Impatience is the Mother of Invention

The Starizona MicroTouch Autofocuser

By Scott Tucker

A couple of months ago I wrote in this magazine about how technology such as CCD cameras and the HyperStar system were making astrophotography much simpler. And, while I certainly praised the fact that this made the process of imaging more enjoyable and opened up this aspect of our hobby to many more people, I may have lamented a bit the demise of the suffering that used to be required to take astrophotos. It didn't seem right that it should be so easy.

Of course, I'm not really complaining about saving time and trouble. I'm fine with not going back to suffering for astrophotos. A major nuisance of deep-sky imaging was the process of focusing. The MicroTouch Autofocuser, available in both wired and wireless models, is a powerful and precise motorized focuser that helps turn focusing from a dreaded, time-consuming, arduous task, into a simple click of a button.

The Way it Was

Thinking back to my days (or nights, rather) of film astrophotography, it never ceases to amaze me how far we've come technologically in less than a decade. My first astrophotos were focused by just looking through the camera viewfinder and hoping for the best. This resulted in some, shall we say, less than successful results. Take for instance the night I drove 150 miles to reach skies darker than the inside of a cow, only to take eight hours of out-of-focus astrophotos.

I decided that was unacceptable, although that may not have been the exact term I used at the time. So I upgraded to using a high-power loupe to magnify the image on the groundglass in the camera's viewfinder. This helped a bit, but was still a hit or miss proposition. Next was the only surefire method of focusing a film camera: the knife-edge focuser. Mine was built from an old plastic CD case, a piece of film, some tape and a couple rubber bands. And it was about as easy to use as a piece of film taped to a CD case and attached to a camera with rubber bands – which is to say, not very.

The jump to CCD technology alone was a huge leap forward in the ease and consistency of focusing. Imagine the difference between, say, trying to hit a baseball with your eyes closed versus swinging with your eyes open. Your batting average is going to go way up. With a CCD camera you can actually get feedback from the computer on the size of a star. Make the star as small as possible and you're golden. While my average went from below the Mendoza line to a perfect thousand, focusing remained tedious.

The process still necessitates focusing by hand, and there are other hassles that make it more time-consuming than necessary. Viewing the computer screen from where you can reach the focus knob isn't always easy. You have to touch the scope and that induces vibrations. You have to make a guess about the actual star size, since the values displayed change slightly due to atmospheric turbulence. In the end, it typically takes at least ten minutes to focus by hand. There's room for improvement.

Impatience Drives Innovation

Technology saves an amazing amount of time. We used to have to wait for things like dinner, film processing, pregnancy tests. Now we get instant results, although the element of suspense is lost, for better or worse.

Think of all the things that technology has made faster and easier: e-mail, for example. Remember when you used to have to walk all the way to the mailbox to get unsolicited junk? Or, consider how online dating has changed lives. You used to have take time to clean up and put on nice clothes to go to a bar. But now you can surf for prospective dates on-line from the convenience of home, while wearing a beat-up Kansas Live in Tuscaloosa 1977 T-shirt and fuzzy bunny slippers. You can't get dates in a bar in fuzzy bunny slippers (or at least it's never worked for me). The Internet has revolutionized activities as varied as the art of spreading rumors, the task of disseminating misinformation, and identity theft.

But now technology can do something you'll actually find useful! It can automatically focus your telescope. Plus it can do it better and faster than you. A process that used to take 10 to 15 minutes now requires only 30 seconds of your precious time. That means more time for you to work on deleting all your junk e-mail.

Focusing Numbers

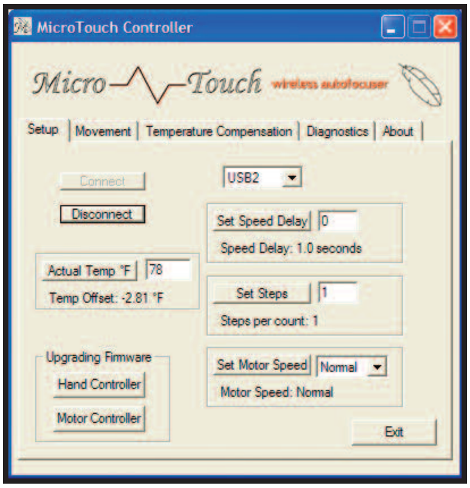
Focusing with a CCD camera, whether manually or automatically, involves the analysis of values displayed by the software controlling the camera. The basic idea is to determine the size of the star, turn the focus knob, see if the star gets smaller or bigger, and continue turning the knob to make the star as small as possible. Doing this requires going past the actual point of best focus, because you don't know what the minimum size of the star will be until you've passed it and started to make the star bigger again.

The usual value for measuring the size of a star is its full width at half max, or FWHM. Imagine a graph of the intensity of a star. A star is not a perfect pinpoint after passing through an optical system. Instead, it is brightest at its center and quickly drops off in brightness away from the center of the star image. The profile of this intensity has a bell shape, and a perfectly focused star creates a very tall, skinny bell. As the star is defocused, the bell spreads out, and the peak intensity (the top of the bell) gets lower because the light is being spread out over a larger area. The FWHM of a star is simply the width of the bell at a point halfway to the top of the bell – the full width of the star image at half its maximum intensity.

The smaller the FWHM value, the smaller the star image. Also, the maximum pixel value, or the intensity of the brightest pixel in the star image, increases as FWHM decreases due to more light being concentrated in a smaller area.

So what are the typical values of the FWHM? It depends greatly on the telescope, the seeing conditions and the CCD camera. This is why you have to pass the point of best focus to find the minimum FWHM value. Even with the same telescope and the same camera, it might be different than on a previous night due to changing atmospheric conditions.

