The Patrick Moore Practical Astronomy Series

More information about this series at <http://www.springer.com/series/3192>

The PixInsight Workspace

Inside PixInsight

Warren A. Keller

Springer

Warren A. Keller
Buckhannon, WV, USA

ISSN 1431-9756 ISSN 2197-6562 (electronic)
The Patrick Moore Practical Astronomy Series
ISBN 978-3-319-25680-1 ISBN 978-3-319-25682-5 (eBook)
DOI 10.1007/978-3-319-25682-5

Library of Congress Control Number: 2016941744

© Springer International Publishing Switzerland 2016

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made.

Cover design by Firdo at studio escalamar

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG Switzerland

*This book is dedicated to my late mother
Roslyn Pearl Schiff with all my love.
She would have been so very proud!
She was my greatest supporter, a world-class
musician and teacher, and the greatest friend
that those who knew her ever had.
She was equally fluent in the languages
of love and Debussy and awaited my latest
astro-image with genuine eagerness
and appreciation. We miss you mom!*

Preface

If the astrophotography community presented an Academy Award for outstanding software tools, Pleiades Astrophoto's PixInsight would have earned that trophy. In an already crowded field of very capable image processing programs, PixInsight has risen above the crowd, taking it by storm. In addition to its state-of-the-art preprocessing capabilities, PixInsight is also a post-processing platform rivaling Adobe® Photoshop®, once the de facto standard for astrophotographers. Now, with PixInsight, astro-imagers, both amateur and professional, can take their images from raw data to finished fine art photographs using a single program.

PixInsight is the brainchild of software developer Juan Conejero of Valencia, Spain. Released in 2004 as limited edition freeware, it had evolved into the commercial product known as PixInsight Core by 2007. PixInsight supports Windows and Mac operating systems, as well as Linux and FreeBSD. As of the 2013 release of version 1.8 Ripley, PixInsight support was limited to 64-bit only. The decision was made to cease development of the 32-bit variety, as modern 64-bit processors are better suited for the program's intensive image processing algorithms. Visit the system requirements page at www.pixinsight.com for hardware recommendations. As of this writing, version 1.8.4 is available at a cost of 230€, which includes free updates for version 1 and email support.

PixInsight is structured much like an operating system, permitting users to develop their own processing modules using the C++ programming language. Scripting is also possible using the JavaScript language. User-created modules can be submitted to Pleiades Astrophoto for possible inclusion in the program. In addition to user submissions and those of Juan Conejero himself, the bulk of the contributions come from members of the official, mostly European PTeam, which includes electrical engineering doctoral candidate Carlos Milovic, professional astronomical image processor Vicent Peris, and others. Their collaboration has

resulted in over 150 cutting-edge tools, created exclusively “For astro-imagers by astro-imagers.” This “For us/By us” mantra is pervasive throughout the PixInsight culture, and a visit to its lively user forum bears this out. Its developers and many enthusiastic users are convinced that this level of specialization is required for the demanding tasks of astronomical image processing.

PixInsight’s closest competitor in the post-processing arena is Adobe® Photoshop®. And while Photoshop’s power and versatility continues to be effectively adapted to the needs of astrophotographers by enterprising users, it is a generic editing program designed for everything from the graphic arts to the enhancement of terrestrial photographs. As a result, many of its tools are not useful for astro-imagers, who often purchase third-party plugins and automated Actions to expand the program’s ability to better handle astronomical data. By comparison, all of PixInsight’s tools are specifically designed for astronomical image processing, so the need for additional purchases of this type is unnecessary.

While a workflow consisting of multiple programs can be complementary, there is a bit of contention between the camps. PixInsight (PI) users tend to frown upon Photoshop’s manual selections and painting features as a “Fast Food” approach to the discipline, while some Photoshop® zealots have the opinion that PixInsight presents too steep a learning curve to climb. In truth, any specialized software worth its salt requires significant time to master, and it is the goal of this book to considerably level the learning curve.

