A METHOD FOR IMPROVED VISUAL POSITIONAL ESTIMATES OF NOVA AND SUPERNOVA CANDIDATES

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Abstract

For a faint nova or for supernova candidates in crowded star fields, accurate reporting of their locations is essential. With a modest-sized telescope, a reticle eyepiece, a good star catalogue, and a pair of reference stars, positional estimates accurate to a few arcseconds are possible using a technique adapted from photography. The uncertainty in the position can be quantified if three or more reference stars are used.

1. Introduction

If a visual nova or supernova hunter comes across a potential discovery, the star's position must be passed on to others for confirmation. Standard procedure is to plot the candidate in a star atlas, then measure the celestial coordinates as accurately as possible. This method may be accurate to an arcminute or so for novae, and in most cases this is sufficient. But if the nova or supernova is faint and located in a crowded field, ambiguity could arise, and professional resources could be wasted in examining the wrong star. This paper describes the adaptation of a technique used for measuring star positions on photographic plates. The idea is to make the measurements on the sky itself.

2. Equipment

To use this method, the observer needs a clock-driven telescope, an illuminated reticle eyepiece, and a catalogue of star positions. Estimates could be made with an unguided telescope, but they would have to be made quickly, degrading accuracy.

3. Method and measurements

The method is based on a technique for estimating the position of a star on a photograph (Fox 1988), using two reference stars of known position. Instead of using a fine scale to measure distances on a photograph, the observer uses a reticle to measure angular separations in the sky.

At least two reference stars must be found such that the distances between the reference stars and the nova/supernova candidate are less than the width of the reticle scale. Three measurements must be made: the distance between the reference stars, and the distance between each of the reference stars and the candidate star. Distance units are arbitrary; using the smallest reticle division is a natural choice. The separation between the two reference stars will be used to convert the observer's units into standard angular units later in the calculation.

One more piece of information is required to solve uniquely for the position of the nova/supernova candidate. The observer must select one of the two reference stars as the prime reference star, and determine whether the position angle of the candidate is smaller or larger than the position angle of the other reference star (position angles are referenced to the prime reference star). This relative position angle determination is made at the eyepiece.

4. Selection of the reference stars

If the observer has a choice in selecting reference stars, the best arrangement is one where lines drawn from the reference stars through the candidate star intersect at right angles. Because there is some always some uncertainty in the distance measurements, the "error box" about the candidate star will be smallest when the two "error rings" from each reference star cross at right angles.

If possible, avoid having the reference and candidate stars all in a line. The candidate star's position will be poorly constrained perpendicular to the line. Figure 1 graphically

