Measurement of Double Stars Using Webcams 2011 and 2012

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Abstract: A description is given of the equipment and software used to image and measure 97 different double star systems. A summary of these measurements is provided.

Introduction

Measuring double stars using webcams has been demonstrated and well documented by others. The equipment and software necessary to measure double star separations and position angles were assembled using prior Journal of Double Star Observations (JDSO) papers as a guide. Following is a description of the equipment and software used to image and measure 97 different double star systems. A total of 224 measurements were completed during 2011 and 2012.

Equipment and Software Used

CCD Cameras

Four different CCD cameras were used to collect the data presented here. All of the cameras used could be considered "webcams", having a USB computer interface and live view capability. Video data were captured and saved in an Audio Video Interleaved (AVI) format. Frame rates used varied, depending on the subject star's magnitude, f-number of the optical system, and sensitivity of the camera being used. Typical frame rates were between 5 and 60 frames per second.

Initially, imaging was done using one of three low cost cameras. These were the Celestron Neximage, Phillips Toucam, and Logitech Fusion webcams. The stock Neximage camera fit into a standard 1¼" focuser and required no modification. Both the Toucam and Fusion were modified for astronomical imaging use. Their lenses were removed and they were fitted with 1¼" nose piece adaptors. Double stars as faint as magnitude 8 could be imaged using these cameras when combined with a fast 6" f/5.6 Newtonian with no Barlow lens. At higher f-numbers, f/12, magnitude 7 stars or brighter could be captured. Above f/12, stars of magnitude 6.5 or brighter could be imaged. Despite the limitations of these cameras, a significant number of double stars were imaged using the Neximage, Toucam, and Fusion cameras. Later these webcam cameras were replaced with a more sensitive Imaging Source camera. Good results were achieved using the Imaging Source camera with the ICX618 CCD monochrome chip. Magnitude 8 stars were imaged at relatively high f-numbers using this monochrome camera. The Imaging Source camera was combined with a small homemade 4" f/29 Schiefspiegler telescope to provide acceptable images even with separations as close a 2 arc-seconds.

Observing List

An observing list matching the limitations of the webcam cameras was prepared. Skytools 3 was used to prepare a "webcam-able" list. A search of the Skytools' database produced a list containing more than 150 double stars. All of these became candidates for webcam imaging. To date, however, only 97 have been imaged and measured. The webcam-able list included

only those double stars with both major and minor stars brighter than magnitude 8. In addition, separations of 3 arc-seconds or greater were selected for the initial observation, given typical seeing conditions in New Jersey. It should be noted that many of the tighter doubles with faint minor stars could not be imaged until the more sensitive Imaging Source camera was acquired.

Laptop Computer

A laptop computer was used to control each camera and to capture the AVI files via a USB interface. In addition, the laptop was used to control an Orion Sirius German equatorial mount (GEM) using Skytools with Realtime, ASCOM, and EMOD plugins.

Portable Mass Storage

An external hard drive was used to store the AVI files as they were recorded. The older laptop used for imaging had a small internal hard drive that could not support one night's imaging.

Telescope and Barlow Lenses

Three different telescopes were used during 2011 and 2012. Double stars were imaged using a homemade 6" f/5.6 Newtonian during 2011. Two different Barlow lenses, 2x and 3x, were used when needed to improve the image scale of this fast Newtonian. A 6" f/12 Newtonian was constructed by the end of 2011. Later, in May of 2012 the construction of a 4" f/29 Schiefspiegler was completed. It was used for imaging during the second half of 2012.

German Equatorial Mount

A medium duty Orion Sirius German Equatorial Mount (GEM) was used for all data collection. The GEM was controlled by a laptop computer as noted above.

Software

AMCap and IC Capture – AVI File Capture Software

The Imaging Source camera was supplied with capture software, IC Capture. AMCap was used with the other three webcam cameras.

Skytools 3 – Webcam List Creation, Logging and GEM control

Skytools 3 is multifunctional software for observation planning, and logging. Skytools was also used to control the GEM mount during each imaging session.

Reduc – Post Processing Software

Reduc was used to determine the position angle and separation of each double star imaged. Reduc performed a drift analysis using the "drift" AVI file to determine the camera orientation. Each "drift" AVI was recorded with the telescope mount stopped and not tracking. The subject star "drifted" across the CCD chip of the camera, documenting a different star location in each consecutive frame of the drift AVI file, essentially recording the rotation of the earth about its own axis.

