

Installing CHDK on the Canon SX120IS Camera

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Introduction

The digital camera is a useful instrument for the measurement of light pollution. It can be used to simultaneously create a photographic record of a scene and perform the function of a light meter. If the camera is properly calibrated, the numerical value of a pixel in the image can be related to luminance (brightness) in the image. Then a digital camera becomes a low-cost measuring instrument, replacing specialized instruments of much higher cost.

The Canon SX120IS is a point-and-shoot camera that normally produces JPEG formatted images. This exercise was undertaken in order to obtain RAW format images from the camera. The JPEG images have a non-linear luminance-pixelnumber response, with 8 bit (1:256) dynamic range. The RAW format images have a linear luminance-pixelnumber response, with 12 bit (1:4096) dynamic range. A linear response curve should simplify calibration.

Fortunately, the Canon Hacker's Development Kit [1] has generated software that supplements the Canon SX120IS operation, including the capability for on-screen live histograms and RAW format output. Everything is available to make this work, but finding and interpreting the material is somewhat challenging. This document will hopefully speed up the process.

Much of this document is 'cut and paste' from other sources, so the content is not original. I have organized the flow of information, the references and the specifics of the SX120IS camera.

1. Obtain a suitable SD storage card.

You may be able to use the card that's currently in the camera, but SD cards are very inexpensive and it's convenient to have a card dedicated for this purpose. The best capacity is 2GB. A larger card must be partitioned, which complicates the install process.

I obtained Kingston 2GB SD storage card SD/2GBCR.

2. Obtain a USB SD card reader

Camera card readers are very inexpensive. You will need one to read the SD card. Mine is a SanDisk SDR-88.

3. Format the card

The card I purchased was already formatted, as confirmed below. However, if the card must be formatted, the instructions are here [2].

Here are the instructions for formatting a card:

- Format the card to FAT16 with a desktop computer via a USB card reader and create the DCIM and MISC folders on the newly formatted card. Alternatively, you can format your

card with the camera, which in some models creates a FAT16 filesystem. (Note that the Canon SX200 IS, firmware version 1.00D formats the SD card to FAT32. Therefore formatting the SD card in an SX200 IS will not give you a partition from which CHDK can be booted, and you must use the terminal commands on a PC). You can check how an SD card has been formatted by running the "strings" Unix command on the volume, and looking at the output for FAT16 or FAT32.

- Important: Due to the limitations of FAT16 this will not work with cards bigger than 4G!

I didn't have to actually do this, because the card was formatted to FAT16, which is confirmed below.

4. Make the card Bootable

The camera needs to know that there is computer programming code on the SD card, so the card needs the magic word `BOOTDISK` must be on the card.

I prefer to use Linux if possible, but in this case I couldn't determine the mount point of the card, so I decided to use Windows XP.

Under Windows, I plugged in the card reader and plugged the card into the reader. The card plus USB reader appear as drive `I:\`.

Basically, you are going to manually change a few bytes in the card header to make it bootable. Here are the steps I used to make the card bootable (cribbed from one of the above sites):

- (a) HDHacker [3] is a free utility that allows direct manipulation of the information on a memory card.
- (b) Download, install and run the HDHacker utility.
- (c) Select the proper drive letter corresponding to your SD card in the card reader.
- (d) Select `logical drive` and `first sector` (probably the default)
- (e) `Read sector from disk`
- (f) Save this sector to a file for safety (512 bytes) (I named it: `BootSector_Drive_I.dat`)
- (g) Download and install the HexEdit file editor [4]
- (h) We now use the hex editor to edit this file. Position the cursor at offset `0x40` (decimal 64) and type `BOOTDISK` in ASCII mode. Keep in mind that, if you do not see `FAT12` or `FAT16` around `0x36` (decimal 54) in the hex editor, you probably picked the wrong drive. Do not overwrite anything in that case.
- (i) Save it as a different file (I named it: `SDBootSectorBootable.dat`)
- (j) Use the HDHacker command `Load sector from file` to retrieve this new file containing `BOOTDISK` information.
- (k) Use the HDHacker command `write sector on disk` to write the new file to the SD card. Don't forget to select the correct drive letter, or you could trash your main hard drive!

The SD card is now bootable.

5. Determine version of the firmware on your camera

In order to install the correct CHDK software, you need to know the version of the firmware in your camera. That information is in the metadata (exif file) stored with any photograph taken by that camera.

On my linux machine, the program `exiftool` is installed [17], so I can run the command `exiftool foo.jpg` where `foo.jpg` is some image taken with the camera, and it will dump out the version number.

Here's how you do it under Windows.

Using the instructions in this document [6]:

CameraVersion is a small Windows tool that helps to get the 'real' firmware version of a Canon Powershot camera. Based on Phil Harvey's ExifTool, it shows the firmware version based on the EXIF data from a Canon JPG image. Download the app. from here [5].

The file is a self-extracting archive, it contains CameraVersion.exe (the executable file) OS requirements: MS Windows OS (2000 / XP / Vista / 2003 / 2008 / Seven) You will need to shoot a jpeg image and have it saved on the SD card. Have the card inserted into a card reader connected to a PC. Start the tool (CameraVersion.exe), select the file.

