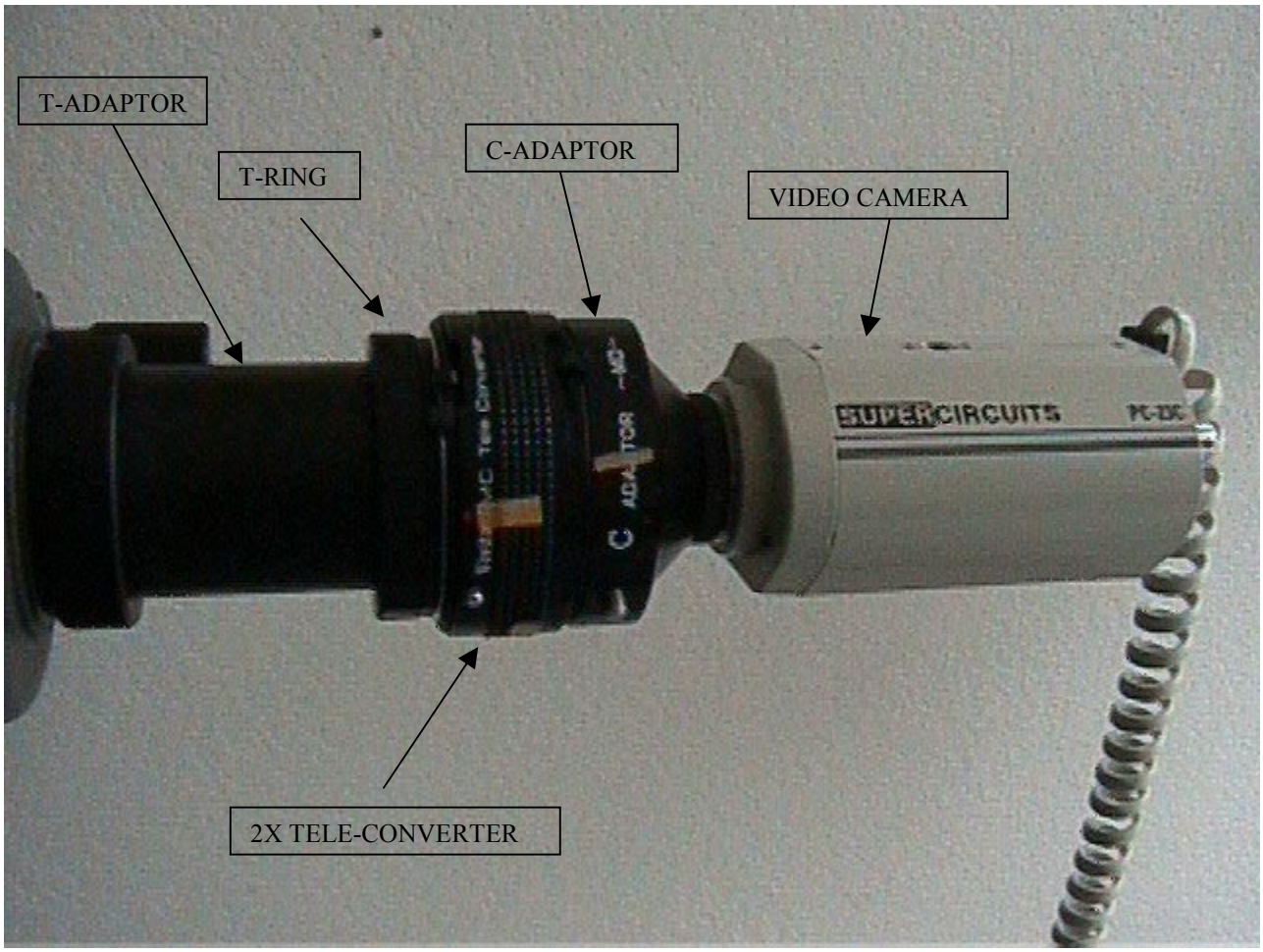
DOUBLE STAR MEASUREMENTS USING A VIDEO CAMERA

