

Contents

Foreword to 1st Edition *xv*

Foreword to 2nd Edition *xvii*

Preface *xix*

Acknowledgments *xxvii*

1 Introduction 1

1.1 Why Do We Need Color Management? 1

1.2 Closed-loop Color Control 3

1.3 Need for an Open System 4

1.4 A Color Management System 5

1.5 Color Management Workflows 8

1.6 ICC – International Color Consortium 10

1.7 RGB and CMYK Color Specification 13

1.8 CIE 1931 Yxy and CIE 1976 L*a*b* 16

1.9 Color Conversions 17

1.10 Three Cs of Color Management 19

1.11 Profile Types 20

1.11.1 Custom Profiles 20

1.11.2 Generic Profiles 21

1.11.3 Standard Profiles 22

1.12 Color Gamuts 24

1.13 Rendering Intents 26

1.14 Color Accuracy 28

1.15 Late-binding Workflows 29

1.16 Spot Colors and Proprietary Systems 30

1.17 Benefits of Color Management 31

1.18 Summary 34

2 Principles of Light and Color 37

2.1 Introduction 37

2.2 Light Source – Object – Human Observer 38

2.3 Electromagnetic Radiation 39

2.3.1 The Visible Spectrum 39

2.4 Specifying the Light Source 40

2.4.1 Spectral Power Distribution 40

2.4.2	Color Temperature	42
2.4.3	CIE Illuminants and Standard Sources	43
2.4.4	Viewing Booths	45
2.4.5	“Warm” and “Cold” Colors	46
2.5	Measuring the Sample Spectrum	46
2.5.1	Practical Color Samples	47
2.6	Quantifying Human Color Vision	49
2.6.1	CIE Standard Observer	50
2.6.2	Trichromatic Vision	51
2.7	Changing the Light Source	53
2.7.1	Chromatic Adaptation	53
2.7.2	Yellow Sodium-Vapor Street Lighting	54
2.7.3	Metamerism – Matching Jacket and Trousers	56
2.7.4	PANTONE® D50 Lighting Indicator	58
2.8	Vision and Measurement	58
2.8.1	Viewing the Invisible – Infrared	59
2.8.2	Ultraviolet Fluorescence	60
2.8.3	Color Illusions	60
2.8.4	Color Appearance Modeling	61
2.9	Summary	63
3	Color by Numbers	65
3.1	Introduction	65
3.2	Basic Attributes of Color: Hue, Saturation, and Lightness	66
3.3	Munsell Color System	67
3.4	CIE Color Specification	68
3.5	XYZ Tristimulus Values	69
3.5.1	Calculating XYZ	69
3.5.2	XYZ Example Colors	71
3.5.3	XYZ for Light Sources	72
3.6	CIE 1931 Yxy System	72
3.6.1	Advantages of the Yxy Chromaticity Diagram	74
3.6.2	Disadvantages of the Yxy Chromaticity Diagram	75
3.7	CIE 1976 L*a*b* System	77
3.7.1	L*a*b* Practical Examples	80
3.7.2	L*a*b* vs. Spectral Data	82
3.8	CIE 1976 L*C*h	83
3.9	Quantifying Color Difference	84
3.9.1	Calculating ΔE	85
3.9.2	Improved ΔE Equations	88
3.9.3	Which ΔE Should I Use?	91
3.9.4	ΔE and Images	92
3.10	Summary	93
4	Measuring Instruments	95
4.1	Introduction	95
4.2	Instrument Types	96

- 4.3 Instrument Filter Bands 97
 - 4.4 Densitometers 98
 - 4.4.1 Density Equation 99
 - 4.4.2 Status Densitometry 99
 - 4.4.3 Density and Process Control 100
 - 4.5 Colorimeters 101
 - 4.5.1 Filter-based Colorimetry 101
 - 4.5.2 Improvements in Display Colorimeters 103
 - 4.6 Spectrophotometers 104
 - 4.6.1 Spectrophotometer Features and Functions 106
 - 4.6.2 Ever Popular X-Rite i1Pro2 109
 - 4.6.3 OBA and UV Fluorescence 110
 - 4.6.4 M0, M1, M2, M3 Measurement Modes 111
 - 4.7 Smartphone and Other Low-cost Systems 114
 - 4.8 Inter-instrument and Inter-model Agreement 115
 - 4.9 Instrument Repeatability vs. Accuracy 116
 - 4.10 Instrument Calibration 117
 - 4.11 Summary 120
- 5 Inside Profiles 121**
- 5.1 Introduction 121
 - 5.2 ICC Profile Specification 122
 - 5.3 Hexadecimal Profile Encoding 123
 - 5.4 Structure of an ICC Profile 124
 - 5.5 Profile Header 124
 - 5.5.1 Preferred CMM 125
 - 5.5.2 Specification Version 125
 - 5.5.3 Profile Class 126
 - 5.5.4 Data Color Space and PCS 127
 - 5.5.5 Flags 128
 - 5.5.6 Rendering Intent 130
 - 5.5.7 PCS Illuminant 130
 - 5.5.8 Profile Creator 130
 - 5.6 Tag Table 131
 - 5.6.1 Profile Description Tag 131
 - 5.6.2 XYZ Primaries Tag 132
 - 5.6.3 Tone Reproduction Curve Tag 133
 - 5.6.4 Media White Point Tag 133
 - 5.6.5 Chromatic Adaptation Tag 133
 - 5.6.6 Lookup Table Tags 135
 - 5.6.7 Target Tag 137
 - 5.6.8 Gamut Tag 139
 - 5.6.9 Optional Tags 139
 - 5.6.10 Private Tags 140
 - 5.7 Version 2 and Version 4 Profiles 140
 - 5.8 Version 5 Profiles and iccMAX 141

