

- 1 Introduction p. 1
- 1.1 Overview p. 1
- 1.2 Organization of This Book p. 2
- 1.3 Terminology and the MATLAB Programming Language p. 4
- 1.3.1 Getting Started p. 5
- 1.3.2 Getting Help p. 6
- 1.4 Other References p. 9
- 2 Visualization Considerations p. 11
- 2.1 Why Visualize? p. 11
- 2.2 Characteristics of Good Data Visualization p. 12
- 2.3 Data Quantity and Dimension p. 13
- 2.4 Color, Light, and Shading p. 14
- 2.5 Motion p. 17
- 2.6 Interaction p. 17
- 3 Plotting in Two Dimensions p. 19
- 3.1 Sources of Data p. 19
- 3.1.1 Function Data p. 19
- 3.1.2 Measured Data p. 20
- 3.2 Importing Data p. 21
- 3.2.1 MATLAB Data Formats p. 21
- 3.2.2 Importing High-Level Data p. 22
- 3.2.3 Importing Low-Level Data p. 24
- 3.3 Elementary 2-D Plots p. 25
- 3.3.1 A General Overview of the Plot Command p. 26
- 3.3.2 Logarithmic Plots p. 35
- 3.4 Simple 2-D Plot Manipulation p. 37
- 3.4.1 Generating Plots with Multiple Data Sets p. 37
- 3.4.2 Using Axis to Customize Plots p. 41
- 3.4.3 Creating Supporting Text and Legends p. 51
- 3.4.4 Text Placement p. 57
- 3.4.5 Special Text Character Formats p. 60
- 3.4.6 Using Subplot to Create Multiple Axes p. 63
- 3.5 Specialized 2-D Plotting p. 67
- 3.5.1 Bar Graphs p. 67
- 3.5.2 Histograms p. 72
- 3.5.3 Stairstep Graphs p. 74
- 3.5.4 Stem Plots p. 75
- 3.5.5 Plots with Error Bars p. 77
- 3.5.6 Pie Charts p. 78
- 3.5.7 Area Plots p. 83
- 3.5.8 Working with Complex Data p. 84
- 3.5.9 Using the Polar Coordinate System p. 87
- 3.5.10 Plotting Functions with MATLAB p. 91
- 3.5.11 Creating Filled Plots and Shapes p. 93
- 3.6 Plot Editing in the MATLAB Figure Window p. 95
- 3.6.1 Plot Editing Mode p. 96

- 3.6.2 The Property Editor p. 97
- 3.6.3 Zooming and Rotating p. 98
- 3.6.4 Exporting, Copying, and Pasting p. 99
- 3.7 Illustrative Problems p. 100
- 4 Plotting in Three Dimensions p. 101
- 4.1 Elementary 3-D Plotting p. 101
- 4.1.1 Using Plot3 p. 101
- 4.1.2 Creating 3-D Meshes and Surfaces p. 104
- 4.1.3 Waterfall Plots p. 109
- 4.1.4 3-D Plots of Non-Uniformly Sampled Data p. 110
- 4.1.5 Creating Shaded Surface Plots p. 112
- 4.1.6 Removing Hidden Lines p. 113
- 4.1.7 Contour Plots p. 115
- 4.1.8 Quiver Plots p. 121
- 4.1.9 Combination Plots p. 122
- 4.1.10 3-D Stem Plots p. 127
- 4.1.11 Generating Surfaces with Triangles p. 129
- 4.1.12 Polygons in a 3-D Space p. 131
- 4.1.13 Built-In Surface Functions p. 132
- 4.2 Simple 3-D Plot Manipulation p. 136
- 4.2.1 The Camera Toolbar p. 136
- 4.2.2 Generalizing the Axis for 3 Dimensions p. 138
- 4.2.3 3-D Plot Rotation p. 140
- 4.2.4 Using the View Command p. 142
- 4.3 Volume Visualization p. 145
- 4.3.1 Scalar Volume Data p. 145
- 4.3.1.1 Slice Planes p. 147
- 4.3.1.2 Contour Slices p. 149