By Steve Bodin


Gamma Virgo

When I received my first telescope at the age of 12 back in the 50's, I knew little of the motions of the stars. I can remember looking at Castor and puzzling on why I could not resolve the star. After all, my Norton Star Atlas listed the double at 3.9 sec and my 60mm was capable of that. I turned my astronomical attention to the planets and deep sky. It was many years before I realized that the stars could change position in very short order. When mini-computers became available in the mid 70's I wrote a program to solve stellar orbital elements and plot the results. Castor was about 2 seconds during the mid 50's! This was a relief! So I went back to double star observing. But this time, I was going to make measurement of all the stars that I observed. A filar was out of the question; too expensive. So a calibrated reticle eyepiece was constructed; still in use today, but in the finder. I was thinking one of the methods more accurate available to the amateur on the cheap was photography, but my desire was to measure doubles near the resolving power of the telescope. Photography would not work for close doubles due to the atmosphere and it turbulence. Then the low light level video camera was invented, for the military, if I remember correctly. As with all new technology, it was too expensive. But the home burglar alarm market would change that. Now LLL cameras are available and very inexpensive.



I purchased a camera about 5 years ago with the intent of using it on double stars. Worked great, could reach 10th mag on my 8-inch Celestron SC. But I could not figure out how to convert 'pretty pictures' into real data. So back to the

planets, video works well on them too. Finally, after surfing the web one night, I ran across a video astronomy site that linked to R.J.Stekelenburg in the Netherlands who wrote a freeware program to automatically stack video frames for making 'pretty pictures' from video camera output. This is the Astrostack program mentioned in Sky & Telescope a few months ago. I fooled around with video images of doubles that I had and realized that not only could accurate video stacked images down to the scope limit of resolution be had, but also accurately timed video trails of star with the drive off could be stacked into a single image. This could then be measured to obtain the image plate scale and an accurate 270 deg direction for PA. I was in business, back to double stars in a big way. Measured about 800 this last year. This method is both fast and accurate. Appendix A and B show the accuracy.

I wrote two small programs to reduce the data obtained from Astrostack output. First is StarDrift to determine plate scale. Second is BinaryStar to measure the stacked images. Both are uploaded to the 33doubles files in zip form.

Procedure is this: First get a camera, less than $100 here. I prefer the PC-23 from Supercircuits; 0.04 lux, $89. There are procedures on the web to convert the auto-shutter to manual override. This is necessary for the close bright stars since the auto-shutter will not engage on small point sources. Could use a filter, works, but not fun swapping in and out in the dark. On a 'movable primary' type telescope, it is necessary to have a setup that is fixed behind the back end of the scope. My setup is shown, I use Minolta camera stuff, but anything is possible as long as your focal length is constant from night to night or you'll be constantly recalibrating you plate scale, also not fun.

Second: shoot some videotape. Or record directly to a computer, as that is where it needs to go anyway. I found that I prefer videotape. This is a good storage medium for the raw data holds about 200 computers' full of data on one $5 videotape. S-VHS or Hi-8 or D-video is desired for the resolving power, but standard will work.

Third: load the data onto the computer. This will depend on if you recorded directly to computer in step 2. And also on the type of video capture that your computer has. I got an ATI USB All-in Wonder for less than $100 and it works great. Load about 5-10 sec of data on the computer from 2 shots of the star. One with clockdrive ON and one with the drive OFF, for the trailed 270 deg image. Actually, I have had good luck with only trailed images of wide (>20 sec) doubles using my big DOB, since Astrostack can successfully stack moving images into the picture necessary for measuring and the trailed picture for 270 deg calibration.

Fourth: calibrate the plate scale of your telescope/ barlow/ projection/ whatever combination. This is easy, but time consuming and iterative. Record some doubles; a wide range of separations is desirable; 2 to 200 second, if possible. Turn the video camera so that the image is more or less erect. Try a dry run during the day. Then put the trailed, approximately 5 second long clips on the computer. Use Astrostack to get a trailed image at base 1x resolution. Astrostack will tell you the number of video frames that are in the image. Write this down for use in the StarDrift program. Use the BinaryStar program to measure the length on the drifted star trail in pixels; make 2-3 estimates. Type the frame count and pixel length into the StarDrift program along with star declination and, presto, plate scale in arc-sec/pixel. Make many estimates and average the results. Also plot the separation error vs. separation, I use Excel, and plot the results to correct for other non-linear errors from all of the test stars. Use the Astrostack magnification for finer resolution of tight doubles. Be sure to code your output pictures for the blowup used so that the BinaryStar program can correctly scale the picture. Always use unity magnification for the drifted image. It is length of trail that makes for accuracy here.

Now it is time to measure some stars! I typically do about a dozen a night usually in 1-2 hours. Then go back to visually looking around. That's why we do astronomy, isn't it? It still takes about 4 hours to reduce all that data the next day or when it is cloudy like now in the winter.

