Trials of the Novice
Star Hopping the Hard Way
The FOV method

Star hopping using the lens field of view (FOV), at least for me, was one of the more difficult techniques to learn. Obviously. for objects that are located very close to a naked eye object (say within 1-2 degrees), it is much easier. However, as one moves further away from naked eye objects, it becomes increasingly more difficult.

Recently, I had the experience of helping my daughter Kelsey work through a particularly difficult sequence of star hopping associated with the Universe Sampler. Within this certification, there are a few objects that are quite faint and not really close to anything. She needed to find NGC 4361 which is a magnitude 10.0 planetary nebula in Corvus. For her first attempt, she tried to locate this object by using the finder scope on an 8" SCT and basic triangulation. After two hours, she finally gave up somewhat dejected. I must admit that I also was unable to find it using this scope. Although I am sure that we could get close, we just hadn't studied the star patterns thoroughly enough to correlate the mirrored image in the lens with the rotated images in the finder scope. Since the image itself is very faint, it doesn't just "jump right out" at you when you get it in the field of view of the lens.

The next day, we sat down and prepared a very detailed star hopping plan for finding this object using our little 4.5 inch Newtonian. We decided to use this scope for several reasons:

1. With the 32mm lens, it gets a 1.5 degree FOV.
2. The unit finder is easy to use to get located on any naked-eye object.
3. The manual controls are easy to use and do a nice job of smooth movement of the OTA.
4. This scope has a limiting magnitude of 12.8 which put this nebula fairly well within the range of the scope.
5. We were in a very dark site (West Texas) and were pretty sure that we would be able to see this faint object, even in this small scope. (I wouldn't recommend trying to find such a dim object in this small a scope anywhere except a very dark site).

Here are the lessons we learned as we worked through this process.

Using a Reflector:

The reflector is quite a bit easier to use than a Schmidt Cassegrain because the image orientation within the lens is not mirrored. Normally, it will be rotated 180 degrees, but this will depend on how you have the scope setup and what angle the focusing tube makes with the horizontal (See the prior lesson on image orientation). Although, I will concentrate on the reflector here, the information also applies to a refractor if a diagonal is not in use.

First, it is absolutely essential that you have access to a good star atlas or a software program that can display an area of the sky. It is useful to be able to set a filter such that only the stars brighter than a specified magnitude are displayed. I use "The Sky – Level 1" software since I got that program free with my telescope. It has everything needed. I am not recommending this program over others, e.g.

like Starry Night Pro, because they all seem to have similar features and they are all sufficient for our purposes.

Second, you need to know fairly precisely the field of view of your lenses. This can be calculated or measured directly by experiment. Use the widest FOV lens that you have. For me, this is a 32mm lens that provides a 1.5 degree field of view when used on our 4.5 inch reflector. If you don't know the FOV of your lens on your telescope, hear is a handy website with a calculator.
http://www.csgnetwork.com/telefov.html

You can experimentally determine the actual FOV's by measuring the amount of time it takes a star (one near the Zenith and Celestial Equator) to traverse the diameter of the lens while looking through it. The earth rotates at about 15 degrees per hour (0.004167 degrees per second), so just time the transit across your lens and calculate the degrees in decimal form. There are also several references on the internet that talk about this technique in more detail. You can find them by searching on "telescope field of view"

Third , locate the closest naked-eye object to the object of interest (call this the "marker-object"). It is useful to determine as close as possible the angular separation between the marker-object and your target-object. Knowing the angular separation gives you good quick estimate of how many FOV's of the lens that you will be needing to move. The less the better obviously, as this process can be somewhat intensive for objects that have a lot of separation (more than 2-3 degrees).

Step 1: (Construct a finder-chart)

It is necessary to construct a sky map (finder-chart) that includes both the marker-object and the target-object. I really don't like to create paper documents, but for me it is necessary. Because the image in a reflector is rotated, you need to be able to rotate the finder-chart to match the orientation of the images in the eyepiece. If you have a software program that will do this, then that will work.