Although Reduc can be calibrated for any telescope, Barlow lens, and camera combination using a calibration double star, this option was not used. Instead, image scales were determined from star drift data using LiMovie as explained below. The image scale for each optical system was input directly into Reduc once determined using LiMovie.

LiMovie – Image Scale Estimation

LiMovie is freeware that was written to assist in the measurement of occultations. It was used to determine the image scale of each telescope, camera, and Barlow lens combination using drift AVI files. LiMovie tracked the subject star's drift, frame by frame, reporting its pixel position in x and y coordinates for each frame. A comma delimited file containing these frame-by-frame pixel positions was exported from LiMovie. The comma delimited file was opened using Excel for analysis.

The first and last star locations were used to determine the total number of pixels the star drifted. The frame rate of the AVI and the total number of frames was used to determine the total elapsed time of the trial. Using the Declination of the subject star, the image scale of the combined camera, Barlow lens, and telescope system was calculated as follows:

Image Scale = (15*t*Cosine(Dec))/Pix

in arc-sec/pixel, where:

t = Total elapsed time in Seconds
DEC = Declination in degrees
Pix = Length of Star Trail in pixels

Registax – Imaging Stacking and Enhancement

Registax was used for stacking the individual frames of the AVI file recorded with the GEM tracking. Stacking is a common method used to improve the signal to noise ratio, thus producing an improved image. Registax has an image quality assessment routine that selects the good frames captured between periods of bad seeing. Registax aligned and stacked each good frame, producing a final jpg image of the double star system. Registax was also used to stack drift AVI files,

producing an artificial star trail image.

The star trails point westward. Reduc uses this fact during its Drift analysis of each artificial star trial image. In addition, the star trail image was used to determine the double star's correct orientation as it was copied onto the record-plate. See an example of a record-plate in Appendix B.

VirtualDub – AVI Editing and Conversion

On occasion, captured AVI files required some editing. When needed, VirtualDub was used to shorten and/or copy AVI files. AVI files recorded by the IC Capture software were not compatible with the Reduc software. However if each file was copied and resaved using VirtualDub, Reduc would accept and process the copied version without complaint.

Paint.net – Imaging Editing and Plate Preparation

Paint.net was used to edit and enhance the quality of the double stars imaged. Techniques similar to those employed to enhance deep sky object images were used to improve each double star image. Enhanced double star images were copied into a record-plate to permanently document the recorded image. In addition, the measured separation and position angle and other information such as its Right of Ascension (RA) and Declination (Dec), the date recorded, and equipment used was added to the record-plate. See an example of a record-plate in Appendix A.

Double Star Observation and Imaging

Each double star observation included recording a total of four AVI files. Two were captured with the GEM tracking at a sidereal rate, and two "drift" AVI files were recorded with the GEM stopped and not tracking. Frame rates used varied depending on the subject star's magnitude, f-number of the optical system, and sensitivity of the camera being used. Typical frame rates were between 5 and 60 frames per second.

As each double star was imaged, a log of each observation was recorded using Skytools' logging feature. These logs included the seeing and transparency conditions at the time of the observation, the date, equipment, Barlow lens employed (if any), the direction of the drift, and general description of the relative magnitudes and separation of the major and minor stars.

Post Processing

Post processing of the four AVI files recorded for each double star was completed as follows:

One of the two AVI files recorded with the GEM tracking was stacked and enhanced using Registax to create an image of the double star in jpeg format. Registax was also used to stack one of the drift AVI files, producing an artificial star trail image. The star trail image was saved in both bitmap and jpeg formats.

The jpeg version of the star trial image was used to rotate and orient the final double star jpeg image on the record-plate, as noted above. The bitmap version of the star trail image was used by Reduc to establish the image angle for the double star being analyzed. The two AVI files recorded with the GEM tracking were then separated into individual bitmap images using the AVI-to-bitmap conversion routine within Reduc. These individual bitmap images were processed by Reduc to determine each separation and position angle.

The measured separations, position angles, and all other relevant information were recorded in an Excel file.

Final Data Records

Table 1 (following page) provides a summary of the observations made during 2011 and 2012. Appendix A shows a printer friendly positive, as well as a negative record-plate of one of the observations. These plates were made as a record for each observation.

