

Warren A. Keller

Inside PixInsight

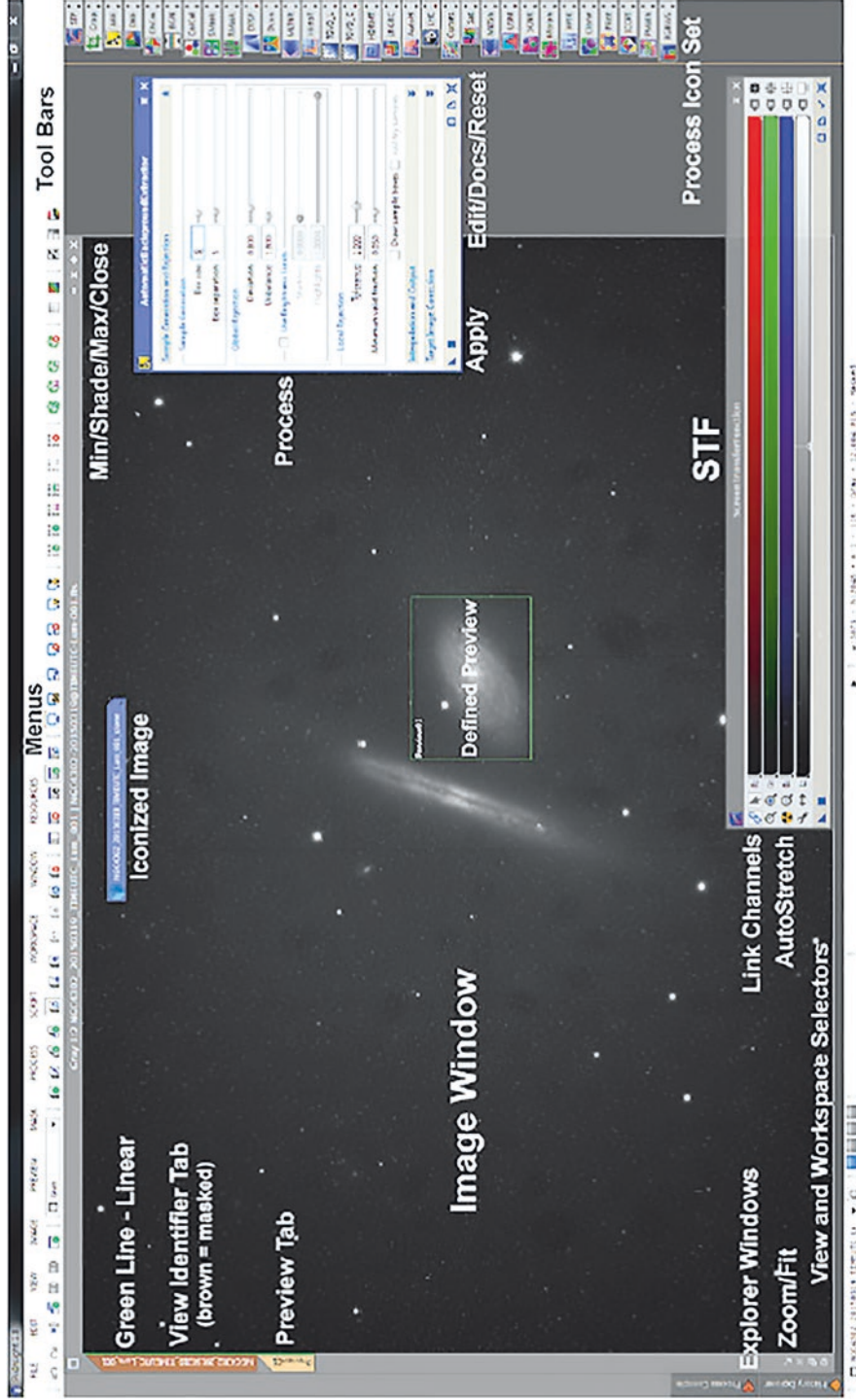
Second Edition

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Warren A. Keller

Second Edition

 Springer

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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 (PI) would have earned that trophy. In an already crowded field of capable image-processing programs, PI has risen above the competition, taking it by storm. In addition to its state-of-the-art preprocessing capabilities, PI is also a post-processing platform rivaling Adobe® Photoshop®, once the de facto standard for astro-photographers. Now, with PI, astro-imagers, both amateur and professional, can take their images from raw data to finished fine art photographs using a single program.