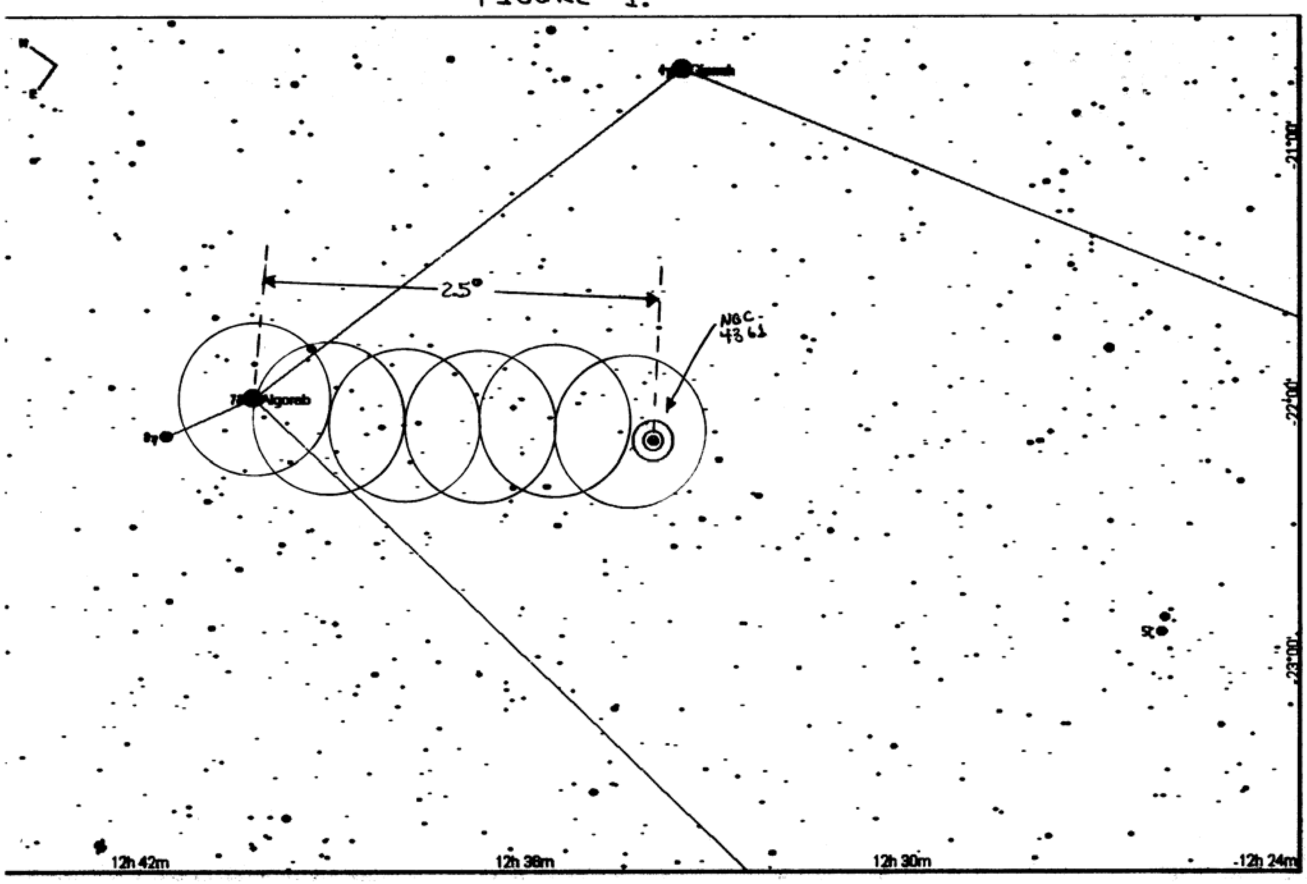
The finder-chart should include all the brightest stars between the marker-object and the target-object so that you have recognizable patterns that you can easily see. Somewhere between 8-10 magnitude should be enough, but you may have to go a little higher. Just be sure that you will be able to see them using the lowest power magnification you have (i.e. the lens with the largest true FOV). Use the brightest stars available that still allow you to have very easily distinguishable patterns. For me, I like to use geometric shapes, particularly triangular shapes and also distinctive double's that are close together with about the same magnitude so they look like "snake-eyes" on a pair of dice.