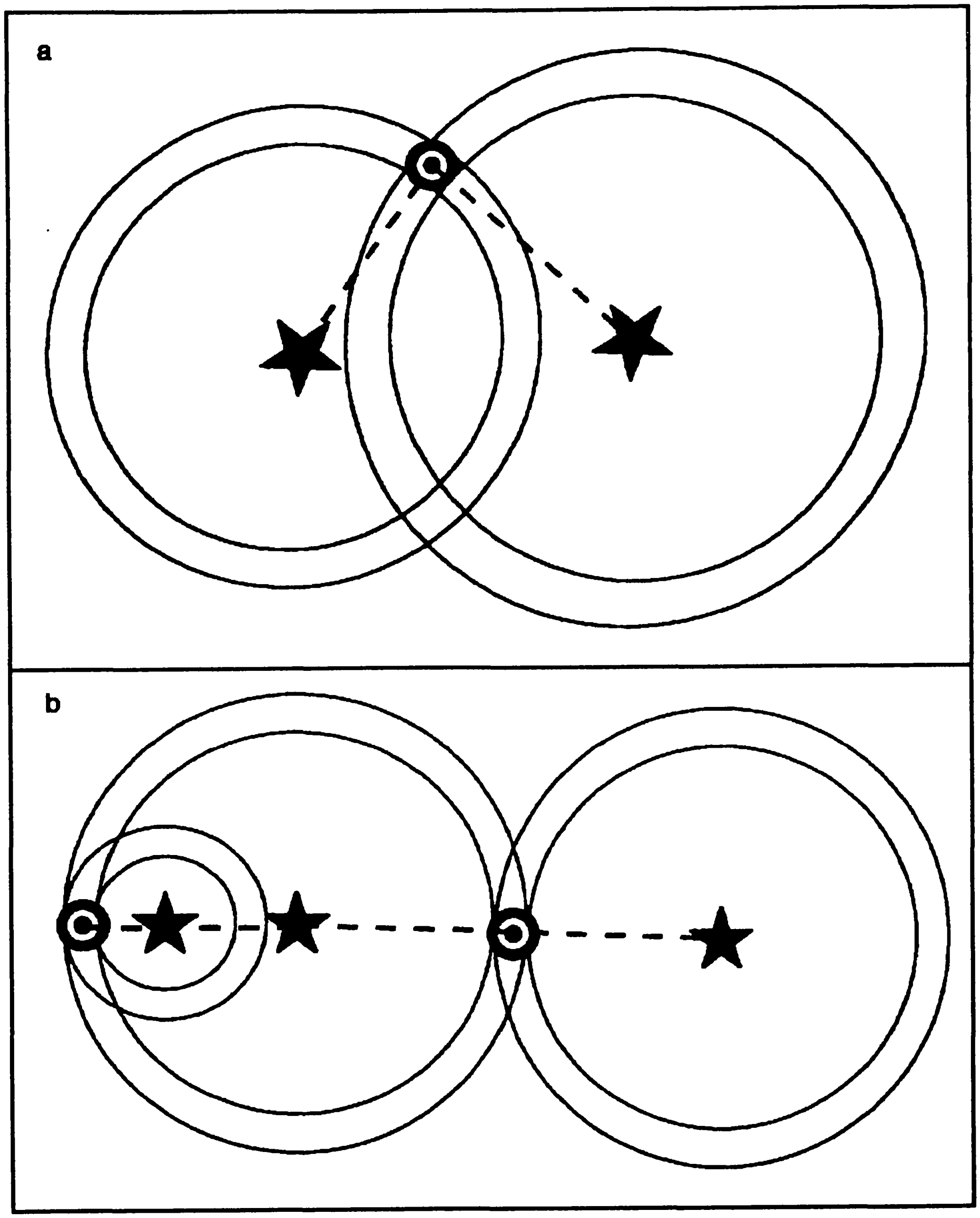

Figure 1. Top (a) shows optimally-selected reference stars (★) at right angles with candidate star (⊙). Bottom (b) shows reference stars (★) which are too close together or in a line with candidate star (⊙).

illustrates these points. Worse still is having the distance between the reference stars much smaller than the distance to the candidate star.

5. Errata

I encountered several problems with the Fox reference. First, the criterion for which of the reference stars one should use for the position angle determinations is ambiguous. Second, Fox measures angles from north through west, rather than the traditional east. Third, under some circumstances (still under investigation), the angle given by his equation (S11) must be subtracted from 360 degrees to obtain the correct answer.

6. Results

To test this method, I used a 9.8-cm Maksutov telescope with a Celestron MicroGuide 12-mm illuminated reticle eyepiece. I selected M44 (the "Beehive" cluster) to carry out the test, as it afforded numerous closely spaced, bright stars. The test pretends that one of the stars is a nova candidate, using the reference stars to estimate its position. This estimate can then be compared with the "true" catalogued position.

Figure 2 shows a plot of M44 (using Voyager II software), along with the sixth magnitude "nova" (SAO 98021) and reference stars (SAO 98032, 98024, and 98010).