PI 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. PI supports Windows and OS X operating systems, as well as Linux and FreeBSD. As of the 2013 release of version 1.8 Ripley, PI support was limited to 64-bit only. The decision was made to cease development of the 32-bit version, 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 1.8.5 includes free updates and email support. It was the many additions and improvements included in this latest version of PI that necessitated the updates provided by this second edition of *Inside PixInsight*.

PI 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 professional astronomical image processor Vicent Peris, electrical engineering doctoral candidate Carlos Milovic, and others. Their collaboration has resulted in more than 150 cutting-edge tools, created exclusively “For astro-imagers by astro-imagers.” This “For us/By us” mantra is pervasive throughout the PI 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.

PI’s closest competitor in the post-processing arena is Adobe® Photoshop®. Although Photoshop’s power and versatility continue 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 PI’s tools are specifically designed for astronomical image processing, so additional purchases of this type are unnecessary.

A workflow consisting of multiple programs can be overlapping, and there is a bit of contention between the camps. 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 PI presents too steep a learning curve. 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.

PI’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. Although, as of this writing, PI’s official help file remains incomplete, a wealth of textual information is provided in mouseovers that appear when the cursor is hovered 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 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 are even processing challenges and a gallery to share your images with others.

Several excellent video tutorials are available on the World Wide Web. Nearly every successful PI 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 (<https://www.ip4ap.com>) is strongly recommended. They will get you comfortable navigating the user interface of the program. Additionally, PI workshops and one-on-one tutoring are offered the world over, by the author and other PI experts. Although this book alone 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 parts: preprocessing, linear post-processing, nonlinear post-processing, and special processing. The first part – preprocessing – covers everything you need to know to produce calibrated, aligned, and stacked master image files. The parts on post-processing will help you transform those master files into works of art. The final part will address special processes such as creating mosaics and working with narrowband data.

PI is capable of scientific analysis, but the emphasis of *Inside PixInsight*, like PI 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 the 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 will encounter in image processing. It is strongly suggested that you read the text in its entirety, especially in the early stages. You might assume that a particular section does not apply to you, but it will likely contain valuable information that does. Enjoy *Inside PixInsight*!

Buckhannon, WV, USA

Warren A. Keller



Acknowledgments

This book would not have been possible, or even necessary, if not for the genius of Mr. Juan Conejero. 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 serving as a technical reviewer for some of the first edition's material, despite his busy schedule as a doctoral candidate in electrical engineering, and to Vicent Peris Baixauli for his innovative approaches to astro-image processing.

I cannot thank Dr. Ron Brecher enough for his role as my technical reviewer for both the first and second editions. Ron was absolutely invaluable in making sure that the text was as accurate and readable as possible. He embraced the task with gusto, even offering his own useful suggestions.

Thanks very much to Jim Morse Esq. for proofreading the second edition so carefully. Thanks also to my friends Richard S. Wright, Jr., of Software Bisque, and Dr. Stuart Forman for catching what the others missed in the first edition.

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 Wechselberger, Georg Viehovever, and other brilliant members of the PI community – thank you for your help in filling in some of the blanks.