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Table 1: Summary of Double Star Observations, 2011 and 2012

RA+DEC	Discoverer	Sep	PA	Date	N	Remarks
00026+6606	STF3053AB	15.20	71.960	2011.710	2	HR9094
00491+5749	STF 60AB	13.28	322.15	2011.710	2	Achird
01001+4443	STF 79	7.75	195.22	2011.857	4	HR 283
01057+2128	STF 88AB	29.66	160.48	2011.767	2	Psi 1 Psc
01137+0735	STF 100AB	23.00	63.26	2011.767	2	Zeta Psc
01496-1041	ENG 8	184.52	250.73	2011.767	2	Chi Cet
01536+1918	STF 180AB	7.41	0.11	2011.997	2	Mesarthim
01562+3715	STFA 4AB	203.15	297.48	2011.767	2	56 And
01580+2336	H 5 12AB	37.40	47.47	2011.767	2	Lambda Ari
02039+4220	STF 205A-BC	10.07	64.67	2011.767	2	Almaak
02128-0224	STF 231AB	16.80	234.12	2011.767	2	66 Cet
02358+3441	AG 304	142.59	16.82	2011.767	2	15 Tri
02507+5554	STF 307AB	29.23	299.84	2012.494	4	Miram
03009+5221	STF 331	12.04	84.95	2012.022	6	HR890
03543-0257	STF 470AB	6.91	351.13	2011.997	2	32 Eri
04226+2538	STF 528	19.22	24.29	2012.494	4	Chi Tau
04254+2218	STF 541AB	344.48	173.94	2011.997	2	Kappa 1 Tau
04287+1552	STFA 10	341.19	347.18	2011.997	2	Theta 2 Tau
04306+1612	LDS2246	253.95	130.42	2011.997	2	HR 1427
04320+5355	STF 550AB	10.60	308.02	2012.991	2	1 Cam
04393+1555	STFA 11	444.07	194.39	2011.997	2	Sigma 2 Tau
04422+2257	S 455Aa-B	63.77	213.46	2012.494	4	Tau Tau
05061+5858	STFA 13AB	180.16	10.34	2011.997	2	11 Cam
05228+0333	STF 696	31.99	29.72	2011.997	2	23 Ori
05322+1703	STF 730	9.53	139.42	2011.997	2	HR 1847
05354-0525	STFA 16AB	51.99	92.84	2012.170	2	Theta 2 Ori
05354-0555	STF 752AB	11.61	140.71	2012.170	2	Nair al Saif
06090+0230	STF 855AB	28.98	113.57	2012.170	2	HR 2174
06116+4843	STF 845	7.48	357.78	2011.997	2	41 Aur
06238+0436	STF 900AB	12.22	28.42	2012.170	2	Epsilon Mon
10084+1158	STFB 6AB	175.21	307.05	2012.381	2	Regulus
10433+0445	STF1466AB	6.73	239.65	2012.381	2	35 Sex
10556+2445	STF1487	6.71	112.49	2012.381	2	54 Leo
12021+4303	FOR 1AB	273.55	61.98	2012.381	2	67 UMa

Table 1 continues on next page.