PixInsight’s user interface offers a dizzying array of drop-down menus and sub-menus, and navigation would be daunting without the aid of adequate documentation. While, as of this writing, PI’s official help file remains far from complete, a wealth of textual information exists in mouseovers that appear when the cursor is floated over a process dialog. Another excellent resource for learning the software is the aforementioned user forum, where tutorials are often posted by Juan Conejero or Vicent Peris. There too, answers to questions may be solicited from the PTeam and from advanced users. The forum also provides a place to post bug reports or items on your wish list that you’d like to see added to the software. New processes and scripts are announced there as well. There’s even a gallery to share your images with others.

Several excellent video tutorials are available on the World Wide Web. Nearly every successful PixInsight user owes part of their victory to the free video tutorials of Ian “Harry” Page (Harry’s Astroshed) and the commercial video series by IP4AP (Image Processing for Astrophotography). Before beginning this book in earnest, viewing IP4AP’s free primer chapters (<http://www.ip4ap.com>) is strongly recommended. They will get you comfortable with navigating the user interface of the program. Additionally, PixInsight is being taught via workshops led by Vicent Peris and Carlos Milovic in both Europe and the Americas. While this book, however comprehensive, cannot hope to cover every possible scenario you may face in astronomical image processing, *Inside PixInsight*, in conjunction with these other valuable resources, will paint a complete picture.

Inside PixInsight is divided into four main sections—Preprocessing, Linear Post-processing, Nonlinear Post-processing, and Special Processing. The first section, Preprocessing, will teach you everything you need to know to produce calibrated, aligned, and stacked master image files. The middle sections of the book on Post-processing will help you transform those master files into works of art. The final section will address special processes such as creating mosaics and narrow-band images.

While PI is capable of scientific analysis, the emphasis of *Inside PixInsight*, like PixInsight itself, is on the technical art of astrophotography and specifically the deep-sky variety. This book assumes you've already begun your journey in astro-image processing and does not attempt to teach all of its concepts from the ground up. Wherever possible, *Inside PixInsight* follows a chronological path, from the beginning of workflow to its successful conclusion. It is intended to be a practical guide, featuring the best choices for most situations but cannot present all the choices for the many variables you'll encounter in image processing. It is strongly suggested that you read the text in its entirety, especially in the early stages. While you might assume that a particular section doesn't apply to you, it will contain valuable information which does. Enjoy *Inside PixInsight*!

Buckhannon, WV

Warren A. Keller

Acknowledgments

This book would not have been possible, or even necessary for that matter, if not for the genius of Mr. Juan Conejero of Pleiades Astrophoto, the developer of PixInsight Core. I want to personally thank Juan for his support of this project.

Thanks also to the other primary developers of the program—Carlos Milovic for proofreading the material as a technical editor despite his busy schedule as a doctoral candidate in electrical engineering and Vicent Peris Baixauli for his innovative approaches to astro-image processing.

I cannot thank Dr. Ron Brecher enough for his role as my primary technical editor. Ron was invaluable in making sure that the text was as accurate and readable as possible, and he embraced the task with gusto. Thanks also to my friends Richard S. Wright Jr. of Software Bisque and Dr. Stuart Forman for catching what the others missed.

To Ian “Harry” Page, Dave Raphael, Steve Leshin, and Rogelio Bernal Andreo—thank you for helping me get started with this incredible program.

To Michael Miller—thanks for your image contributions and support.

To David Ault, Gerald Weschselberger, Georg Viehoveer, and other members of the PixInsight community—thank you for your help in filling in some of the blanks.

Many thanks to my business partner at IP4AP Peter Proulx for recognizing my talent as a teacher and for helping me establish an international reputation as such.

Thanks to Alfredas Degutis for giving me the first opportunities to flex my muscles as a technical writer and presenter and to Sean Walker (and Robert Naeye) of Sky & Telescope magazine for allowing me to write for that venerable publication multiple times.

Thanks to my mentors in astrophotography Jerry Lodriguss, Ron Wodaski, Kevin Nelson, and Barry Poteete for showing me the way.

