SBIG
ASTRONOMICAL
INSTRUMENTS

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Application Note
SBIG Type 3 Image File Format
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This application note describes the file formats used to save SBIG images on both the PC and and the Macintosh computers. The files contain the image data as well as header information describing the image in terms of exposure time, telescope, etc. The files come in two varieties: Compressed and Uncompressed. In addition the file format has evolved throughout the development of these CCD cameras and has finally settled down to the "Type 3" format described herein.

Type 3 Format

The Type 3 format starts with a 2048 byte header of ASCII information followed by the image data in one of two varieties: Compressed or Uncompressed. The ASCII information for Type 3 files consists of a line showing the type of camera used to acquire the image and the variety of image data (Compressed or Uncompressed) as shown in the example below:

XXX Compressed Image<lf><cr>
or
XXX Image<lf><cr>

where <lf> and <cr> represent the linefeed (hex 0A) and carriage return (hex 0D) characters. The XXX at the front of the first line can be "ST-6", "ST-4X", ST-5", "ST-7", "ST-8", "PixCel255", "PixCel237","ST-9", "ST-1K", "ST-10", "ST-2K", "STV" or a generic "SBIG"[1]. After the 1st line are several lines of parameters in the format:

Parameter = Value<lf><cr>

where "Parameter = " is a string describing the parameter and "Value" is a string containing the value of the parameter. If the parameter represents a string, like the Note parameter, as opposed to a numeric value, like the Exposure parameter, then empty strings are written as a single "-" (dash) character.

At the end of all the parameters is the line:

End<lf><cr><ctrl-z>

used to signify the end of the of the image information. The <ctrl-z> is used to tell DOS commands like TYPE to stop and not display any further data. The remainder of the 2048 bytes in the header are unused and are typically NULL characters. The parameters for a Type 3 file are shown below:

[1] If the camera type is listed as "SBIG" and not one of the specific models then the User_2 field will specify the camera name as obtained from the SBIG Universal Driver using the Get CCD Info command, request 0. In addition these files should have a ".SBIG" extension.

Table 1
Type 3 Parameters

XXX Compressed Image
File_version = 1
Data_version = 1
Exposure = xxx
Focal_length = xx.xxx
Aperture = xx.xxx
Response_factor = xx.xxx
Note = xxxxxxxx
Background = xxx
Range = xxx
Height = xxx
Width = xxx
Date = xx/xx/xx
Time = xx:xx:xx
Exposure_state = xx
Temperature = xx.xx
Number_exposures = xx
Each_exposure = xx
History = xxxxxx
Observer = xxxxxxxx
X_pixel_size = xx.xx
Y_pixel_size = xx.xx
Pedestal =xx
E_gain = x.xx

The following parameters are optional and may be present

User_1 = xxxxxxxx
User_2 = xxxxxxxx
User_3 = xxxxxxxx
User_4 = xxxxxxxx
Filter = xxxxxxxx
Readout_mode = xx
Track_time = xxx
Sat_level = xxx
End

Table 2
Parameter Descriptions

XXX Compressed Image - This indicates the type of camera used to take the image and the fact that the data is compressed as described below. The XXX will be ST-4X, ST-5, ST-6, ST-7, ST-8, PixCel255, PixCel237, ST-9, ST-10, ST-1K, ST-2K, STV or SBIG. See footnote 1 above.

XXX Image - This indicates the type of camera used to take the image and that the image data is not compressed and is saved as N rows of M pixels where N and M are specified by the

Height and Width entries in the header. The pixels are two byte unsigned integers each with the least significant byte before the most significant byte. The pixels are written with pixel (1,1) first, proceeding in left-to-right order to pixel (1,M), followed by the subsequent N-1 rows of pixel data. See footnote 1 above.

File_version - This field should be 3 to indicate the file is Type 3.

Data_version - This field describes the version of the image data and will be 1.

Exposure - This field indicates the exposure time in 1/100ths of a second.

Focal_length - This field indicates the focal length in inches of the telescope used to capture the image.

Aperture - This field indicates the aperture area in square-inches of the telescope used to capture the image.

