.2.5 Motion and area MT	56
	3.2.6 Colour representation in the cortex	57
3.3	L+NL models	60
0.0	References	62
CHAPTER 4	Adaptation and efficient coding	65
4.1	The purpose of adaptation	65
4.2	Efficient representation	67
4.3	The neural code	70
4.4	Mean and contrast adaptation	71
	4.4.1 Adaptation to the mean (light adaptation)	72
	4.4.2 Contrast adaptation	77
4.5	Statistics of natural images as a function of dynamic range	80
	4.5.1 Methods	81
	4.5.2 Results	81
	4.5.3 Discussion	88
	References	91
CHAPTER 5	Brightness perception and encoding curves	95
5.1	The Weber–Fechner law: brightness perception is logarithmic	95
5.2	Stevens' law: brightness perception is a power law	98
5.3	Connecting the laws of Weber–Fechner and Stevens	99
5.4	Crispening: brightness perception is neither logarithmic nor a	
<b>C.</b> .	power law	100
	5.4.1 Two studies by Whittle	101
	5.4.2 Whittle's model for brightness perception: advantages	101
	and limitations	104
	5.4.3 Two alternatives to Whittle's model	105
5.5	Detecting thresholds depends on frequency: the Contrast	103
0.0	Sensitivity Function	106
5.6	Effect of the surround on brightness perception: the system	100
5.0	gamma	109

ţ		System gamma as a function of dynamic range	111
	3	perception	116
Ę	5.8 E	Brightness, lightness and HDR images	117
		Perceptual linearisation: gamma, log, PQ and HLG	119
		5.9.1 Gamma correction	120
	5	5.9.2 Logarithmic encoding	121
		5.9.3 PQ: Perceptual Quantisation	121
	5	5.9.4 HLG: Hybrid Log-Gamma	123
	5	5.9.5 Comparing PQ and HLG	124
	F	References	127
CHAPTER	6 0	Colour representation and colour gamuts	131
(	<b>3.1</b> L	Light and colour	131
(	<b>3.2</b> T	Trichromacy and colour matching	133
(	<b>3.3</b> T	The first standard colour spaces	136
6	<b>6.4</b> P	Perceptually uniform colour spaces	140
		HDR colour spaces	145
		Colour gamuts	146
		Brighter displays have larger gamuts	148
		BD gamuts are not the whole picture	150
(		Brightness, hue and saturation are not independent	151
		5.9.1 Saturated objects appear brighter	152
	6	5.9.2 Increasing the brightness or saturation of a reflective	
	_	object can make it appear fluorescent	153
		References	154
CHAPTER		Histogram equalisation and vision models	157
7	<b>7.1</b> F	From image processing to neural models	157
		7.1.1 Histogram equalisation	157
	7	7.1.2 Perceptually-based contrast enhancement	159
	7	7.1.3 Connection with the Retinex theory of colour vision	160
		7.1.4 Connection with neuroscience	164
	7	7.1.5 Efficient representation allows to explain these connections	164
-	7.2 \	Visual induction: contrast and assimilation	165
4		7.2.1 The LHE model can't reproduce assimilation	166
		7.2.2 Introducing spatial frequency into the LHE model	
		7.2.3 Retinal lateral inhibition can explain assimilation	
		7.2.4 The LHE model with dual wide-narrow surround	109
	,	produces both assimilation and contrast	172
-	7.3 F	Retinal processing optimises contrast coding	174
		A final reformulation of the LHE model	177
•		7.4.1 Pre-correcting for changes in induction	181
		References	182
	1.		102

CHAPTER 8	Vision models for gamut mapping in cinema	185
8.1	Introduction	185
8.2	Related work	187
8.3	Gamut mapping with the LHE model	188
	8.3.1 Gamut mapping by applying LHE in RGB	189
	8.3.2 Gamut extension by applying LHE in AB channels of	
	CIELAB	191
8.4	Gamut mapping with modified LHE model	197
	8.4.1 Some vision principles for gamut mapping	198
	8.4.2 Proposed gamut mapping framework	199
	8.4.3 Psychophysical evaluation	204
	8.4.4 Does any error metric approximate our psychophysical	
	results?	208
8.5	Conclusion	210
	References	210
<b>CHAPTER 9</b>	Vision models for tone mapping in cinema	215
9.1	Introduction	
9.2	Some vision principles relevant for HDR imaging	
9.3	Proposed framework	223
	9.3.1 Tone mapping of ungraded footage	224
	9.3.2 Tone mapping of graded content	230
	9.3.3 Inverse tone mapping of graded content	231
	9.3.4 Model tuning by cinema professionals	232
9.4	Validation: psychophysical tests	233
	9.4.1 TM of ungraded footage	233
	9.4.2 TM of graded footage	236
	9.4.3 ITM of graded footage	
9.5	Limitations of objective metrics	239
9.6	Discussion	241
9.7	Conclusion	
	References	243
<b>CHAPTER 10</b>	Extensions and applications	247
10.1	Combining gamut mapping and tone mapping	
10.2	Tone mapping and viewing condition adaptation	
	10.2.1 Updates to the $\gamma_{adj}$ model	
10.3	Tone mapping for improved HDR video coding	
	10.3.1 HDR video coding experiments	
10.4	Tone mapping for photorealistic style transfer	264
10.5	Tone mapping for dehazing	269
10.6	Tone mapping for backlit images	274
10.7	Encoding curves and colour issues in HDR	275
	10.7.1 HDR imaging from multiple exposures	

	10.7.2 Colour matching images with unknown non-linear encodings	285
	References	290
<b>CHAPTER 1</b>	1 Open problems: an argument for new vision models	
	rather than new algorithms	295
11.1	The linear receptive field is the foundation of vision models	295
11.2	Inherent problems with using a linear filter as the basis of a	
	vision model	297
11.3	Conclusion: vision-based methods are best, but we need new	
	vision models	299
	References	299
Index		301