- 4.3.1.3 Isosurfaces and Isocaps p. 151
- 4.3.2 Vector Volume Data p. 153
- 4.3.2.1 Stream Plots p. 156
- 4.3.2.2 Stream Lines p. 157
- 4.3.2.3 Stream Particles p. 159
- 4.3.2.4 Stream Ribbons p. 160
- 4.3.2.5 Stream Tubes p. 161
- 4.3.2.6 Cone Plots p. 162
- 4.4 A Word About Annotating 3-D Plots p. 164
- 4.5 Illustrative Problems p. 165
- 5 Image Graphics p. 167
- 5.1 Image Files and Formats p. 167
- 5.1.1 Common Image File Types p. 168
- 5.2 Image I/O p. 170
- 5.2.1 Reading a Graphics Image p. 172
- 5.2.2 Displaying a Graphics Image p. 173
- 5.2.3 Writing a Graphics Image p. 175
- 5.3 Image Types and Properties p. 176

- 5.3.1 Indexed Images p. 176
- 5.3.2 Intensity Level Images p. 178
- 5.3.3 Truecolor Images p. 181
- 6 Generating Output p. 183
- 6.1 The Quickest Way to Paper p. 183
- 6.1.1 Page Setup p. 184
- 6.2 Printing Colored Lines to Black & White Printers p. 185
- 6.3 Electronic Output p. 186
- 6.3.1 Using File Export p. 186
- 6.3.2 Using the Windows Clipboard p. 186
- 6.4 Using the Print Command p. 187
- 6.4.1 Creating Hardcopy with PRINT p. 187
- 6.4.2 Creating Graphics Files Using Print p. 187
- 6.4.3 Adding Additional Figures to a File p. 188
- 6.4.4 Publishing Using 4-Color Separation p. 188
- 6.4.5 EPS with a Preview Image p. 188
- 6.4.6 Rendering Method with -zbuffer or -painters p. 189
- 6.4.7 Indicating Which Figure Window to Print p. 189
- 6.4.8 Saving Figures for Future Use p. 190
- 7 Handle Graphics p. 191
- 7.1 Graphics Objects p. 191
- 7.2 Graphics Objects Hierarchy p. 193
- 7.3 Graphics Objects Handles p. 198
- 7.3.1 Determining Handles at Creation p. 199
- 7.3.2 Getting Handles of Current Objects p. 200
- 7.4 Properties p. 202
- 7.4.1 The Property Editor p. 203
- 7.4.2 Manipulating Properties p. 204
- 7.4.3 Universal Object Properties p. 206
- 7.4.3.1 ButtonDownFcn, BusyAction, and Interruptible p. 207
- 7.4.3.2 Children and Parent p. 208
- 7.4.3.3 Clipping p. 208
- 7.4.3.4 CreateFCN and DeleteFCN p. 210
- 7.4.3.5 HandleVisibility p. 211
- 7.4.3.6 HitTest p. 212
- 7.4.3.7 Selected and SelectionHighlight p. 212
- 7.4.3.8 Tag and Type p. 213
- 7.4.3.9 UserData p. 214
- 7.4.3.10 Visible p. 214
- 7.5 Object Specific Properties p. 214
- 7.5.1 Root Properties p. 215
- 7.5.1.1 Display Related Root Properties p. 216
- 7.5.1.2 Root Properties Related to the State of MATLAB p. 217
- 7.5.1.3 Behavior Related Properties of the Root p. 219
- 7.5.2 Figure Properties p. 220
- 7.5.2.1 Figure Properties Affecting Position p. 222

- 7.5.2.2 Style and Appearance Properties of the Figure Object p. 223
- 7.5.2.3 Figure Properties that Control the Colormap p. 224
- 7.5.2.4 Figure Properties that Affect Transparency p. 225
- 7.5.2.5 Properties that Affect How Figures are Rendered p. 225