Response_factor - This field specifies the CCDs response calibration factor.

Note - This field is the annotation attached to the image. The maximum allowed length of the note is 70 characters.

Background - This is the value of the Background parameter used to display the image when it was last saved.

Range - This is the value of the Range parameter used to display the image when it was last saved.

Height - This is the height of the image in pixels.

Width - This is the width of the image in pixels.

Date - This field shows the date the image was captured. Note that the date is in the format MM/DD/YY where MM is the month, DD is the day and YY is the year. For historical compatibility the YY field is only 2 digits. If you want to know the full 4 digit year see the User_4 field below.

Time - This field shows the time the image was captured.

Exposure_state - This field contains sets of bits indicating whether ABG was active during the exposure, whether Double Correlated Sampling was used and whether DC Restore was used.

Temperature - This field indicates the temperature of the CCD in °C at the end of the exposure.

Number_exposures - This field indicates how many images were co-added to produce a composite image.

Each_exposure - For composite images this field indicates the exposure time of the individual exposures in 1/100ths of a second.

History - This is a string of characters indicating which image processing functions have peen performed on the image. The following is the mapping between individual characters in the string and the operation performed:

@ - Modifications made before history established.

A - Co-addition of image.

B - Image linearly scaled.

D - Image dark subtracted.

E - Cool pixels removed.

F - Flat field corrected.

G - Image smoothed.

H - Image sharpened.

I - Image pseudo flat field corrected.

J - Image quantized or posterized to less than 16 bits precision.

K - Warm pixels removed.

L - Image flipped horizontally.

M - Image flipped vertically.

N - Image zoomed with pixel interpolation.

O - More than 40 operations performed.

P - Image log scaled.

Q - Pixels combined.

R - Image auto dark subtracted.

S - Image zoomed with pixel replication.

T - Image clipped and filled (ST6COLOR)

U - Image converted to 8 bit log format (ST6COLOR).

V - Image merged to color using 2 color merge (ST6COLOR).

W - Image merged to color using 3 color merge (ST6COLOR).

X - Image translated and back filled (ST6COLOR)

Y - Image pixels inverted.

Z - Image sharpened with unipolar algorithm.

[- Image sharpened with one-sided sharpening.

\ - Image modernized by replacing ST6COLOR history characters[2]

] - Image resampled to make square pixels.

^ - Image averaged.

_ - Constant added to or subtracted from image.

` - Constant multiplied by or divided into image.

0 - (Zero) The history string is set to '0' for new images. This is not a C null string, it is actually the '0' character.

a - Image enlarged 2X by pixel interpolation.

b - Image reduced 2X by pixel combining.

c - Column or Row repair.

d - Adaptive dark subtraction.

e - Pseudo 3D

f - Auto Dark HPR

g - HPR Subtract

h - Deconvolve

i – Median filter image.

j - Set saturation level.

k – DDP Image.

l – Rotate image.

m – Fix uncooled TDI image.

n – Fix ME spikes.

o – Fix blooming streaks.

p – Remove image wedge or gradient

q – Extract Red, Green or Blue channel

r – Extract Luminance Channel

s – Rotate image clockwise

t – Rotate image counter-clockwise

u – Median combine 3 images

v - Rotate image 180°

w – Image is raw Single Shot Color data

Please note the SBIG reserves the use of the characters '@' through '~' (decimal 64 through 126) for their use, and that any other characters added to the history string by other users should not use those characters.

Observer - This string contains the name of the observer who captured the image.

X_pixel_size - This field indicates the width in millimeters of the pixels in the image.

Y_pixel_size - This field indicates the height in millimeters of the pixels in the image.

[2] The ST6COLOR software used history codes 'S', 'T' and 'V' differently than described in this table. Modernizing replaces 'S' with 'T' (clip operation), 'T' with 'U' (compress operation) and 'U' with 'X' (translate operation).

Pedestal - This field indicates any pedestal (constant value) that has been subtracted from each pixel in the image.[3]

E_gain - This field gives the conversion factor between pixel values and electrons of charge in the CCD. The units are e^-/count.

