Analysis of Camera Delay Corrections for use in R-OTE and Occular occultation timing extraction programs

By Tony George
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Abstract

A study of internal camera delay corrections provided by Gerhard Dangl in his website at http://www.dangl.at/ausruest/vid_tim/vid_tim1.htm#methodes was performed to determine their suitability for use in the occultation timing extraction software programs R-OTE and Occular when processing integrated camera Limovie or Tangra .csv files. The analysis found that the documented diagram delays were useful and resulted in appropriate corrections, but the correction tables did not. The correction table, when used with R-OTE and Occular produced corrections that were in error by approximately one half. This is likely because the tables were produced for correction of manually reduced times where the time is derived from the middle-of-integrated-bin. Both R-OTE and Occular derive times from the start-of-integrated-bin. In addition, correction tables used by John Talbot in the Excel spreadsheet report used in OccultWatcher were derived from the Gerhard Dangl correction tables. The OccultWatcher Excel report spreadsheet corrections and are also in error by approximately one half when used for R-OTE or Occular derived times from integrating camera. A new table of corrections for use with R-OTE and Occular are provided.

The following is a study of camera internal delay correction tables provided by Gerhard Dangl in his website http://www.dangl.at/ausruest/vid_tim/vid_tim1.htm#methodes . To study camera delay issues, we need to have a data file that is precisely time stamped with video time inserter (VTI) time stamps that are delayed according to Gerhard Dangl's measurements, and the data file should also contain an occultation light curve with a known disappearance and reappearance time. Such a data set cannot be achieved from a real world occultation, as the true times of the event are never known. So, for this study, I created a synthetic data .csv file with an exact camera internal time stamp delay as specified in Gerhard Dangl's camera delay tables superimposed on a known light curve with known disappearance and reappearance times. Once the file is created, it can be analyzed with R-OTE and Occular to see if the corrections shown in Gerhard Dangl's tables should be applied to get agreement with the times derived from the light curve analysis programs.

The WAT910HX camera was selected for this analysis, as that is the camera I use for most occultations. It has integration capability and requires internal camera delay corrections as per Gerhard Dangl's analysis. For this study, a camera mode of X64 (64-field integration) was selected for analysis.

Camera Delay Analysis Parameters

Here is the camera delay analysis data provided for the WAT910HX at X64 mode of operation.
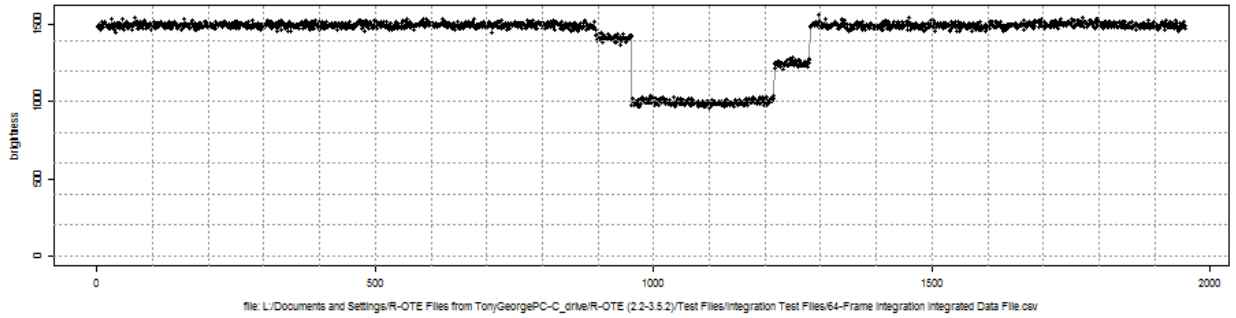
In the above table of camera delay for the WAT910HX the following points apply to the diagram for clarification:

1. The 'Real time segment' line is the field number in real time
2. The rows labeled 'Camera odd field exposure sequence' and 'Camera even field exposure sequence' show what is being recorded inside the camera in real time. Camera fields labeled O1 and E1 contain the same video field exposure image and therefore show the same exposure value for all 64 fields of the integration
3. The line labeled 'Contents of camera output field sequence' shows the output of the camera at the field level in real time
4. The line labeled 'VTI time stamping of output fields' shows the real time VTI time stamp that is applied to the output field in real time. In this example, the VTI time stamp of output field O1 (exposed at real time segment 1) is stamped with VTI time stamp for field 65 and is output at the real time of field 66.
5. The line labeled 'VTI time correction … in field resolution' provides a recommended correction if fields are measured in Limovie and then shows the equivalent real time VTI time stamp on each of the fields output from the camera.
6. The line labeled 'VTI time correction … in frame resolution' provides a recommended correction if the frames are measured in Limovie or Tangra, and then shows the equivalent real time VTI time stamp on each of the frames output from the camera.
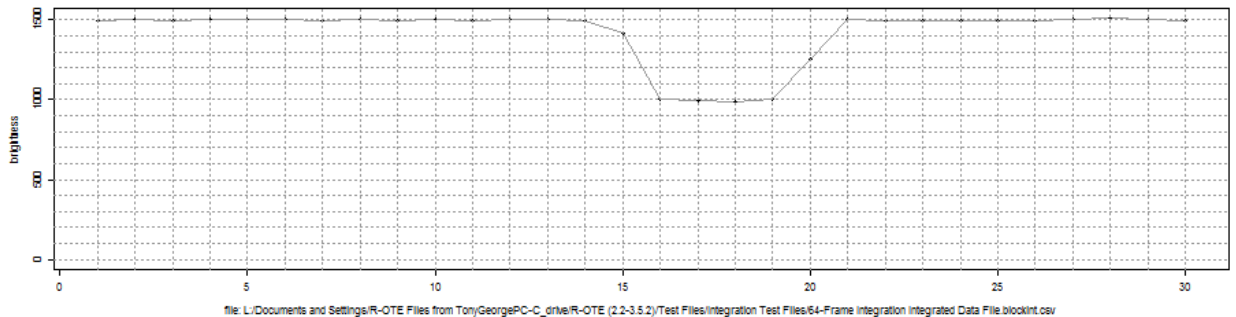
Based on the above, for this study, a field delay of 64 fields was used to generate the synthetic data file. This is derived from the fact that the O1 field recorded at time t1 in the camera is output with VTI time stamp 65 – a difference of 64 fields.

The synthetic light curve file was generated as follows:

1. A synthetic real time line was created at the field level, starting at time 10.000 seconds and incrementing at the rate of 1.001/60 seconds – the NTSC rate for fields
2. A second time line was created with a 64-field 'delay' as documented in Gerhrad Dangl's anslysis of camera delay for the WAT910HX integrating at mode X64. In this second time line, the first field is labeled with the time stamp 11.0677333 seconds, a time equivalent to a 64-field delay
3. A synthetic occultation light curve was created with the R-OTE sample generator. The occultation was set with real time values as follows:
   a. There were 1955 total readings in the synthetic file
   b. Disappearance = field 950 = 25.832 seconds
   c. Reappearance = field 1250 = 30.838 seconds
   d. D and R fields were arbitrarily selected. The event times were taken directly from the synthetic real time line for the fields selected for D and R
   e. Intensity of star = 500, intensity of asteroid = 1000, baseline noise = 50, and event noise = 50
   f. True SNR = 500/50 = 10, so the event is going to be quite obvious – an effort to test the delay correction rather than inject noise to confuse whether or not the delay correction is working correctly. Other tests could be done with more noise added, however, that is not the focus of this study.
   g. The light curve was generated with a 64-field integration, with readout noise of 15 within each integrated block. This was an arbitrary amount of noise added to the integration blocks to make the light curve look similar to real light curves.
   h. The synthetic light curve appears as follows:

file: L:/Documents and Settings/R-OTE Files from TonyGeorgePC-C_drive/R-OTE (2.2-3.5.2)/Test Files/Integration Test Files/64-Frame Integration Integrated Data File.csv
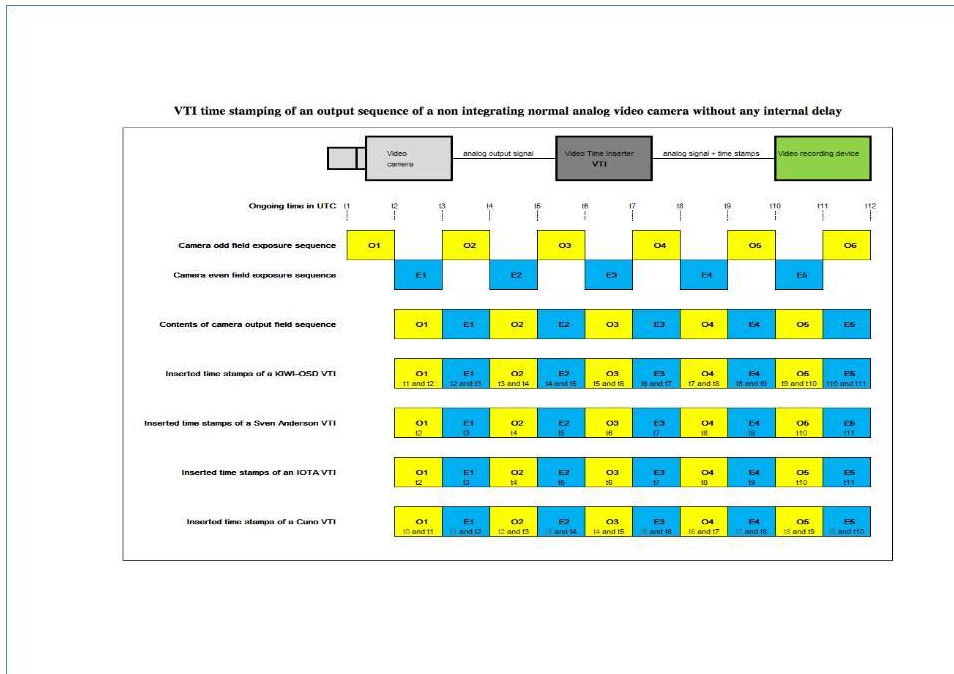
4. The synthetic light curve was concatenated into an R-OTE csv file format, using the 64-field delay time line with the 'real time' occultation light curve.
5. The concatenated .csv file was opened in R-OTE and analyzed to derive the D and R times that would be obtained from the synthetic file similar to a real file with 64-field camera delay time stamps.
    a. Time stamps were processed to associate a time stamp with the start of the first field. A timedelta (the duration of each field) was set at 1.001/60 or 0.0166833333 seconds pre field.
    b. The time line was checked for data continuity. No time line errors were found, validating that the synthetic file was created correctly.
    c. The file was block integrated by a factor of 64 readings (to agree with apparent 64-integration present in the data file)
    d. The block-integrated light curve appears as follows:

file: L:/Documents and Settings/R-OTE Files from TonyGeorgePC-C_drive/R-OTE (2.2-3.5.2)/Test Files/Integration Test Files/64-Frame Integration Integrated Data File.blockInt.csv

The results of the analysis of the synthetic 64-field block-integrated light curve are discussed in the Results section below.

VTI Correction

In addition to internal camera delay corrections, there is also a correction that needs to be applied to the VTI time stamp depending on which VTI is used and how the VTI time stamps are recorded by Limovie and/or Tangra. The following diagram from Gerhard Dangl demonstrates this issue. In the top row, a hypothetical time line starting at time t1 shows the exposures of each field O1 and E1 and then in the rows below, the VTI time stamps that are actually applied on the O1 and E1 fields as they come out from the camera.

VTI time stamping of an output sequence of a non integrating normal analog video camera without any internal delay

R-OTE requires the t1 time (the start time of each field) be input to the program to get accurate event times for measure disappearance and reappearance of the occultation. Some VTIs output a time that is 1-field late, that is, the t2 time is stamped on the O1 field, instead of the t1 time. The IOTA and Sven Anderson VTIs are examples of this. The KIWI VTI stamps the O1 field with t1 and t2 times, however, both Limovie and Tangra records the t2 time in the .csv file output, so a delay is also necessary for a KIWI VTI. As a consequence, .csv files recorded with these VTIs and reduced with R-OTE require and 1-field correction be applied. This correction will not be applied to this study, however, as no VTI delay in the time stamp is assumed in the synthetic data set.