Measurement of Double Stars Using Webcams 2011 and 2012

Table 1 (continued): Summary of Double Star Observations, 2011 and 2012

RA+DEC	Discoverer	Sep	PA	Date	N	Remarks
12351+1823	STF1657	20.05	270.39	2012.381	2	24 Com
12492+8325	STF1694AB	20.93	323.85	2011.777	2	HR 4893
12560+3819	STF1692	19.20	229.40	2012.381	2	Cor CAROLI
13101+3830	STFA 24AB	275.61	296.28	2012.381	2	17 CVn
14407+1625	STF1864AB	95.77	185.35	2012.498	4	Pi 1 Boo
14450+2704	STF1877AB	3.42	340.87	2012.575	2	Izar
14514+1906	STF1888AB	6.65	301.19	2012.575	2	Xi Boo
15141+3147	STT 292	118.15	157.27	2011.641	2	HR5674
15156+3319	STFA 27	103.88	77.69	2012.381	2	Delta Boo
15245+3723	STFA 28a-BC	107.64	170.75	2011.639	2	Alkalurops
15387-0847	STF1962	11.79	190.52	2011.639	2	HR5816
15394+3638	STF1965	305.99	6.45	2011.625	2	Zeta 2 CrB
16081+1703	STF2010AB	26.79	13.32	2011.641	2	Mirfak
16081+1703	STF2010AB	27.01	14.14	2011.64	2	Kappa Her
16147+3352	STF2032AB	7.25	237.87	2011.625	2	Sigma CrB
16224+3348	STFA 29AB	354.69	164.20	2011.63	2	Nu 1 CrB
16362+5255	STFA 30AC	89.78	193.94	2011.641	2	17 Dra
16406+0413	STFA 31Aa-B	229.25	69.38	2011.625	2	37 Her
17037+1336	STFA 33AB	305.59	116.57	2011.625	2	HR6341
17053+5428	STF2130AB	2.50	6.85	2011.641	2	Mu Dra
17146+1423	STF2140Aa-B	5.76	99.98	2011.639	2	Rasalgethi
17150+2450	STF3127Aa-B	12.52	288.48	2012.059	5	Sarin
17237+3709	STF2161Aa-B	4.21	320.37	2011.639	2	Rho Her
17322+5511	STFA 35	61.99	310.44	2011.611	2	Kuma
17419+7209	STF2241AB	29.95	16.45	2011.611	2	Dsiban
17419+7209	STF2241AB	29.98	15.84	2011.665	4	Psi 1 Dra
18002+8000	STF2308AB	19.27	232.11	2011.767	2	41 Dra
18015+2136	STF2264	6.54	259.34	2011.640	3	95 Her
18055+0230	STF2272AB	6.56	129.42	2011.705	6	70 Oph
18078+2606	STF2280Aa-B	13.80	179.93	2011.640	3	100 Her
18443+3940	STFA 37BC	210.87	171.82	2011.607	4	Epsilon 1 Lyr
18455+0530	STF2375Aa-Bb	2.91	114.85	2012.805	2	HR7048
18465-0058	STF2379Aa-B	12.64	122.31	2011.611	2	5 Aql
18501+3322	STFA 39AB	45.44	148.72	2011.641	2	Sheliak
18512+5923	STF2420AB	36.38	318.01	2011.611	2	Omicron Dra

Table 1 concludes on next page.

Measurement of Double Stars Using Webcams 2011 and 2012

Table 1(conclusion): Summary of Double Star Observations, 2011 and 2012

RA+DEC	Discoverer	Sep	PA	Date	N	Remarks
18562+0412	STF2417AB	22.43	103.97	2011.611	2	Theta 1 Ser
19050-0402	SHJ 286	39.35	209.63	2011.611	2	15 Aql
19121+4951	STF2486AB	7.29	206.14	2012.190	4	HR7294
19153+1505	STTA178	89.13	267.03	2011.611	2	HR7300
19287+2440	STFA 42	424.37	28.33	2011.611	2	Alpha Vul
19307+2758	STFA 43Aa-B	34.81	54.78	2011.611	2	Aberio
19418+5032	STFA 46Aa-B	41.50	127.76	2012.190	4	16 Cyg
19546-0814	STF2594	169.80	36.95	2011.767	2	57 Aql
20136+4644	STFA 50Aa-C	60.13	164.13	2011.665	4	31 Cyg
20145+3648	ENG 72AB	213.95	158.91	2011.576	2	29 Cyg
20210-1447	STFA 52Aa-Bb	208.83	266.85	2011.767	2	Dabih
20299-1835	SHJ 324	22.49	237.25	2011.767	2	Omicron Cap
20410+3218	STF2716Aa-B	3.54	51.63	2012.731	2	49 Cyg
20467+1607	STF2727	9.54	266.40	2011.751	4	Gamma 2 Del
20585+5028	STF2741AB	1.96	30.43	2012.731	2	HR 8040
21069+3845	STF2758AB	31.91	150.63	2012.036	6	61 Cyg
21287+7034	STF2806Aa-B	13.88	248.93	2011.641	2	Alfirk
21434+3817	S 799AB	148.51	59.65	2011.576	2	79 Cyg
21520+5548	STF2840AB	17.77	196.14	2011.576	2	HR8357
22038+6438	STF2863Aa-B	8.18	279.65	2011.579	2	Alkurhah
22038+6438	STF2863Aa-B	8.51	273.34	2011.71	2	HD 209790
22288-0001	STF2909	2.16	160.03	2012.89	2	Zeta 1 Aqr
22359+3938	STF2922Aa-B	22.53	184.85	2012.24	4	8 Lac
23052-0742	STFA 59AB-C	257.62	149.24	2012.00	2	83 Aqr
23191-1328	STF2998Aa-B	12.57	349.16	2012.89	2	94 Aqr
23248+6217	H 6 24AB	96.13	225.67	2011.71	2	4 Cas
23460-1841	H 2 24	7.45	131.53	2012.89	2	107 Aqr
23590+5545	STF3049AB	3.48	327.93	2011.71	1	HD 224572

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Appendix A