- 7.5.2.6 Properties Related to the Current State of a Figure p. 226
- 7.5.2.7 Figure Properties that Affect the Pointer p. 229
- 7.5.2.8 Figure Properties that Affect Callback Execution p. 230
- 7.5.2.9 Figure Properties that Control Access to Objects p. 234
- 7.5.2.10 Figure Properties that Affect Printing p. 235
- 7.5.3 Axes Properties p. 236
- 7.5.3.1 Axes Properties Controlling Boxes and Tick Marks p. 238
- 7.5.3.2 Properties Affecting Axes Character Formats p. 245
- 7.5.3.3 Axes Properties Determining Axis Location and Position p. 245
- 7.5.3.4 Axes Properties Affecting Grids, Lines, and Color p. 248
- 7.5.3.5 Properties Affecting Axis Limits p. 256
- 7.5.3.6 Axes Properties Related to Viewing Perspective p. 265
- 7.5.4 Line Properties p. 266
- 7.5.5 Rectangle Properties p. 272
- 7.5.6 Patch Properties p. 273
- 7.5.6.1 Properties Defining Patch Objects p. 275
- 7.5.6.2 Properties Specifying Lines, Color, and Markers p. 277
- 7.5.6.3 Properties Affecting Lighting and Transparency p. 280
- 7.5.7 Surface Properties p. 281
- 7.5.8 Image Properties p. 287
- 7.5.9 Text Properties p. 289
- 7.6 Setting Default Properties p. 295
- 7.7 Undocumented Properties p. 296
- 7.8 Using Findobj p. 297
- 7.9 Illustrative Problems p. 300
- 8 Using Color, Light, and Transparency p. 301
- 8.1 Simple Color Specifications p. 301
- 8.2 Color Maps p. 301
- 8.2.1 Effects of Color Maps in General p. 304
- 8.2.2 Color Axis Control p. 305
- 8.2.2.1 Color Control with Direct Mapping p. 305
- 8.2.2.2 Color Control with Scaled Mapping p. 306
- 8.2.3 Color Maps as they Relate to Graphics Objects p. 307
- 8.2.3.1 Color Maps and the Surface Object p. 307
- 8.2.3.2 Patch Objects and the Color Map p. 313
- 8.2.3.3 Images and the Color Map p. 315
- 8.2.4 Color Shading p. 319
- 8.2.5 Brightening and Darkening Color Maps p. 319
- 8.2.6 Spinning the Color Map p. 322
- 8.2.7 Making Use of the Invisible Color with NaN p. 323
- 8.2.8 Creating Simple Color Bars p. 328
- 8.2.9 The Pseudocolor Plot p. 329

- 8.2.10 Texture Mapping p. 334
- 8.3 Modeling Object Lighting p. 338
- 8.3.1 Light Properties p. 338
- 8.3.2 Functions that Make Use of Light p. 339
- 8.3.2.1 Lighting Commands p. 343
- 8.3.3 Lighting Models p. 344
- 8.3.3.1 The Diffuse Lighting Model p. 344
- 8.3.3.2 The Ambient Lighting Model p. 346
- 8.3.3.3 The Specular Lighting Model p. 347
- 8.3.3.4 Combining Lighting Models p. 349
- 8.3.3.5 A Final Word on Light Objects p. 350
- 8.3.4 Creating Color Varying Lines with Surface Objects p. 350
- 8.4 Object Transparency p. 352
- 8.4.1 Alpha Properties p. 352
- 8.4.1.1 AlphaData p. 353
- 8.4.1.2 Alphamap p. 353
- 8.4.1.3 ALim p. 353
- 8.4.1.4 ALimMode p. 353
- 8.4.1.5 AlphaDataMapping p. 354