Occular requires the t2 time be input to the program to get accurate event times. For most .csv files, not VTI delay correction need be applied to Occular derived times.

Results

Below is the table of results. The 'true time' of the occultation disappearance and reappearance is shown in Column 2. The uncorrected measured disappearance and reappearance times for R-OTE and Occular are shown in Columns 3 and 4. The field correction to the measured times recommended by Gerhard Dangl are shown in Column 5. The measured times were corrected using various options including Gerhard's recommended correction, Gerhard's recommended correction X 2, and a 64-field correction indicated by Gerhard's camera delay diagram. The corrected times are shown in Columns 6 – 9. The difference between the true time and the corrected measured time are shown in Columns 10 – 13. The results show that for R-OTE and Occular analysis of integrated camera results, Gerhard Dangl's recommended corrections are off by at least ½ of the full correction needed – approximately 0.508 seconds. When a 2x Gerhard's correction is applied to R-OTE results, the difference is negative – approximately 0.014 – 0.036. If a 64 field correction is applied to R-OTE results, the difference is less than for either of the Gerhard Dangl correction options, and closer to the true value. If a 64-field correction is applied to Occular results, the difference in comparable to but slightly greater than the 2X Gerhard Dangl correction. Here is the table of results:

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6 – 9				Column 10 – 13			
Event	Simulated Disappearance True Time (seconds)	R-OTE Measured Disappearance (Uncorrected) Time	Occular Measured Disappearance (Uncorrected) Time	Field Correction recommended by Gerhard Dangl (fields)	Corrected Disappearance Time Analysis (seconds)				Difference between corrected times and True Time (seconds)			
					R-OTE Correct by Gerhard Dangl correction	R-OTE Correct by 2X Gerhard Dangl correction	R-OTE Correct by 64 fields	Occular Correct by 64 fields	R-OTE Correct by Gerhard Dangl correction	R-OTE Correct by 2X Gerhard Dangl corretion	R-OTE Correct by 64 fields	Occular Correct by 64 fields
Disapperance	25.832	00:26.902	00:26.932	-32.5	26.340	25.818	25.834	25.846	0.508	-0.014	0.002	0.014
Reappearance	30.838	00:31.886	00:31.993	-32.5	31.344	30.802	30.818	30.925	0.506	-0.036	-0.020	0.087

Conclusions

Gerhard's correction tables are off by at least ½ of the full correction needed for analyses done with R-OTE or Occular. If VTI delays are considered as a separate correction, then a delay of 64-fields is observed to be the correction that produces results closest to the true time in R-OTE and Occular.

This study has provided a better understanding of how the Gerhard Dangl camera delay corrections need to be applied for R-OTE and Occular measured results. With this understanding, I have created a full table of corrections by Camera and integration setting (if applicable) appended to the end of this paper. These corrections should be applied to all R-OTE and Occular measured times produced from integrating video cameras on all future reports provided to IOTA.

Recommendations

The correction tables provided in this paper should be used by Bob Anderson to create either an automatic correction in R-OTE, or, a pop up table of corrections that the user can apply. If corrections can be applied prior to submission of results to regional coordinators, it will greatly simplify the data gathering and reporting process.

Similarly, the correction tables provided in this paper should be used by John Talbot to provide a separate correction option in the OccultWatcher Excel spreadsheet if R-OTE or Occular are used in the data reduction and corrections are not already applied to the results by the program.

Neither the correction tables in Gerhard Dangl's website, nor the current corrections provided in the OccultWatcher Excel spreadsheet report should be used with R-OTE or Occular derived times when processing integrated camera Limovie or Tangra .csv files.

