DSLR Astrophotography and Linux

Introduction

Digital Single Lens Reflex (DSLR) cameras are a popular choice for astrophotography. Even a basic level DSLR camera (a so-called *entry level* camera) can produce stunning photographs in ideal conditions and the ability to reprocess a digital image afterwards can help make a satisfactory image when the conditions are less than perfect. Gone are the days when an image was either bad or good with no possibility of further enhancement! The appeal is obvious.

No matter how the DSLR camera is used, be it on a tripod taking wide angle shots of a spectacular sky, or piggy-backed on a guided telescope while using a high power lens to catch a deep-sky object, or even fixed at the focal plane of a telescope capturing the detailed dust lanes of a galaxy, the camera is used in much the same way. Once the camera settings are chosen and the image is in focus, the button is clicked and the camera goes to work gathering light to construct the image. It is a simple routine that is repeated again and again and again …

In fact there is nothing really for you to do here once things have been set up, and indeed, the thing most likely to spoil the shot is you manually clicking the button and triggering unwanted vibration! You need to get away from there! This is when automating the procedure with a computer becomes most desirable. What could be better than being out of harm's way, scanning the sky with binoculars and enjoying the splendid sights on show, while your computer is taking a series of many shots of your main target for the evening? If you already have a camera and computer (preferably a laptop - for reasons of portability), there is no financial cost provided you opt for a linux approach. Of course you will need to learn something about the linux operating system (OS) to get going. But if that sounds like too much effort, weigh it against the fact that all of the required software is absolutely free! Furthermore, I can assure you that you will never regret learning something about linux. If this appeals to you, read on.

Installing Linux

Linux is an OS that is freely available. All you have to do is decide which version you want then download and install it. These different versions can look very different, but at heart they will have the same kernel of basic utilities controlling your computer. Here I will focus on the linux versions known as Raspian, Linux Mint, and Ubuntu, which are widely used and very popular. (Other linux versions can also be used, but the detailed implementation is likely to be different.) Raspian is of course the principal OS of the Raspberry Pi, which offers a ridiculously cheap (and entertaining) option to anyone who does

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not have a laptop computer readily to hand. Check out the Raspberry Pi home pages at www.raspberrypi.org.

If you do not have a Raspberry Pi, ideally you will have an old Laptop lying around that is no longer capable of running the latest incarnation of Microsoft Windows but is otherwise quite usable. In which case you can replace the existing OS entirely with linux. (I have installed Linux Mint 18 on an old Acer netbook with just 8 Gb of disk and it works just fine.) Alternatively you can create a dual boot system hosting both Windows and linux if your system disk is big enough (say 60 Gb).

To install linux you first have to download the appropriate system image or .ISO file from the home page of your chosen linux. These are easily found in a web search. The same pages will tell you how you can install the OS, but I give a (necessarily brief) overview here.

To install Raspian on a Raspberry Pi you can burn the Raspian image directly onto the micro SD card that the Pi uses as its main `disk', using whatever image writing software you have on your main computer. (On a linux machine you can use the program dd, while on Windows you can use the win32 disk imager utility - as instructed on the Raspberry Pi home pages: www.raspberrypi.org.) Before inserting the micro SD card into your Pi, you are advised first to edit the config.txt file on the Pi /boot directory to set some operating parameters appropriate for your hardware (including the option to activate internet access). Then, you can insert this into the Pi and boot up.

In the case of a laptop, if it has a DVD read-writer you can burn the linux image on to a DVD. Otherwise, you can use USB image writing software to burn the image on a USB memory stick. Next you have to ensure that your laptop can boot up from either of these sources. This means interrupting the default boot up procedure and editing the BIOS software. How this is done is specific to your particular hardware, so consult your user manual. It is not difficult in principle, but it can be tricky to interrupt boot up at the right time and you may have to try more than once. When the change has been made, shut down the computer and then reboot with the DVD or memory stick inserted, this will give you access to the new system image, from where you can install linux on your laptop. Note that the install procedure will allow a complete overwrite and turn your computer into a purely linux system, or you can set up a dual boot system with your original OS still available as a boot up option. For an old laptop I advise the former – you are not going to have much disk to play around with. But remember to back up your old data if you don't want to lose it!

