

---

# Contents

---

<b>Acknowledgments</b> . . . . .	ix
<b>Introduction</b> . . . . .	xi
<b>Chapter 1. Principles of Depth and Shape Perception</b> . . . . .	1
1.1. Function of the eye . . . . .	1
1.2. Depth perception without stereoscopy . . . . .	2
1.2.1. Monocular cues . . . . .	2
1.2.2. Proprioceptive cues . . . . .	7
1.3. Depth perception through stereoscopic vision . . . . .	9
1.4. Perception of inclinations and curves . . . . .	10
1.4.1. Perception of inclination and obliqueness . . . . .	10
1.4.2. Perception of curves . . . . .	14
1.5. Artificial stereoscopic vision . . . . .	22
<b>Chapter 2. Technological Elements</b> . . . . .	25
2.1. Taking a picture . . . . .	25
2.2. Reproduction . . . . .	26
2.2.1. Colorimetric differentiation . . . . .	27
2.2.2. Differentiation by polarization . . . . .	28
2.2.3. Active glasses . . . . .	30
2.2.4. Auto-stereoscopic screens . . . . .	31
2.2.5. Virtual reality headsets . . . . .	33
2.3. Motion parallax restitution . . . . .	34
2.3.1. Pseudoscopic movement . . . . .	34

---

2.3.2. Correcting pseudoscopic movements . . . . .	35
2.3.3. Monoscopic motion parallax . . . . .	40
<b>Chapter 3. Causes of Visual Fatigue in Stereoscopic Vision . . . . .</b>	<b>41</b>
3.1. Conflict between accommodation and convergence . . . . .	41
3.2. Too much depth . . . . .	44
3.3. High spatial frequencies . . . . .	46
3.3.1. Limits of fusion . . . . .	49
3.3.2. Comfort and high frequencies. . . . .	50
3.4. High temporal frequency . . . . .	52
3.5. Conflicts with monoscopic cues. . . . .	52
3.6. Vertical disparities. . . . .	53
3.7. Improper device settings . . . . .	55
3.7.1. Quality of image and display . . . . .	55
3.7.2. Differences between left and right images . . . . .	56
3.7.3. Speed of correction of pseudoscopic movements . . . . .	57
<b>Chapter 4. Short- and Long-term Consequences . . . . .</b>	<b>59</b>
4.1. Short-term effects . . . . .	59
4.1.1. Decreasing ease of accommodation . . . . .	59
4.1.2. Decrease in stereoscopic acuity. . . . .	59
4.1.3. Effects on the punctum proximum. . . . .	61
4.1.4. More subjective effects . . . . .	61
4.2. Long-term consequences . . . . .	62
4.2.1. Long-term effects on children . . . . .	62
<b>Chapter 5. Measuring Visual Fatigue . . . . .</b>	<b>63</b>
5.1. Visual acuity . . . . .	63
5.1.1. Different possible measurements. . . . .	64
5.1.2. Optotypes. . . . .	64
5.2. Proximum accommodation function . . . . .	65
5.3. Ease of accommodation. . . . .	66
5.4. Stereoscopic acuity . . . . .	67
5.4.1. Tests of distance vision . . . . .	67
5.4.2. Tests of near vision. . . . .	68
5.5. Disassociated heterophorias . . . . .	71
5.6. Fusional reserves. . . . .	72
5.7. Subjective tests. . . . .	74

---

<b>Chapter 6. Reducing Spatial Frequencies</b> . . . . .	75
6.1. Principle . . . . .	75
6.2. Technical solution . . . . .	75
6.2.1. Wavelets. . . . .	76
6.2.2. BOX FILTER . . . . .	92
6.2.3. Using a rolling average and other “blurs” . . . . .	98
6.2.4. Comparison of algorithms . . . . .	103
6.2.5. Chosen solution . . . . .	114
6.3. Experiment. . . . .	116
6.3.1. The task . . . . .	116
6.4. Measurements of fatigue taken . . . . .	118
6.4.1. Objective measurements . . . . .	118
6.4.2. Procedure . . . . .	119
6.4.3. The subjects. . . . .	120
6.5. Result . . . . .	120
6.5.1. Proximum accommodation function . . . . .	120
6.5.2. Ease of accommodation. . . . .	121
6.5.3. Stereoscopic acuity . . . . .	122
6.5.4. Effectiveness in execution of the task . . . . .	122
6.5.5. Subjective measurements. . . . .	123
6.5.6. Conclusions. . . . .	124
6.5.7. Discussion. . . . .	124
<b>Chapter 7. Reducing the Distance Between the Virtual Cameras</b> . . . . .	131
7.1. Principle . . . . .	131
7.1.1. Usefulness of stereoscopy in depth perception . . . . .	132
7.1.2. The objects . . . . .	133
7.1.3. Hypothesis . . . . .	142
7.2. Experiment. . . . .	142
7.2.1. Tasks. . . . .	142
7.2.2. Experimental conditions . . . . .	143
7.2.3. Subjects . . . . .	144
7.2.4. Measurements . . . . .	144
7.3. Results . . . . .	145
7.3.1. Results for fatigue . . . . .	145
7.3.2. Perception results . . . . .	147
7.4. Discussion . . . . .	152
7.4.1. Influence on visual fatigue . . . . .	152
7.4.2. Influence on visual perception. . . . .	153

<b>Conclusion</b> . . . . .	155
<b>Bibliography</b> . . . . .	157
<b>Index</b> . . . . .	167