Thanks to John Watson, Maury Solomon, Nora Rawn, and the rest of the Springer team for believing in me and for turning my manuscript into a finished book.

Thanks to everyone else who has supported me in my efforts—my wife Christine, my dog Jack, my many friends in astronomy, the thousands of viewers around the world of my video tutorial series, and last but not least—you the reader. Thank you all!

About the Author

Warren Keller has taught astro-image processing since 2005, via his website IP4AP.com (Image Processing for Astrophotography). His articles and images have been published in *Sky & Telescope and Astronomy* magazine, as well as many places on the World Wide Web including NASA's Astronomy Picture of the Day (APOD). Three of his large format prints were chosen for 2012's prestigious *Starstruck: The Fine Art of Astrophotography* traveling exhibit. He was the North American representative for Atik CCD Cameras and was a consultant to Celestron where he designed AstroFX software for the Nightscape CCD camera. Working part-time for Quantum Scientific Imaging (QSI), he was elected to the board of directors of the Advanced Imaging Conference (AIC) in 2015. Warren has presented at the Advanced, North East, Midwest, RAW, and CAPS imaging conferences and was the coordinator of the Southwest Astrophotography Seminar (SWAP) in 2013–2014. He has also spoken at SCAE, RTMC, the Black Forest, Texas, Okie-Tex, Winter, Green Bank, Almost Heaven, Apollo Rendezvous, and Hidden Hollow star parties.

Contents

Part I Preprocessing

1 Image Evaluation	3
Processes, Scripts, and Explorer Windows	3
Blink.....	4
STF: ScreenTransferFunction	5
Suggested Workflow	7
The Image and Process Windows	8
SubframeSelector Script	8
Table.....	10
Plots.....	10
Output	10
Subframe Weighting	11
 2 Calibration and Integration	 13
Calibration.....	13
Bias and Dark Frames.....	14
Flat Frames.....	15
ImageIntegration of Bias and Dark Frames	16
Auto Stretch	18
Superbias.....	20
Undo/Redo	21
ImageCalibration of Flat Frames	21
ImageIntegration of Flat Frames.....	22
ImageCalibration of Light Frames.....	23

Alternate Calibration Methods.....	25
Sans Dark Frames	25
Early Bias Subtraction of Darks	25
3 Cosmetic Correction	27
CosmeticCorrection	28
OSC.....	29
Real-Time Preview.....	29
Use Auto Detect.....	30
Use Master Dark	31
Use Defect List	32
4 One-Shot Color.....	35
DSLR	37
OSC.....	37
Advanced STF for OSC and Monochrome Images	38
Alternative OSC Methods.....	39
5 Star Alignment.....	41
Dithering	42
DSLRs.....	42
StarAlignment.....	43
Binning.....	43
6 Image Integration.....	47
ImageIntegration	48
Reference Image	48
Combination.....	50
Normalization	50
Weights.....	50
Pixel Rejection (1)	51
Pixel Rejection (2)	51
NoiseEvaluation Script	52
ROI (Region of Interest)	53
Super Luminance	54
Pseudoluminance	54
7 Batch Preprocessing.....	55
New Instance Icon.....	55
Save Process Icons	56
Merge Process Icons	57
Complimentary Icons.....	57
BatchPreprocessing Script	58
BPP Tabs	58
Add Custom	58

FITSHeader.....	58
Bias Tab.....	59
Darks Tab.....	59
Script Limitations.....	60
Flats Tab.....	60
Lights Tab.....	61
Output Folders.....	63
 Part II Linear Post-Processing	
 8 File Preparation.....	67
Projects.....	67
Normalized Range.....	69
DynamicCrop.....	69
New Instance Redux.....	69
 9 BackgroundModelization.....	73
Uneven Field Illumination.....	73
BackgroundModelization.....	75
AutomaticBackgroundExtractor.....	75
DynamicBackground (Extraction).....	77
Advanced BackgroundModelization.....	81
RGBWorkingSpace.....	82
ChannelExtraction.....	82
ChannelCombination.....	84
Special Techniques.....	84
Relink Channels.....	86
CanonBandingReduction Script.....	87
 10 Introduction to Masks.....	89
Luminance Masks.....	91
Color Mask Conversion.....	92
Compare.....	93
Mask Application.....	93
Rendering Modes.....	93
Mask Control.....	94
More Efficient Luminance Masks.....	95
RangeSelection.....	96
Star Masks.....	97
Wavelets.....	97
Linear.....	97
 11 Deconvolution.....	101
To Luminance/Lightness.....	101
When Linear.....	101

