

# Displays

## Fundamentals & Applications

Rolf R. Hainich  
Oliver Bimber



**CRC Press**

Taylor & Francis Group

Boca Raton London New York

CRC Press is an imprint of the  
Taylor & Francis Group, an **informa** business

AN A K PETERS BOOK

# Contents

Preface	xv
1 Introduction	1
1.1 Displays: A Bird's-Eye View	2
1.2 Milestones of Display Technology	3
1.3 Organization of the Book	11
2 Fundamentals of Light	15
2.1 Introduction	15
2.2 Electromagnetic Radiation	16
2.3 Principles of Light Generation	17
2.4 Measuring Light	34
2.5 Physics of Light	40
2.6 Summary	59
3 Principles of Optics	61
3.1 Introduction	61
3.2 Wave Optics	62
3.3 Geometric Optics	65
3.4 Formation of Point Images	73
3.5 Lasers	87
3.6 Summary	97
4 Basics of Visual Perception	99
4.1 Introduction	99
4.2 The Human Visual System	100
4.3 Colorimetry	106
4.4 Depth Perception	116
4.5 Motion Pictures	127
4.6 Summary	129

<b>5</b>	<b>Holographic Principles</b>	<b>131</b>
5.1	Introduction . . . . .	131
5.2	Holography: A Summary. . . . .	133
5.3	Interference and Diffraction. . . . .	136
5.4	Holographic Optical Elements (HOE). . . . .	154
5.5	Optical Holography. . . . .	168
5.6	Summary. . . . .	186
<b>6</b>	<b>Display Basics</b>	<b>187</b>
6.1	Introduction . . . . .	187
6.2	Fundamental Measures. . . . .	188
6.3	Color and Intensity Production. . . . .	203
6.4	Signal and Image Processing. . . . .	212
6.5	Electronics. . . . .	227
6.6	Assembly. . . . .	236
6.7	Summary. . . . .	252
<b>7</b>	<b>Spatial Light Modulation</b>	<b>253</b>
7.1	Introduction . . . . .	253
7.2	Transmissive Displays. . . . .	254
7.3	Reflective Displays. . . . .	260
7.4	Transflective Displays. . . . .	276
7.5	Emissive Displays. . . . .	278
7.6	High Dynamic Range Displays. . . . .	290
7.7	Bidirectional Displays. . . . .	293
7.8	Projection Displays. . . . .	294
7.9	Summary. . . . .	318
<b>8</b>	<b>Projector-Camera Systems</b>	<b>321</b>
8.1	Introduction . . . . .	321
8.2	Challenges of Nonoptimized Surfaces. . . . .	323
8.3	Geometric Registration. . . . .	324
8.4	Radioinertic Compensation . . . . .	331
8.5	Correcting Complex Light Modulations. . . . .	343
8.6	Overcoming Technical Limitations . . . . .	350
8.7	Summary. . . . .	365
<b>9</b>	<b>Three-Dimensional Displays</b>	<b>367</b>
9.1	Introduction . . . . .	367
9.2	Three-Dimensional Displays: Basic Considerations . . . . .	369
9.3	Spatial Stereoscopic Displays. . . . .	381
9.4	Autostereoscopic Displays . . . . .	395
9.5	Light-Field Displays. . . . .	407

- 9.6 Computer-Generated Holograms. . . . . 419
- 9.7 3D Media Encoding . . . . . 431
- 9.8 Summary. . . . . 435
  
- 10 Near-Eye Displays 439
  - 10.1 Introduction . . . . . 439
  - 10.2 Eye Physiology. . . . . 442
  - 10.3 Brightness and Power Consumption. . . . . 444
  - 10.4 Display Technologies for Near-Eye Displays. . . . . 445
  - 10.5 Examples of Near-Eye Displays. . . . . 447
  - 10.6 Optical Design . . . . . 450
  - 10.7 Laser Displays. . . . . 457
  - 10.8 Focus and Accommodation. . . . . 464
  - 10.9 Holographic lineage Generation for NED. . . . . 468
  - 10.10 Optical Combiners. . . . . 472
  - 10.11 Contact Lens Displays. . . . . 477
  - 10.12 Adaptive Displays and Eye Tracking . . . . . 481
  - 10.13 lineage Integration. . . . . 493
  - 10.14 Summary. . . . . 503
  
- 11 Discussion and Outlook 505
  - 11.1 Introduction. . . . . 505
  - 11.2 Next Steps in Display Technology. . . . . 506
  - 11.3 A Short Reflection on Displays. . . . . 507
  - 11.4 Brain-Computer Interfaces: The Ultimate Solution? . . . 508
  
- Image Processing for Displays 517
  - A The Fixed-Function Graphics Pipeline. . . . . 518
  - B The Programmable Graphics Pipeline. . . . . 522
  - C Graphics Hardware . . . . . 523
  - D GPU Programming Languages. . . . . 524
  - E An Introduction to GPU Programming by Example . . . 527
  - F The Swiss Army Knife of GPU Image Processing . . . 529
  
- Bibliography 547
  
- Index 566