- 5.9 How Does a Lookup Table Work? 142
- 5.10 Summary 144
- 6 Managing Color in Digital Cameras 147**
 - 6.1 Introduction 147
 - 6.2 Scanner Profiling 148
 - 6.2.1 Making a Scanner Profile 148
 - 6.3 Paradigm Shift from Scanners to Digital Cameras 149
 - 6.4 Color Management for a Digital Camera 152
 - 6.4.1 Bayer Color Filter Array 152
 - 6.4.2 In-Camera JPEG Processing 153
 - 6.4.3 Camera RAW Processing 154
 - 6.4.4 Camera RAW Color Management 155
 - 6.4.5 Creating a Camera RAW Profile 157
 - 6.4.6 Digital Negative – DNG 157
 - 6.5 File Formats for Digital Cameras 159
 - 6.5.1 JPEG Lossy File Format 160
 - 6.5.2 TIFF Lossless File Format 161
 - 6.6 Studio Color Management 161
 - 6.7 Summary 162
- 7 Monitor Profiles 165**
 - 7.1 Introduction 165
 - 7.2 Three Cs of Monitor Profiling 167
 - 7.3 Monitor Profiling Solutions 167
 - 7.3.1 Free Utilities 167
 - 7.3.2 Commercial Profiling Software 168
 - 7.3.3 Integrated Soft Proofing Solutions 169
 - 7.3.4 Hardware Calibrated Monitor Systems 170
 - 7.4 Monitor Basics 171
 - 7.4.1 External Brightness and Contrast 171
 - 7.4.2 RGB Primaries 172
 - 7.4.3 White Point 174
 - 7.4.4 Monitor Gamma 174
 - 7.4.5 Luminance Levels 175
 - 7.4.6 The Dingy Yellow Effect 175
 - 7.5 Making a Monitor Profile 177
 - 7.6 Checking a Monitor Profile 178
 - 7.7 Monitor Profiles and Windows 179
 - 7.8 Monitor Profiles and Web Browsers 180
 - 7.9 Monitor Profiles and Mobile Devices 181
 - 7.10 Soft Proofing in Adobe Acrobat 182
 - 7.11 Standards for Viewing Booths 183
 - 7.12 Summary 184
- 8 Press and Printer Profiling 187**
 - 8.1 Introduction 187
 - 8.2 The Three Cs in Printer Profiling 188

- 8.3 Calibration in Inkjet Systems 188
 - 8.3.1 Ink Limiting 189
 - 8.3.2 Ink Hooking 190
 - 8.3.3 Ink Splitting 191
- 8.4 Calibration in Digital Presses 192
- 8.5 Calibration in Offset Printing 193
 - 8.5.1 G7 Calibration 194
 - 8.5.2 Shared Neutral Appearance vs. Full Color Match 196
- 8.6 Printer Test Charts 197
 - 8.6.1 Commonly Used Printer Test Charts 197
 - 8.6.2 Visual vs. Random Layout 199
- 8.7 Printing and Measuring the Test Chart 200
 - 8.7.1 RGB or CMYK or Halftone Printer? 200
 - 8.7.2 Printing with “No Color Management” 202
 - 8.7.3 Layout for Different Measuring Instruments 204
 - 8.7.4 White Backing 205
 - 8.7.5 Examining the Measurement File 205
 - 8.7.6 Averaging Measurement Files 206
- 8.8 Making a Printer Profile 206
 - 8.8.1 Black Channel Generation 206
 - 8.8.2 Profile Quality 209
- 8.9 Checking the Printer Profile 210
 - 8.9.1 Quantitative Checking 210
 - 8.9.2 Qualitative Checking 212
- 8.10 Reference Printing Conditions 213
 - 8.10.1 Developing Reference Printing Conditions 214
 - 8.10.2 American and European Reference Printing Conditions 215
 - 8.10.3 Using Reference Printing Conditions in Prepress and Press 217
 - 8.10.4 “Printing to the Numbers” 219
- 8.11 Rendering Intents 221
 - 8.11.1 Perceptual Rendering Intent 222
 - 8.11.2 Relative Colorimetric Rendering Intent 223
 - 8.11.3 Absolute Colorimetric Rendering Intent 224
 - 8.11.4 Saturation Rendering Intent 225
- 8.12 Device Link Workflows 225
 - 8.12.1 ICC Device Linking 225
 - 8.12.2 Proprietary Device Linking 226
- 8.13 Process Control in Printing 227
- 8.14 Summary 230
- 9 Spot Colors & Expanded Gamut Printing 233**
 - 9.1 Introduction 233
 - 9.2 Specifying a Spot Color – PANTONE MATCHING SYSTEM® 236
 - 9.2.1 PANTONE Guides 236
 - 9.2.2 Pantone Digital Color Libraries 239
 - 9.2.3 PANTONE Ink Formulation Recipes 241
 - 9.2.4 Advantages and Disadvantages of the PMS System 242