Regularization	102
Motion Blur PSF	102
Parametric PSF	104
External PSF	104
DynamicPSF	104
PSF Model Functions	104
Channels	105
Amplitude	105
Other Criteria	105
Generate the PSF	107
Use Previews	107
Deconvolution	107
PSF	107
Algorithm	107
Iterations	107
Target	108
Deringing	108
Local Deringing	109
Wavelet Regularization	109
Range Selection	110
Experiment	110
Advanced Previews	111
12 Linear Color Processing and Noise Reduction	113
Linear Color Processing	113
ChannelCombination	113
BackgroundNeutralization	114
PreviewAggregator Script	115
Show/Hide Previews	116
ColorCalibration	116
SCNR	119
Linear Noise Reduction	121
ExtractWaveletLayers Script	121
MultiscaleLinearTransform Noise Reduction	122
Masking	124
Linear Mask	125
Luminance and Chrominance	126
OSC	126
MureDenoise Script	126
Part III Nonlinear Post-Processing	
13 Delinearization and LRGB Combination	131
Delinearization	131
What Is Linear?	131
Linear Histogram Manipulation	131

Nonlinear Histogram Manipulation	133
HistogramTransformation	134
Normalization	135
The Home Stretch	135
Stay Gray	138
MaskedStretch.....	138
AutoHistogram.....	140
Color Balance.....	141
LRGB Combination	144
LRGBCombination	144
14 A Look Back	149
Drop-Down Menus	149
File	149
Edit.....	150
View	153
Image.....	153
Preview.....	153
Mask.....	153
Process	154
Script.....	154
Workspace.....	154
Window	154
Resources	154
Explorer Windows	155
Tool Bars	156
Channel Selector	156
View Selector	157
Projects and History	157
Accommodation of Outside Data.....	158
Format Explorer	158
Additional Processes.....	159
Statistics	159
Geometry.....	159
ChannelMatch	159
FastRotation	159
Rotation.....	160
LinearFit.....	160
DynamicAlignment.....	161
Containers	162
Global Reset.....	165
Script Installation.....	165
INDI	165
15 Nonlinear Noise Reduction.....	167
TGVDenoise	167
Mode	168

Strength	169
Edge Protection	170
Smoothness	170
Iterations	171
Local Support	171
ACDNR	171
Noise Reduction Settings	172
Edge Protection	172
Lightness Mask	174
16 High Dynamic Range Compression	175
HDRMultiscaleTransform	175
Wavelet Layers	175
Mode	176
Scaling Function	176
Other Options	177
Expressions	179
Destination	180
SubstituteWithPreview Script	182
GradientHDRCompression	183
Max. log10	183
Min. log10	184
17 Contrast and Sharpness	185
Contrast	185
Contrastiveness	185
CurvesTransformation	188
LocalHistogramEqualization	192
Advanced Masking	193
CloneStamp	195
Difficult Cases	196
Sharpness	197
MultiScaleLinearTransform Sharpening	197
UnsharpMask	200
Masking	201
18 Color Saturation	203
‘Good Luminance Gone Bad’	203
CurvesTransformation	204
ColorSaturation	205
ColorMask Script	208
19 Fine Finishers	211
DarkStructureEnhance Script	211
ExponentialTransformation	212