Links:

PC23C Camera Modification
http://www.eaglequest.com/~pgoelz/shutter.html

R.J. Stekelenburg Astronomy software
http://utopia.knoware.nl/users/rjstek/english/software/index.htm

http://www.supercircuits.com/

APPENDIX A: Calibration Doubles from WDS Database as measured by 8 inch SC

HR	MN	TNTS	DEG	MIN	CATNUM	G	WDS PA	WDS SEP	DATE	PA	SEP	SCOPE	SETUP	Sep Error	PA Error	ABS PA Error
20	37	5	+14	36	BU 151AB	1	348.2	0.568	2001.56	350	0.50	8	VID	-0.07	1.80	1.8
20	37	5	+14	36	BU 151AB	1	348.5	0.57	2001.65	349	0.54	8	VIDL	-0.03	0.50	0.5
20	37	5	+14	36	BU 151AB	1	348.9	0.573	2001.76	355	0.57	8	VID6X	-0.01	6.10	6.1
15	23	2	+30	17	STF1937AB	1	73.3	0.647	2001.35	74	0.66	8	VID	0.01	0.70	0.7
15	23	2	+30	17	STF1937AB	1	73.6	0.645	2001.39	61	0.67	8	VID	0.03	-12.60	12.6
15	23	2	+30	17	STF1937AB	1	73.6	0.645	2001.39	78	0.60	8	VID	-0.05	4.40	4.4
15	36	0	+39	48	STT 298AB	1	160.8	0.613	2001.5	168	0.63	8	VID	0.02	7.20	7.2
21	44	1	+28	45	STF2822AB	4	309.7	1.816	2001.73	309	1.81	8	VID3X	-0.00	-0.70	0.7
21	44	1	+28	45	STF2822AB	4	309.7	1.816	2001.76	309	1.90	8	VID6X	0.08	-0.70	0.7
2	2	0	+02	46	STF 202AB	4	270.4	1.814	2001.85	276	1.92	8	VID3X	0.11	5.60	5.6
2	2	0	+02	46	STF 202AB	4	270.3	1.814	2001.86	269	1.83	8	VID3X	0.02	-1.30	1.3
11	18	2	+31	32	STF1523AB	1	266.8	1.832	2001.33	269	1.63	8	VID234	-0.20	2.20	2.2
17	5	3	+54	28	STF2130AB	4	15.8	2.234	2001.61	18	2.39	8	VIDL	0.16	2.20	2.2
18	44	3	+39	40	STF2383Cc	4	81.8	2.345	2001.56	83	2.49	8	VID	0.15	1.20	1.2
18	44	3	+39	40	STF2383AB	4	349.8	2.558	2001.56	350	2.44	8	VID	-0.12	0.20	0.2
19	45	0	+45	8	STF2579AB	4	223.6	2.614	2001.65	227	2.67	8	VIDL	0.06	3.40	3.4
13	55	0	-08	4	STF1788AB	5	98.0	3.511	2001.35	100	3.51	8	VID234	0.00	2.00	2
13	55	0	-08	4	STF1788AB	5	98.0	3.511	2001.39	104	3.54	8	VID	0.03	6.00	6
18	5	5	+02	30	STF2272AB	1	145	4.102	2001.47	144	4.19	8	VID	0.09	-1.00	1
18	5	5	+02	30	STF2272AB	1	144.9	4.109	2001.5	144	4.23	8	VID	0.12	-0.90	0.9
20	46	2	+15	54	STF2725	5	10.8	6.083	2001.56	10	6.12	8	VID	0.04	-0.80	0.8
3	36	8	+00	35	STF 422	5	270	6.674	2001.86	274	6.50	8	VID3X	-0.17	4.00	4
16	14	7	+33	52	STF2032AB	4	236.2	7.041	2001.5	236	7.25	8	VID	0.21	-0.20	0.2
16	14	7	+33	52	STF2032AB	4	236.2	7.041	2001.51	237	7.21	8	VID	0.17	0.80	0.8
20	46	7	+16	7	STF2727	4	265.8	9.237	2001.56	266	9.22	8	VID	-0.02	0.20	0.2
20	46	7	+16	7	STF2727	4	265.8	9.233	2001.76	266	9.05	8	VID6X	-0.18	0.20	0.2
													AVG	0.02	1.17	2.57
													SIGMA	0.11	3.75	2.93
													MAX	0.21		12.6

Appendix B: Plots of Accuracy of Video Double Measurements