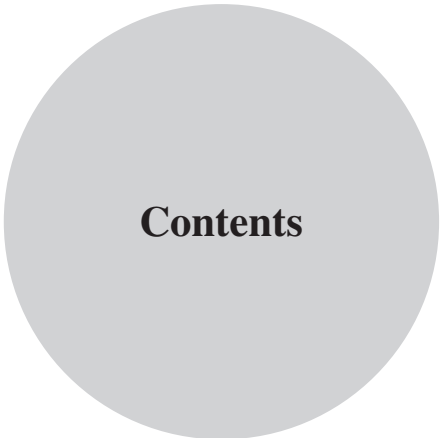
Many thanks to my business partner at IP4AP, Pete Proulx, for recognizing my talent as a teacher back in 2005 and for helping me establish an international reputation as such.

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 many times.

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

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About the Author

Warren A. 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*, *Astronomy*, and *Chinese National Astronomy* magazines, 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 later worked for Quantum Scientific Imaging (QSI). He was a consultant to Celestron, where he co-designed AstroFX software for the Nightscape CCD camera.

Warren was elected to the board of directors of the Advanced Imaging Conference (AIC) in 2015. He 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, Starfest, and Hidden Hollow star parties. The first edition of *Inside PixInsight* was Springer Nature's top seller in physics and astronomy in 2016 and was chosen as a *Sky & Telescope* magazine Hot Product for 2018.

Part I



Preprocessing



Image Evaluation

Quality deep-sky astrophotographs are achieved by digitally combining the signal present in multiple subexposures (subs). In this manner, inherent noise and other artifacts are attenuated, so that even the weak signal of dim regions becomes strong enough to be displayed and even enhanced. To that end, preprocessing, which can include image calibration, cosmetic correction, debayering, alignment, and image stacking must be performed accurately to ensure best results. In a perfect world, you could forge ahead with these tasks. In the real world however, it's good practice to evaluate the quality of your exposures before proceeding. While some imperfect subs may contribute to a good result, those with particularly poor attributes such as bad focus or tracking, weak contrast, or artifacts such as excessive airplane and satellite trails, may best be discarded rather than permitted to adversely affect the stacked master file. PixInsight (PI) offers several resources for image evaluation.

Processes, Scripts, and Explorer Windows

PI's tools are divided into two categories: processes and scripts. Processes are hard-coded tools developed primarily by the PTeam and written in the C++ programming language, using the PixInsight Class Library (PCL) framework. Scripts, on the other hand, are open source, and can be edited by an advanced user using the JavaScript language. Although some scripts

are products of the PTeam, many are third-party contributions by PI users. Each is available via its respective drop-down menu at the top of the workspace, and together from the View menu's Explorer Windows/Process Explorer. This window, along with five other Explorer Windows can be opened, moved, or closed according to your preferences. For our first foray into the program, we'll choose Blink, found in the Process menu's ImageInspection submenu (Fig. 1.1).

By the way, 'ImageInspection' isn't a typo – most of PI's functions are named with this conjoined convention (e.g., ImageInspection, AutoHistogram, etc.).