- 8.4.1.6 FaceAlpha p. 354
- 8.4.1.7 EdgeAlpha p. 354
- 8.4.1.8 FaceVertexAlphaData p. 354
- 8.4.2 Alpha Functions p. 355
- 8.4.2.1 alpha p. 355
- 8.4.2.2 alphamap p. 355
- 8.4.2.3 alim p. 356
- 8.4.3 Setting a Single Transparency Value p. 357
- 8.4.4 Mapping Data to Transparency p. 357
- 8.5 Illustrative Problems p. 359
- 9 Animation p. 361
- 9.1 Frame-by-Frame Capture and Playback p. 361
- 9.1.1 Taking a Snapshot p. 363
- 9.1.2 Playing a Movie p. 366
- 9.1.3 Preallocating Memory p. 367
- 9.1.4 Practically Speaking p. 368
- 9.1.4.1 Recording the Entire Figure p. 368
- 9.1.4.2 Animating a Portion of the Figure p. 369
- 9.1.5 Making an AVI Movie p. 371
- 9.2 On-the-Fly Graphics Object Manipulation p. 372
- 9.2.1 Simple Animation Functions p. 372
- 9.2.2 The Wrong and Right Way to Animate Graphics p. 373
- 9.2.3 The Need for Speed p. 376
- 9.2.4 Animating Lines p. 376
- 9.2.5 Animated Rotations p. 377
- 9.2.6 Forcing a Graphic to Leave a Trail p. 382
- 9.3 Choosing the Right Technique p. 383

- 10 Elements of GUI Design p. 385
- 10.1 What is a MATLAB Graphical User Interface? p. 385
- 10.2 The Three Phases of Interface Design p. 386
- 10.2.1 Analysis p. 387
- 10.2.2 Design p. 387
- 10.2.2.1 User Considerations p. 387
- 10.2.2.2 The Reason for the GUI p. 387
- 10.2.2.3 Cognitive Considerations p. 388
- 10.2.2.4 Physical Considerations p. 389
- 10.2.3 Paper Prototyping p. 389
- 10.2.3.1 Appearance p. 389
- 10.2.4 Construction p. 390
- 10.3 UI Control Elements p. 391
- 10.3.1 The Styles p. 391
- 10.3.1.1 Check Boxes p. 391
- 10.3.1.2 Editable Text p. 392
- 10.3.1.3 Frames p. 393
- 10.3.1.4 Pop-Up Menus p. 394
- 10.3.1.5 List Boxes p. 395
- 10.3.1.6 Push Buttons p. 395
- 10.3.1.7 Toggle Buttons p. 396
- 10.3.1.8 Radio Buttons p. 396
- 10.3.1.9 Sliders p. 397
- 10.3.1.10 Static Text p. 398
- 10.3.2 UI Control Properties p. 398
- 10.3.2.1 Uicontrol BackgroundColor p. 400
- 10.3.2.2 Uicontrol ButtonDownFcn p. 400
- 10.3.2.3 Uicontrol CData p. 400
- 10.3.2.4 Uicontrol Callback p. 400
- 10.3.2.5 Uicontrol Enable p. 401
- 10.3.2.6 Uicontrol Extent p. 402
- 10.3.2.7 Uicontrol ForegroundColor p. 402
- 10.3.2.8 Uicontrol Font Angle, Name, Size, Units, and Weight p. 402
- 10.3.2.9 Uicontrol HorizontalAlignment p. 403
- 10.3.2.10 Uicontrol Min, Max, and Value p. 404
- 10.3.2.11 Uicontrol SliderStep p. 404
- 10.3.2.12 Uicontrol TooltipString p. 405
- 10.3.2.13 Uicontrol Position p. 405
- 10.3.2.14 Uicontrol String p. 406
- 10.3.2.15 Style p. 406
- 10.3.2.16 ListBoxTop p. 407
- 10.3.2.17 Uicontrol Units p. 408
- 10.3.2.18 Uicontrol Interruptible p. 408
- 10.3.2.19 Uicontrol Tag p. 408
- 10.3.2.20 Uicontrol UserData p. 408
- 10.3.2.21 Uicontrol Visible p. 409