- 9.3 Printing a Spot Color 243
 - 9.3.1 Printing with a Spot Color Ink 243
 - 9.3.2 Simulating a Spot Color in CMYK 244
- 9.4 Spot Colors and Digital Presses 246
 - 9.4.1 Creating a Swatch Book on a Digital Press 247
 - 9.4.2 Spot Color Matching in Digital Presses 247
 - 9.4.3 Spot Color Editor for a Digital Press 249
- 9.5 Expanded Gamut Printing 249
- 9.6 Software Solutions for Spot Colors and Expanded Gamut Printing 253
 - 9.6.1 Gamut Warning in Adobe Photoshop 253
 - 9.6.2 Using PANTONE Color Manager 253
 - 9.6.3 Color Conversion with Esko Equinox 254
 - 9.6.4 Gamut Calculation in Esko Color Engine Pilot 255
- 9.7 Summary 256
- 10 XML and Color Management 259**
 - 10.1 Introduction 259
 - 10.2 Markup Languages 260
 - 10.3 XML Design Principles 261
 - 10.4 Basics of XML 262
 - 10.4.1 Declaration 262
 - 10.4.2 Elements 263
 - 10.4.3 Attributes 263
 - 10.4.4 Schema 264
 - 10.4.5 Private Schemas 265
 - 10.4.6 Validation and Conformance 265
 - 10.5 Working with XML 267
 - 10.5.1 iccMAX 267
 - 10.5.2 Windows Color System (WCS) 268
 - 10.5.3 Color Exchange Format (CxF) 269
 - 10.5.4 X-Rite i1Profiler 271
 - 10.5.5 JDF 272
 - 10.6 XML not-best Practices 272
 - 10.7 Summary 274
- 11 Color Management in Photoshop 275**
 - 11.1 Introduction 275
 - 11.2 Photoshop Through the Ages 276
 - 11.3 Photoshop's Color Management Rules 278
 - 11.3.1 Rule 1: Image + Profile 279
 - 11.3.2 Rule 2: Profile – Connection Space – Profile 279
 - 11.3.3 Rule 3: Real vs. Simulated Conversions 279
 - 11.4 Photoshop's Working Space 280
 - 11.5 Menus in Photoshop 281
 - 11.5.1 Opening an Image 282
 - 11.5.2 Image Status 283
 - 11.5.3 Color Settings 284

11.5.4	Assign Profile	286
11.5.5	Convert to Profile	287
11.5.6	Soft Proof Setup	289
11.6	Photoshop and Printing	290
11.6.1	Photoshop's Print Settings	290
11.6.2	Hard Proofing	292
11.7	Putting It All Together	293
11.8	Summary	295
A Appendix 297		
Index 305		

The first edition of *Understanding Color Management* established an accessible and practical foundation for the topic. Since the first edition was published much has changed in the color management landscape. Many aspects have evolved—the color management industry, the expectations of customers, the scientific and technical understanding of color, and also the color management architecture and the ICC profile format. There now exists a more detailed understanding of the process. International standards developed by ISO, ICC, and Graphic Technology have aided the industry in creating and maintaining good practice. Workflow procedures, based largely on the use of the ICC profile format, have become more sophisticated and more reliable in delivering color management software applications. Color management has become a more integral part of the workflow and the specialist equipment and software tools have proliferated in response to scientific and technical developments and market requirements. The color management workflow has become a more integral part of the workflow and the specialist equipment and software tools have proliferated in response to scientific and technical developments and market requirements. The color management workflow has become a more integral part of the workflow and the specialist equipment and software tools have proliferated in response to scientific and technical developments and market requirements.

The new edition keeps pace with these changes and those familiar with the first will find a wealth of new material. The scientific material has been updated, and the practical implementation arrangements is substantially expanded to include the use of the ICC profile format and calibration and an explanation of the requirements for color management in ISO 15076. The ICC profile format is described in detail, with details of the main file formats explained. The advantages of working with the standard file format of 2001 are discussed and the latest ICC technology—ICCv4—is described.

Through the use of the text, and the extensive use of diagrams and illustrations, the author provides a thorough description of practical color management. The book covers the use of color devices—cameras, displays and printers. The latest color management workflow has been updated for the last decade and is presented and detailed color management workflow is also shown how to make color management work and achieve good color reproduction in production.

The success of this volume is its unique combination of accessible yet thorough description of the science of graphic arts color management, and practical guidelines on how to implement it. As a former Working Group chair of ICC, and a current member of the ISO 15076-2001 Working Group, the author has a unique position to provide