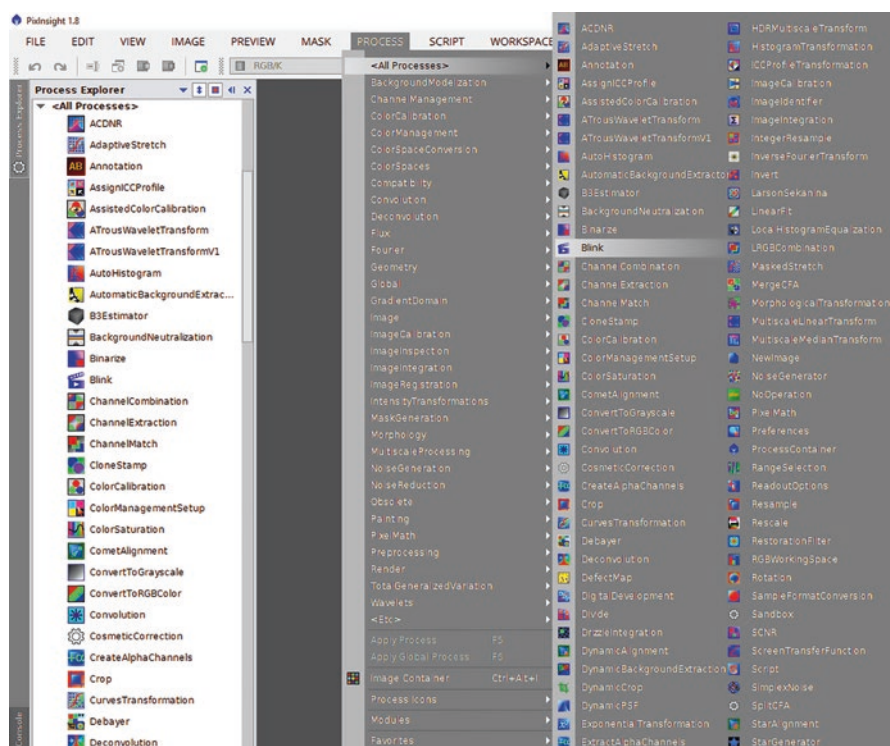


Fig. 1.1 At left (white) is the Process Explorer window. Note that Blink is listed alphabetically and available there, as well as from the All Processes menu at right (gray). Any process would also be listed under its specific submenu, in this case, ImageInspection.

Blink

Blink is a digital version of the blink comparator of old, and helps us determine whether to accept or reject exposures based on the quality of their visual appearance (Fig. 1.2). Upon opening, all of Blink's icons are grayed-out, with the exception of the folder icon at bottom-left. Click once, then navigate to, and choose the images you wish to analyze. Standard file selection conventions such as Ctrl+Click, Shift+Click, and Ctrl+A apply. Images loaded together must have the same geometry. If you used a monochromatic camera, and binned (2×2) the color images, you'll need to blink them separately from the unbinned (1×1) luminance images. When ready, click Open. You can alternatively drag and drop an entire folder to the process. Blink will load the files and enable the other control icons.

Process Console

During image load, something else happens that's hard to ignore. The Explorer Window that abruptly pops up is called the Process Console. The console is reminiscent of a DOS prompt, and while it may take some getting used to, get used to it, because, although you can delay its appearance, you can't make it go away completely. Soon, however, it will become a welcome and trusted resource, as it textually reports everything PI is doing in real-time. In this case, it provides minimal information about the files and the

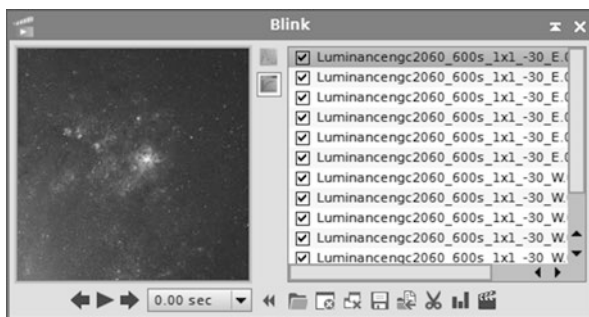


Fig. 1.2 Process Blink lets you quickly evaluate the quality of your subframes by displaying them in an adjustable, automatic continuous loop. In this way, problematic data can be easily identified and eliminated

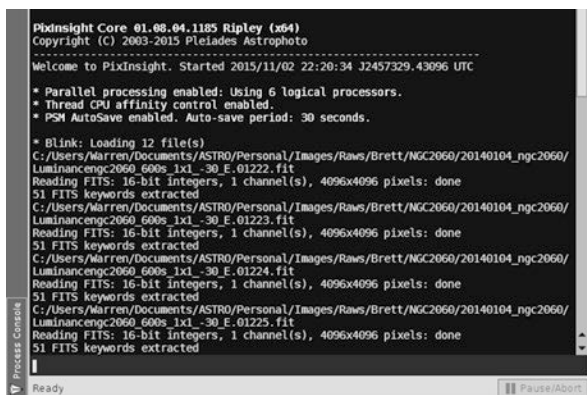


Fig. 1.3 The Process Console reports the progress of processes and scripts in real-time and other important metrics

total load time. With more complex processes, it provides vital statistics that help the user dial-in that tool's settings (Fig. 1.3).