Ideally, it would be best to focus the



telescope every time you point it to a new object. This allows correction for shifting optical components, expansion or contraction of the scope due to changes in temperature, and changes in seeing conditions. If you are manually focusing, this gets pretty old pretty quick. Technology to the rescue!

Autofocusing

The idea behind autofocusing is simple. It does the same thing you would do, only faster and more accurately. The software looks at the FWHM values (or a related value called the Half Flux Diameter, about which below) and moves the focuser to reach the minimum value. The advantages are many – not least of which is that you don't have to touch the scope and induce vibrations, and of course, the usual advantage that a computer can do math faster than you.

The real advantage of the software-driven focusing system, though, is that the computer program knows exactly how much to move the focuser to reach a given FWHM value. It does this by initially learning your telescope system. It determines how much to move the focuser to change the FWHM value by a certain amount. Then, by measuring the current focus position and the current FWHM value, it knows how much to move to reach the minimum value. Plus it knows what the minimum value should be, based on the characteristics of your system.

This is Where the Magic Happens

The MicroTouch Autofocuser is ASCOM compatible and can be controlled by a number of software packages. The focuser ships with a copy of FocusMax, software by Larry Weber and Steve Brady. This program integrates seamlessly with camera control software such as MaxIm DL to allow easy autofocusing.

FocusMax is initially calibrated to the user's telescope system. It learns how quickly the telescope focus converges on the ideal point and how much to move the focus motor to effect a certain change in focus position. Once this is known, the software simply needs to determine whether the telescope is inside or outside of focus and the size of the star image. FocusMax uses a measurement called Half Flux. This measurement is similar to FWHM but is less sensitive to factors such as seeing conditions and light pollution. After calculating the size of the star, it is a simple matter of offsetting the focuser by the correct amount to reach exact focus.

While an understanding of this procedure is useful, all you really need to know is that it works. I prefer to think of it the way I think of my car: I don't need to know the exact inner workings of an internal combustion engine. I just need to know that I can put gas into it and it will get me to a Mexican restaurant. I give it fuel, it gives me burritos. The rest is just magic. You feed an autofocuser photons and it gives you perfect pinpoint stars in less than a minute. Magic!

The entire process is amazingly fast. The focuser is moved to a starting position and a low-resolution image is taken of the full field of view. The brightest star is automatically detected. A high-resolution subframe is then taken of just the bright star. The focus is moved and the star is imaged again. The software then takes a sequence of five or six more images of the star to average out fluctuations due to seeing conditions. There is a dramatic 5-second pause when you think maybe something has gone terribly wrong. Then – abracapocus! – a perfectly focused star image appears on the screen and you can breathe again. Magic!

The MicroTouch Autofocuser

The MicroTouch was designed around the Starlight Instruments Feathertouch Focusers. These focusers are high-precision and feature 10:1 fine focus adjustments. They are available for just about any type of telescope, including popular imaging systems such as refractors and Schmidt-Cassegrains. The quality and prevalence of these focusers made them ideal for a new autofocuser system.

By driving the 10:1 fine focus shaft of the Feathertouch Focuser, the MicroTouch provides extremely high accuracy. Precision is important, especially for fast-focal-ratio imaging systems such as HyperStar. A telescope with a fast focal ratio has a very narrow depth of focus, so being able to move the focuser in tiny increments is essential to achieving exact focus. Each pulse of the MicroTouch stepper motor equals a mere 1/300th of a revolution of the focus shaft. This allows precise focusing of even the most sensitive imaging systems.

Avoiding Entanglement

Having no wires attached is a lofty ideal – just ask Pinocchio. A typical CCD imaging setup has cables for telescope control, the CCD camera, an autoguider, the focuser, and power cords for all those items, plus other accessories like a dew heater. It's only a matter of time before you trip over all those wires, hit your head, and see the wrong kind of stars.

You can get wireless phones, wireless networks, wireless Internet connections, wireless remotes for your TV, and even wireless control for your telescope. Why not a wireless focuser? Aside from the coolness factor (which is always the most important thing, I think), there is a practical side. Many imagers are starting to go

This image of the Iris Nebula was taken by Larry Moore using a HyperStar equipped Celestron C14 and Starlight Xpress SXVF-H9C one-shot color CCD camera.

remote. In the dead of winter, when the skies are clear and the temperatures are 30 degrees below comfortable, it's nice to sit inside while your telescope suffers out in the elements. Having one less cord to run from your scope to the computer simplifies things. The wireless model of the MicroTouch Autofocuser has a range of up to 300 feet.

Additional Features

The MicroTouch Autofocuser also features temperature compensation. This allows the focuser to compensate for changes in focus due to the expansion or contraction of the telescope's optics or mechanical structure. This is ideal for long-exposure imaging.

The temperature compensation, and other features such as the motor speed and direction, focus position and digital readout, wireless connection, and more, can be controlled either through the MicroTouch hand control or through the stand-alone software included with the autofocuser. Firmware updates for the hand control and motor control can also be downloaded to the autofocuser from the Starizona Web site.

Autofocusing is a perfect solution for avoiding one more of the challenges of astrophotography. Wireless connectivity adds the bonus of being able to sit inside toasty warm in the winter or out of the humid bug-filled nights of summer, at your computer in your fuzzy bunny slippers, capturing images of the universe and wondering how you ever got along without all this technological magic.

More details on the MicroTouch Autofocuser at www.starizona.com

For tips and tutorials on focusing, see the Guide to CCD Imaging at www.starizona.com/abc/ccd/ccd.aspx. This site also features a detailed discussion on the mechanics of focusing, including depth of focus, focusing for a curved field, and focusing tolerances.