The following table of corrections should be used for integrating camera delay corrections when analyzing light curves with R-OTE and Occular occultation timing extraction programs:

R-OTE Camera Delay Correction Tables

WAT-120N (CCIR); WAT-120N+ (CCIR); WAT-120N (EIA); and, WAT-120N+ (EIA)

Mode		Field Delay	Time Correction	
WAT-120N	WAT-120N+		CCIR	EIA
Off	High 1-5	2	-0.0400	-0.0334
Frame 1	Slow 1	3	-0.0600	-0.0501
Frame 2	Slow 2	5	-0.1000	-0.0834
Frame 4	Slow 3	9	-0.1800	-0.1502
Frame 8	Slow 4	17	-0.3400	-0.2836
Frame 16	Slow 5	33	-0.6600	-0.5506
Frame 32	Slow 6	65	-1.3000	-1.0844
Frame 64	Slow 7	129	-2.5800	-2.1522
Frame 128	Slow 8	257	-5.1400	-4.2876
Frame 256	Slow 9	513	-10.2600	-8.5586

WAT-910HX and WAT-910BD (CCIR) and WAT-910HX and WAT-910BD (EIA)

Mode		Field Delay	Time Correction	
WAT-910HX		Field Delay		
WAT-910BD			CCIR	EIA
No-integ -- 1/60 or 1/50		1	-0.0200	-0.0167
2X		2	-0.0400	-0.0334
4X		4	-0.0800	-0.0667
8X		8	-0.1600	-0.1335
16X		16	-0.3200	-0.2669
32X		32	-0.6400	-0.5339
64X		64	-1.2800	-1.0677
128X		128	-2.5600	-2.1355
256X		254	-5.0800	-4.2376

Mintron 12V1C-EX　(CCIR) and Mintron 12V1C-EX　(EIA)

Mode		Field Delay	Time Correction	
			CCIR	EIA
Off		0	0.0000	0.0000
2X		1	-0.0200	-0.0167
4X		3	-0.0600	-0.0501
6X		5	-0.1000	-0.0834
8X		7	-0.1400	-0.1168
12X		9	-0.1800	-0.1502
16X		15	-0.3000	-0.2503
24X		23	-0.4600	-0.3837
32X		31	-0.6200	-0.5172
48X		47	-0.9400	-0.7841
64X		63	-1.2600	-1.0511
96X		93	-1.8600	-1.5516
128X		127	-2.5400	-2.1188

PC165DNR　(EIA)

Mode		Field Delay	Time Correction	
PC165DNR　(EIA)			CCIR	EIA
No-integ		1		-0.0167
2X		2		-0.0334
4X		4		-0.0667
8X		8		-0.1335
16X		16		-0.2669
32X		32		-0.5339
64X		64		-1.0677
132X		128		-2.1355
256X		256		-4.2709

SCB-2000N   (EIA)

Mode		Field Delay	Time Correction	
SCB-2000N (EIA)			CCIR	EIA
No-integ		2		-0.0334
2X		3		-0.0501
4X		5		-0.0834
6X		7		-0.1168
8X		9		-0.1502
10X		11		-0.1835
12X		13		-0.2169
14X		15		-0.2503
16X		17		-0.2836
24X		25		-0.4171
32X		33		-0.5506
64X		65		-1.0844
128X		129		-2.1522
256X		257		-4.2876
512X		513		-8.5586

Mallincam MCH Plus Color   (CCIR) and Mallincam MCH Plus Color (EIA)

Mode		Field Delay	Time Correction	
Mallincam MCH Plus Color			CCIR	EIA
Off		1	-0.0200	-0.0167
sense up X2		2	-0.0400	-0.0334
sense up X4		4	-0.0800	-0.0667
sense up X6		6	-0.1200	-0.1001
sense up X8		8	-0.1600	-0.1335
sense up X12		10	-0.2000	-0.1668
sense up X16		16	-0.3200	-0.2669
sense up X24		24	-0.4800	-0.4004
sense up X32		32	-0.6400	-0.5339
sense up X48		48	-0.9600	-0.8008
sense up X64		64	-1.2800	-1.0677
sense up X96		94	-1.8800	-1.5682
sense up X128		128	-2.5600	-2.1355

PC164C-EX2 (EIA); SK-1004XC (CCIR); WAT-902H2 Ultimate (CCIR); and WAT-902H2 Ultimate (EIA)

Mode		Field Delay	Time Correction	
			CCIR	EIA
no-integ		0	0.0000	0.0000

NOTE:

6X		5	-0.1000	-0.0834

Red marked modes should not be used for astronomical recordings with the purpose for time or magnitude measurements. Integration time and exposure time can be different from the nominal values shown in the tables. Integrated segments contain frames with no photometric data and can result in erroneous time or magnitude measurements.