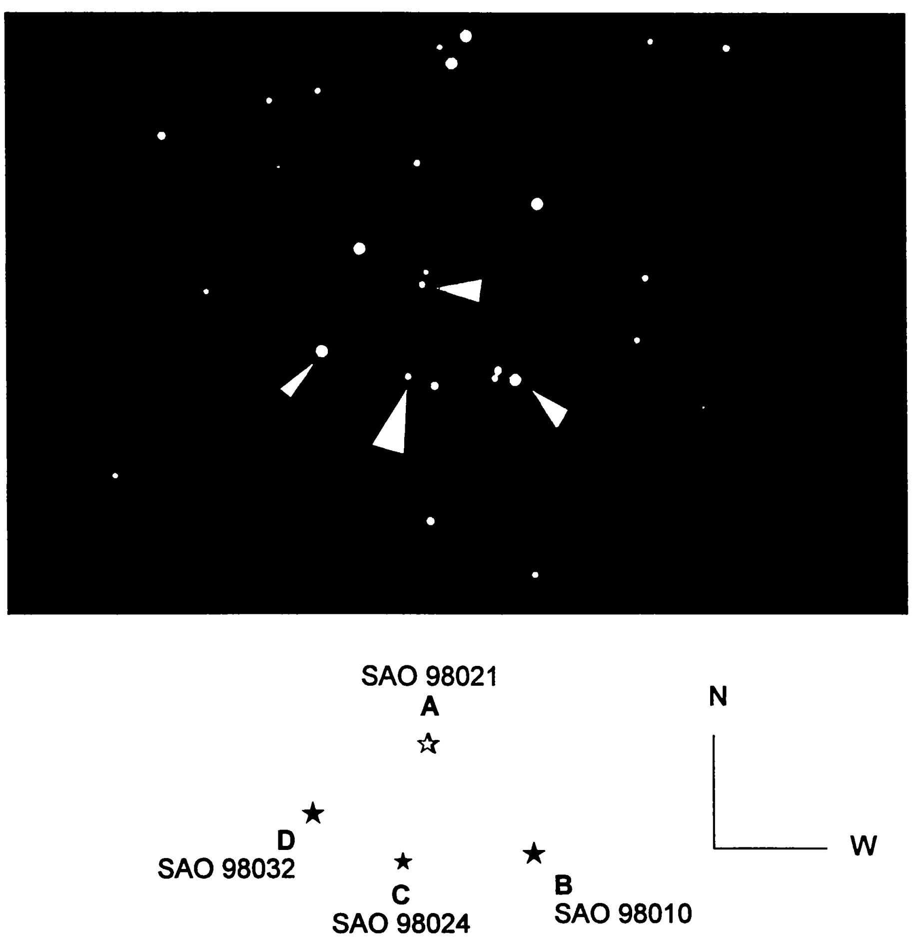

Figure 2. "Nova" candidate (A) and reference stars (B, C, D).

Three reference stars yield three estimates of the position. The average of the three positions serves as the computed position. The standard deviation gives a measure of the uncertainty of the position.

The catalogued RA (Hirshfeld and Sinnott 1982) (epoch 2000) of the "nova" was $8^h\ 40^m\ 22^s$; the estimated value of the RA was $8^h\ 40^m\ 21.0^s + 0.12^s$. The catalogued Declination was $+19^\circ\ 40'\ 11''$; the estimated value was $+19^\circ\ 40'\ 13.0'' \pm 2.1''$.

7. Future work

The method needs to be tried on more examples and with various telescopes to gauge better its strengths and limitations. The problem should be recast to use three reference stars so that no position angles need to be estimated.

8. Summary

I adapted a photometric technique for estimating positions for use by the visual observer. Even with modest equipment, positions accurate to a few arcseconds are possible. With three reference stars, quantitative estimates of the uncertainty may be made.

A listing of the C++ program used to do the calculations is available from me, along with the program on disk for Macintosh users.

9. Acknowledgements

My thanks to Randy Pepper for finding the Fox reference.

References

Fox, J. H. 1988, *Math for Amateur Astronomers*, 2nd ed. Astronomical League, Washington, DC.

Hirshfeld, A., and Sinnott, R. W. 1982, *Sky Catalogue 2000.0*. Sky Publishing Corp., Cambridge, MA.