Step 2. (Draw an overlapping set of FOV circles)

Now, we need to draw onto the finder-chart an overlapping set of FOV circles so that we have a "path" of recognizable objects between the marker-object and the target-object. See Figure 1 for a sample of the one that we drew. I tend to be a bit exacting on these charts and use a compass to draw the FOV's. However, it is fairly easy to just hand draw them by estimating the diameter of the actual FOV of your lens. Just remember to overlap them enough so that from each FOV circle, you can determine the direction to move to the next pattern. You will notice that I used an FOV circle that was only 1.0 degrees in diameter to ensure that I could see everything within the FOV circle.

Study the finder-chart thoroughly. The more you have studied it, the easier it is to find the patterns!!!!

FIGURE 1.



Step 3. (Setup the scope and get ready to hop)

Now you are ready to start hopping. First we need to locate the marker-object in the eyepiece and rotate our finder-chart to match the orientation of the image in the eyepiece. Once you have it located, you should immediately recognize the edge pointing the way to the adjoining FOV circle. (If not, then you may need more stars on your chart to make your patterns easily discernible).

So, just move the telescope in that direction, no more than 1 FOV, and the next pattern should be immediately recognizable. If not, go back, and play with moving it back and forth until you recognize the next pattern. Since you have already rotated the finder-chart to match your lens image orientation, you shouldn't need to rotate the finder-chart again.

The first couple of times I did this, I had to move it back and forth a couple of times to ensure that I was properly moving to next pattern. After a little practice, it will come pretty easy.

Continue to repeat this "hop" sequence until you get to the Target-Object. Don't try to hurry it and jump ahead. I did this and got lost a couple of times. Just "plod" ahead step by step, making sure each time that you have properly located and centered the next pattern in the eyepiece. It make take you 15-20 minutes to get there for a long move, but you will get there!

Step 4. (Concentrating on the target)

Now, you have arrived at the pattern containing the Target-Object. And you have verified that the pattern is correct by matching it with your finder chart. Use the finder-chart to triangulate exactly where the object should be located within the FOV. However, if the object is quite faint, it may not jump right out at you since we are using a low power lens or a small aperture scope. You may need to concentrate on looking for a very faint object.

Some tips:

(1) Concentrate on the darkest spot in the lens FOV for a few seconds. This will help your pupil dilate even more. Now, slowly pan your eye across the FOV and look for any spots that aren't quite as dark as that dark spot you just looked at. This is a quick give-away that something is there.
(2) Use averted vision, slightly off the triangulated spot where the target should be. Sometimes people have better averted vision at specific angles from a centered object, so slowly move your eye in a circle around where the object should be but off-center so that you are using averted vision.
(3) Sometimes a slight tap on the scope, causing it to slightly wobble will reveal motion of a spot that is not quite as dark as it should be.
(4) If the object is a small one, then more magnification may help. Try increasing the magnification in small increments. Just be sure that the correct spot is in the center of the lens before switching lens.

If you aren't able to find it using this technique, then you are probably going to need a bigger aperture scope. I can tell you that we were able to find a 10.0 magnitude planetary nebula (NGC 4361) of size 1.8 arc-minutes with a 4.5 inch Newtonian using this technique. However, we were in a very dark sky location with magnitude 6+ visual skies.

Good luck, and clear skies!
Henry Norton