You can increase the delay in milliseconds of the Process Console's appearance via Edit/Global Preferences/Miscellaneous Process Settings. In many situations, the console will not be displayed if a large enough delay is set.

STF: ScreenTransferFunction

In the background is an image window named BlinkScreen (Fig. 1.4). You'll note that despite the highlighted image's linear state, its visualization appears as if it had been permanently stretched in a nonlinear fashion. This is a testament to PI's ScreenTransferFunction (STF) Auto Stretch. Despite the data remaining linear (as captured by the camera), the visualization is superior to most other processing programs. It is this ability to see the data well that enables the user to perform several repair and preparatory functions before any permanent, nonlinear histogram stretch is applied. More on the STF in the next chapter.

If the contrast levels of individual images vary, double-click Blink's Compute AutoSTF button, second from the top of the dialog, to reset the visualization of the stack.

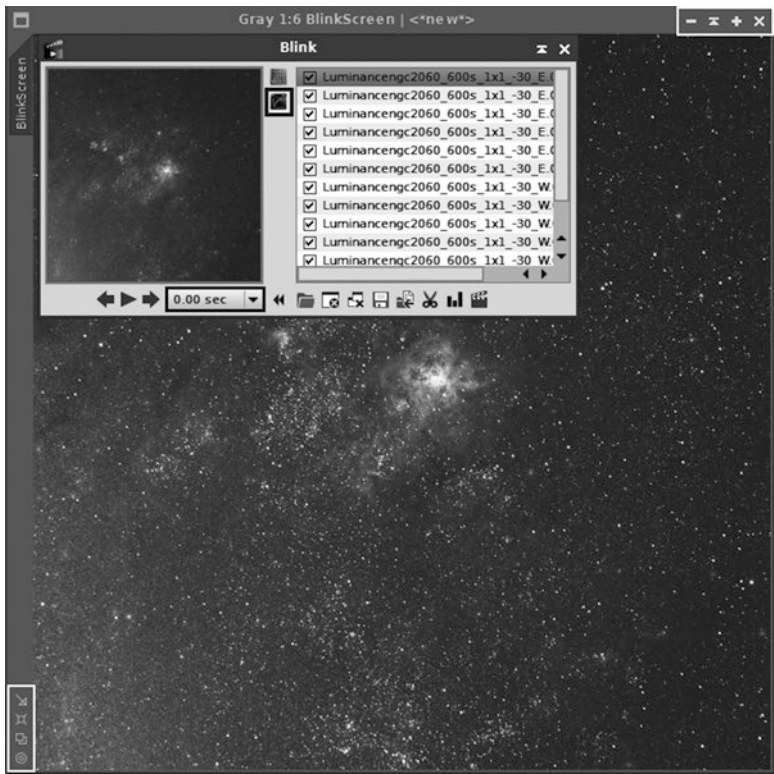


Fig. 1.4 The blue process window appears on top of the image window behind it. Note the various controls at upper-right and bottom-left of the BlinkScreen window

Helpful Hint

An image that initially appears to be very dark generally has excellent contrast and will likely have a good signal-to-noise ratio (SNR). While you can brighten up the image by resetting the temporary stretch with the Compute AutoSTF button, be aware that images with weaker contrast will then appear washed out.

You can alternatively apply a nonpermanent, automatic histogram transformation to all of the images by clicking the button at the very top. With the cursor placed in the image window, you can use the mouse's scroll wheel to zoom in for a closer examination. Hovering the cursor over an area of interest, hold down the Ctrl key while zooming to keep the area centered.