- 10.3.2.22 Other UI Control Properties p. 409
- 10.3.3 Creating Uicontrol Objects p. 409
- 10.3.3.1 Uicontrol Object Layering p. 410
- 10.3.3.2 Framing Objects p. 411
- 10.3.3.3 A Stretchable GUI p. 412
- 10.3.3.4 Predefined GUIs and Dialog Boxes p. 414
- 10.4 Uimenu Elements p. 421
- 10.4.1 Uimenu Properties p. 422
- 10.4.1.1 Uimenu Accelerator p. 423
- 10.4.1.2 Uimenu CallBack p. 424
- 10.4.1.3 Uimenu Checked p. 424
- 10.4.1.4 Uimenu Children p. 425
- 10.4.1.5 Uimenu Enable p. 426
- 10.4.1.6 Uimenu ForegroundColor p. 426
- 10.4.1.7 Uimenu Label p. 426
- 10.4.1.8 Uimenu Position p. 427
- 10.4.1.9 Uimenu Separator p. 427
- 10.4.1.10 Uimenu Interruptible p. 428
- 10.4.1.11 Uimenu Tag p. 428
- 10.4.1.12 Uimenu UserData p. 428
- 10.4.1.13 Uimenu Visible p. 429
- 10.4.1.14 Other Uimenu Properties p. 429
- 10.4.2 Creating Uimenu p. 429
- 10.4.2.1 Top Level Uimenu p. 429
- 10.4.2.2 Menu Items and Submenu Titles p. 430
- 10.4.2.3 Summary p. 431
- 10.5 Low-Level MATLAB GUI Programming Techniques p. 433
- 10.5.1 Strings of MATLAB Statements and Expressions p. 433
- 10.5.2 Programming Approaches in MATLAB p. 435
- 10.5.2.1 Creating All Graphics Elements in the Base Workspace p. 436
- 10.5.2.2 Storing Handles as Global Variables p. 441
- 10.5.2.3 Storing Handles in the UserData Properties p. 445
- 10.5.2.4 Utilizing Tags and the FINDOBJ Command p. 448
- 10.6 High-Level GUI Development - GUIDE p. 450
- 10.6.1 The Layout Editor p. 451
- 10.6.2 The Property Inspector p. 452
- 10.6.3 The Object Browser p. 454
- 10.6.4 The Menu Editor p. 455
- 10.6.5 Saving the GUI p. 455
- 10.6.5.1 The GUIDE Created FIG-File p. 455
- 10.6.5.2 The GUIDE Created M-File p. 456
- 10.6.6 Executing a GUI p. 459
- 10.6.7 Editing a Previously Created GUI p. 460
- 10.7 Common Programming Desires with UI Objects p. 461
- 10.7.1 Creating Exclusive Radio Buttons p. 462
- 10.7.2 Linking Sliders and Editable Text Objects p. 464

- 10.7.3 Editable Text and Pop-Up Menu p. 466
- 10.7.4 Windowed Frame and Interruptions p. 468
- 10.7.5 Toggling Menu Labels p. 471
- 10.7.6 Customizing a Button with Graphics p. 472
- 10.8 The MATLAB Event Queue p. 474
- 10.8.1 Event Scheduling and Execution p. 474
- 10.8.2 Execution Order of Events p. 475
- 10.8.2.1 Mouse Button Pressed Down p. 476
- 10.8.2.2 Mouse Button Released p. 477
- 10.8.2.3 Mouse Pointer Moved p. 477
- 10.8.3 Interruptible vs. Uninterruptible p. 478
- 10.8.4 Common Mouse Action Examples p. 479
- 10.8.4.1 Moving Objects with the Mouse p. 479
- 10.8.4.2 Dynamic Boxes Using the RBBOX Function p. 483
- 10.9 Creating Custom User Interface Components p. 484
- 10.9.1 Simulating Buttons with Image Objects p. 485
- 10.9.2 Creating a Dial p. 489
- Appendix Quick References p. 493
- Index p. 513