In either case, Linux or Windows, we find the following information in the exif file:

Canon Firmware Version 1.00
Firmware revision 1.00 rev 2.00

Just to add to the fun, this is referred to elsewhere as firmrmware revision 1.00B.

6. Install CHDK

Surprisingly, downloads of the CHDK software are not available on the CHDK website, possibly because the code is still in beta test. I found suitable versions on this website [7].

In this case, I downloaded `sx120is-100b-0.9.9-912-full.zip` Notice that the version number of the camera firmware (1.00B) is encoded into the name of the zip file. That assures us that we have the right file¹.

Also of interest is the file named `trunk912.zip`, which contains the source code.

- (a) Download the latest version, unzip it and read the `readme` file. There is a lot of useful information on operating the software in the `readme` file.
- (b) Unzip the archive. Copy the CHDK folder (with its contents), the file `DISKBOOT.BIN` and the file `vers.req` to the SD card.
The files in the CHDK folder are the new commands. `DISKBOOT.BIN` is the binary executable that interprets the new commands. `vers.req` is required for the camera to report its version on the LCD screen. (We don't need that, but it's a useful confirmation.)
- (c) Ensure the the card is in the 'lock' position. (Note: it's very easy to misread the Lock/Unlock indicator. Look at it very, very closely.) Insert the card into the camera.

7. Verify the Firmware Version

This is not essential. But it confirms the version number of the camera and it demonstrates that the camera is reading the SD card correctly.

- (a) Start camera IN PLAYBACK-MODE. To do that, do not power on the camera. Press the 'play' button. (Rear panel of the camera, top left, button shows a square with a right arrow in it.)
- (b) When you extracted the archive it placed a file on your card called `vers.req` (or `ver.req` depending on the camera model). This will allow you to see, with the right camera-button presses, the TRUE firmware version of your camera (and other interesting information).
- (c) Press your `Func Set` button, hold it down. While holding down your `Func Set` button press your `Display` button. You will see the version of the firmware in your camera. Confirm that it is the right firmware to match up with the CHDK that you downloaded. Your real firmware version is NOT 1.0.1.0 nor 1.0.0.0 Your REAL firmware version will look something like: `Firmware Ver GM1.00A`.

¹You could search for a later version of the file by Googling `sx120is-100b`.

(Pressing `Display` again a few times while still holding down your `Func Set` button will let you see even more information about your camera, including total number of shots taken since it was made.)

In my case, camera version shows 1.00B. Total shoot is 550.

8. Run CHDK

- (a) Using the dial on the top of the camera, put the camera in some sort of image mode, such as 'faces'.
- (b) Start the camera using power on button (top of camera).
- (c) You should briefly see the CHDK menu, before it is overwhelmed by the usual Canon menu. If the camera starts showing the date and time entry widget, hit 'MENU' to get out of it.
- (d) Hit the 'DISP' button to get rid of the Canon displays.
- (e) Hit the <alt> button (the 'face' symbol on the rear of the camera, above and to the left of the selection wheel) and then MENU. The CHDK menu should appear.

Congratulations! You now have CHDK operating on your camera.

The CHDK User Manual is here [8]

9. Image Processing

Now we need to give some thought to which file formats to use and how to process the information. The ultimate goal is to get the image into the `imagej` image analysis program [11].

The Canon SX120IS can produce raw files in any of the following formats:

- CRW
- CR2
- THM
- WAV
- DNG

Canon raw format CRW is described here: [9]

Canon raw format 2 CR2 is described here: [10]

According to Wikipedia: [12]

DNG (digital negative) is the only raw image format for which industry-wide buy-in is being sought. It is based upon, and compatible with, the ISO standard raw image format ISO 12234-2, TIFF/EP, and is being used by ISO in their revision of that standard. (See the Standardization section, below.)

Also see [13] According to this, DNG is related to TIFF format.

None of these formats can be read by the ImageJ analysis program. The formats that ImageJ can read are:

- TIFF
- GIF
- PGM
- FITS

- BMP

Of these, TIFF seems like the best bet since DNG is based on TIFF, TIFF uses lossless compression and TIFF is supported by a standard.

Can ImageJ load a DNC format image? Yes and no. It appears to load a 'thumbnail' of 128 x 96 pixels. It can load JPG, even though that's not on the list.

10. Raw Files

Here is the process to have the camera produce RAW files. The first step is to create the `badpixel.bin` file.

- Ensure the memory card is in 'lock' position.
- Startup the CHDK menu:
- Power on the camera
- Place in record mode by half pressing the shutter.
- Press `<alt>` (face)
- Create `badpixel.bin` appears in bottom left of display. Press `Func Set`.
- Menu appears for 'Load script from file'. Press `Func Set` to select.
- Navigate to 'Test' folder. Press `Func Set` to select.
- Navigate to 'Badpixel.lua'. Press the shutter button to start the script.
- Wait. Shutter fires. LED flashes. Busy indicates. Time passes.
- Wait until the message `Press SET to save file`. If the usual CANON menu appears and this message does not appear, enable the CHDK menu with `<alt> <MENU>`. Press `Func Set`.
- Menu shows `File is saved`.
- Press 'Menu' to call up main menu.
- To check that the file has been saved, put the card in the reader and open the CHDK directory. 'badpixel.bin' should be there. If you decide to redo the process, it may be that the file is overwritten without any need to save it again. If you want to make sure you get a new version, erase this one. You'll need to unlock the SD card, erase 'badpixel.bin' and then lock the card.