The following fields are optional. They will be present in most images but may not be present if the image is very old. As the CCDOPS software has evolved these fields have been added to the header a few at a time. If present they will be in the order shown.

User_1 through User_4 - These fields originally intended for the use of non-SBIG software packages and can be up to 64 characters in length each, terminated with the <lf><cr> characters but as time evolved we have used these as a way to evolve the header without breaking third party software packages. SBIG software will ignore and preserve the settings of these 4 user parameters when reading and writing files. Either all 4 should be present or none of them should be present. If present and any one of them is blank then a single dash character ("-") should be written before the <lf><cr> characters. At the current time SBIG's use of thes parameters is as follows:

User_1 – We use this field to indicate the version of CCDOPS software used to capture the image. We strongly recommend you do the same.

User_2 – We use this field to describe the camera as reported by the SBIG Universal Driver (see footnote 1 above), for example "ST-7 Dual CCD Camera". You should do the same. Finally you can detect images from Single Shot Color cameras like the ST-2000XCM by looking for the word "Color" in this string.

User_3 – Sometimes we use this field to specify the Exposure and Each_exposure fields in seconds with the following format:

User_3 = Exposure = XXX.XXX, Each_exposure = XXX.XXX

where the floating point format allows exposures less than 10ms, the limits of these fields in the header proper.

User_4 – We use this field to indicate the full year the image was acquired by adding the string "Y2Kyear = xxxx". This was for Y2K compliance as the Date field above only uses 2 digits to specify the year.

Filter - This field is a 10 character text string indicating the name of the optical filter used when taking the image.

Readout_mode - This field indicates the readout mode the CCD camera's internal firmware utilized in capturing the image.

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[3] All image pixels have a bias of 100 counts added to them to stop underflow due to noise. If you need to flat field correct an image the pixel value that is due to light is:

Actual Counts = Image Counts - 100 + Pedestal

where Image Counts is what is read from the file and Actual Counts is the light response. For flat field correcting images you would multiply the Actual Counts by the flat field correction, not the Image Counts.

Track_time - This field, when non-zero, indicates the exposure used for the Tracking CCD in Self-Guided images.

Sat_level - This field indicates the maximum level you should expect in the pixel data. The ST-4X and ST-5 are 14 bit cameras for example and this setting will be 16383. Note that this level can increase as images are co-added or with Track and Accumulate images.

Image Compression

Type 3 images can be saved using a simple form of image compression. The image compression consists of saving the differences between adjacent pixels and using single bytes for small differences rather than double bytes.

Each line of compressed image data starts with a two-byte integer (least significant byte first) indicating the compressed length of the line in bytes followed by the compressed image data. The 1st pixel of the actual image data is written using two-bytes and is the actual pixel value. Subsequent pixels are written as follows depending on the difference between that pixel and the previous pixel (? = pixel (m,n) - pixel (m, n-1)):

> If $-127 \leq ? \leq 127$ then write ? as a single byte in 2's complement format, otherwise write hex 80 (-128) followed by the actual pixel value using two-bytes (least significant byte first).

The last caveat to the compressed image data is that if any line after being compressed has as many or more bytes than if it were stored uncompressed then that line is stored uncompressed with the 2 bytes of length followed by the actual pixel values written using 2-bytes per pixel (least significant byte first).

Note also that the compression algorithm described above used in saving images is similar though different than the compression algorithm used in downloading images from the older serial based cameras (ST-4X, ST-5 and ST-6). The newer Parallel and USB based cameras feed you uncompressed data so you don't have to worry about that.

FITS Format Images

Please note that SBIG has published a FITS Standard SBIGFITSEXT that SBIG with CCDOps, Software Bisque with CCDSoft and Diffraction Limited with MaximDl all agreed to and implemented. That standard can be found on our Software Developers page <http://www.sbig.com/sbwhtmls/devswframe.htm>.

Revision History

December 10, 2004 – Updated history codes "p" through "w" and made SBIG use of User_1 through User_4 parameters official. Added mention of SBIGFITSEXT