MorphologicalTransformation	213
Structuring Element	213
Morphological Filter	214
Star Masks and MorphologicalTransformation	214
Painting	215
CloneStamp.....	215
Annotation.....	216
20 Archiving and Exporting.....	217
Archiving	217
Saving the Final Image	218
FITS	218
TIFF	218
JPEG	219
Printing.....	222
Color Profile.....	222
Upsample	222
Printer Setup.....	224
Printer Color Management.....	224
Print.....	224
SampleFormatConversion.....	225
Extensible Image Serialization Format (XISF).....	225
21 Learning by Example: One-Shot Color and Monochromatic	
Workflow.....	229
Chart 1-Suggested OSC Workflow Chart	230
One-Shot Color Workflow	232
Cropping	232
BackgroundModelization.....	232
BackgroundNeutralization	233
ColorCalibration	233
Deconvolution	234
Linear Noise Reduction	235
Nonlinear Transformation.....	236
PixelMath.....	238
Nonlinear Noise Reduction.....	238
Dynamic Range Compression.....	239
Color Saturation	240
Contrast Enhancement	244
Sharpening	244
Chart 2- Suggested Monochromatic Workflow Chart.....	247
Monochromatic Workflow	248
Cropping	248
BackgroundModelization.....	249
Creating Chrominance	250

BackgroundNeutralization	250
ColorCalibration	250
Linear Noise Reduction—Chrominance.....	252
Nonlinear Transformation—Chrominance	253
Nonlinear Noise Reduction—Chrominance	253
Deconvolution—Luminance	254
Linear Noise Reduction—Luminance	255
Nonlinear Transformation—Luminance.....	256
Nonlinear Noise Reduction—Luminance.....	257
Luminance and Chrominance	257
Color Saturation	258
Dynamic Range Compression.....	260
Contrast Enhancement	260
Sharpening	260
Star Contribution.....	260

Part IV Special Processing

22 Multiscale, Drizzle, High Dynamic Range, and Comet Techniques.....	265
Multiscale Techniques	265
Example 1	265
Example 2	271
Histogram Repair with PixelMath	274
Drizzle Techniques.....	276
DrizzleIntegration	276
High Dynamic Range Techniques	281
HDRComposition	281
Comet Techniques.....	284
Additional Notes	289
Make a Movie	290
23 Narrowband Processing	293
Introduction.....	293
Hydrogen Alpha Only.....	293
Linear Processing.....	294
Nonlinearization.....	295
Nonlinear Processing	296
Star Removal.....	297
Enhancing Luminance	299
NBRGBCombination Script	300
Bicolor Palettes	304
NBRGBCombination Script	304
HOO Palette	306
SHO-AIP Script	306

Tricolor Palettes	311
Chart 3 - Suggested Narrowband Workflow	311
SHO Palette.....	312
CFHT	312
Other Tricolor Palettes	313
Tricolor Combination.....	313
SHO-AIP Script	315
Alternate Blending Methods	318
Workflow	319
Helpful Hint	319
Color Adjustment.....	321
Galaxy Enhancement	325
File Preparation.....	325
NBRGBC Script.....	326
H-Alpha Mask.....	328
PixelMath.....	329
24 Mosaic Processing	331
Why Mosaics?.....	331
Planning	332
Linear When Possible	333
File Preparation.....	333
Example 1: Two Panel One-Shot Color Mosaic	335
StarAlignment.....	335
Reference Mask	337
GradientMergeMosaic	339
Additional Processing	342
Example 2: Four Panel Monochromatic Mosaic.....	342
File Preparation.....	343
StarAlignment.....	344
GradientMergeMosaic	348
CloneStamp.....	350
Field Illumination.....	351
DynamicCrop.....	352
ChannelCombination	352
Luminance Processing	352
LRGBCombination.....	353
Alternate Workflows	353
L-RGB.....	354
LRGB.....	354
Decisions, Decisions... ..	355
Restrict to Previews.....	355
Final Thoughts	357

25 More Insight	359
Masks	359
Star Masks.....	359
Binarize	362
Contours	362
Combined Masks	363
Range Masks	363
Masks from Previews	363
Masks from Scratch	364
Opacity	367
PixelMath.....	367
Blending.....	367
Subtracting	368
Restoring	368
Afterword.....	369
Index.....	377