Now we need to set up the RAW parameters:

- Power on the camera.
- Show the CHDK menu: `<alt>`, `<MENU>`
- Enable 'Save RAW', 'DNG Format', 'DNG File Extension'

Notice that these settings are lost when the camera is powered off.

Take some pictures. Place the SD card in the card reader. There should be some files ending in `.DNG`, and their corresponding `.JPG` files.

11. Using DCRAW to generate TIFF Format

The program DCRAW [14] can convert from DNC to TIFF format. So we can use it to convert the DNC raw files from the camera into TIFF files for ImageJ.

On our Suse Linux box, DCRAW is already installed. On a Windows machine, you'll need to download the program. This website [15] has a description of doing that, along with a useful tutorial on using DCRAW.

For example, to convert image `crw_0569.dng` to TIFF format, the command line is:

```
dcraw -T crw_0569.dng
```

After running this command, we find the file `crw_0569.tiff`, which will then load into `imagej`.

12. How many bits to each pixel?

How many bits per pixel do we obtain from RAW mode on the Canon SX120IS? You would think this is easy to find out, but it's not.

According to [16]: Bits per unit, 12 bits

The properties of the image may be explored using 'exiftool', which is already installed on this linux box [17].

Example: `exiftool crw_0569.dng`

shows among many other properties

```
Black Level           : 128
White Level           : 4095
```

which implies a 12 bit image (4096 distinct levels).

The tiff image produced by `dcraw` is 8 bits unless specifically asked to produce 16 bits:

```
dcraw -T crw_0569.dng
exiftool crw_0569.tiff
```

```
Bits Per Sample : 8 8 8
```

```
dcraw -4 -T crw_0569.dng
exiftool crw_0569.tiff
```

```
Bits Per Sample : 16 16 16
```

Loading this into `imagej` shows a 16 bit image, histogram etc.

So: the DNG (Raw) image from the camera has 12 bits of resolution. Converting it to TIFF, using DCRAW, the image can have 8 bits of resolution (not useful) or 16 bits of resolution. The image analysis program `ImageJ` automatically adjusts to process 16 bit TIFF raw files.

13. Workflow Summary

```
Canon SX120IS with CHDK software
Configured to generate RAW files in DNG format
```

```
    |
    | file.dng, 12 bit
    v
dcraw -4 -T crw_0569.dng
    |
    | file.tiff, 16 bit
    v
imagej
```

References

- [1] CHDK, the Canon Hacker Development Kit, home page
<http://chdk.wikia.com/wiki/CHDK>
- [2] Formatting the SD card
http://chdk.wikia.com/wiki/Bootable_SD_card
- [3] HD Hacker
http://www.freedownloadcenter.com/Utilities/Disk_Maintenance_and_Repair_Uutilities/HDHacker.html
- [4] HexEdit, a utility that allows editing at the binary level
<http://www.physics.ohio-state.edu/~prewett/hexedit/>
- [5] Camera Version (for Windows)
<http://drop.io/chdkshellbeta/asset/camraversion11-sfx-exe>
- [6] CHDK Installation Guide Supplement to User Quick Start Guide (pdf)
http://chdk.wikia.com/wiki/File:CHDK_Installation_Guide.pdf
- [7] Download site for CHDK software
<http://drop.io/6y1tiuz/>
- [8] CHDK User Manual
http://chdk.wikia.com/wiki/File:CHDK_UserGuide_April_2009_A4.pdf
- [9] Canon raw format, CRW
http://www.sno.phy.queensu.ca/~phil/exiftool/canon_raw.html
- [10] Canon raw format 2, CR2
<http://lclevy.free.fr/cr2/#intro>
- [11] The amazing ImageJ, image analysis program
<http://rsbweb.nih.gov/ij/>
- [12] Wikipedia: Raw Image Formats
http://en.wikipedia.org/wiki/Raw_image_format
- [13] Wikipedia: Digital Negative Format
[http://en.wikipedia.org/wiki/Digital_Negative_\(file_format\)](http://en.wikipedia.org/wiki/Digital_Negative_(file_format))
- [14] DCRAW image file format conversion utility
<http://www.cybercom.net/~dcoffin/dcraw/>
- [15] Tutorial on using DCRAW
http://www.guillermoluijk.com/tutorial/dcraw/index_en.htm
- [16] Home page for CHDK on the Canon SX120IS
<http://chdk.wikia.com/wiki/SX120IS>
- [17] EXIFTOOL, utility for reading metadata from images
<http://www.sno.phy.queensu.ca/~phil/exiftool/>

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