Camera Control Software

With your linux installed you can now start installing the application software you need to turn your laptop/Pi into a controller for your DSLR camera. The

first things you need to install are Gphoto2 and GtKam. Gphoto2 provides a library of utilities for accessing and controlling a huge range of cameras. These utilities can be used from the command line, but it is much more convenient (at least to begin with) to use the graphical user interface provided by GtKam.

On Raspian, Linux Mint and Ubuntu installation is simple and requires the following commands entered into a terminal window:

sudo apt-get install gphoto2
sudo apt-get install gtkam

Since you have to use the `sudo' command you will be asked to enter the system password (which you created when installing linux). This may take several minutes, but is usually straightforward if your internet connection is reliable.

Once these packages have been installed, you are ready to start taking pictures.

Using GtKam

(In this section I will not describe features I haven't used. If they are not mentioned, I have found no need for them.)

Plug your camera into a USB port on your laptop/Pi (using the bespoke USB cable that came with your camera) and switch it on. A panel will open on-screen offering to download your pictures. Most of the time this is precisely what you would want to do, but to get to use GtKam, you must skip this and immediately unmount your camera. This operation varies slightly from one linux version to the next. To begin with look for an *unmount* button on the panel that will allow you to do this. Otherwise you can access the system's file browser, where the camera will be listed and can be unmounted by clicking on one of the offered options indicated by a right-click. Learning how to unmount your camera is important; GtKam will refuse to give you access to your camera because it has been already mounted for another purpose (such as downloading the pictures).

Once you have unmounted the camera, start up GtKam by clicking on a menu option, desktop icon or by issuing the command:
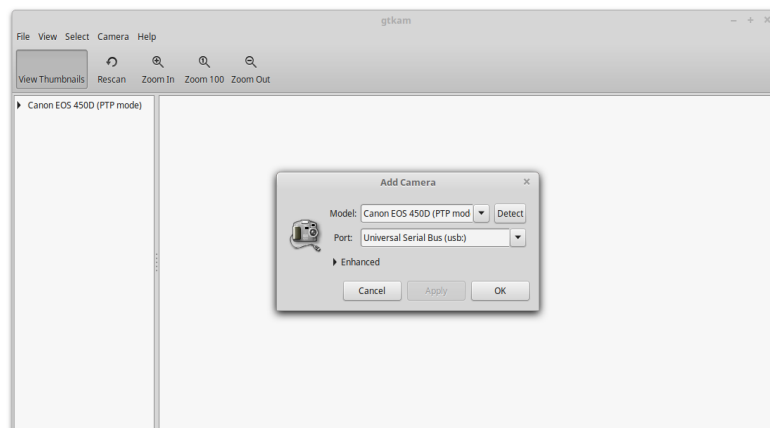
 gtkam

The GtKam panel now opens:
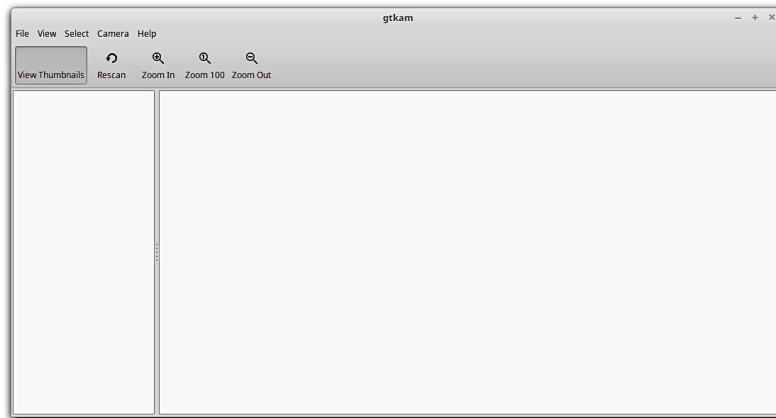
The GtKam Graphical User Interface

Go to the 'Camera' menu at the top of the panel and select 'Add Camera'. On the panel that appears click the button marked 'Detect' and GtKam will scan the USB ports and find your camera. You then click the 'OK' button and your camera name appears in the left panel:


Mounting the Camera

Once you've done this GtKam will remember your camera for future occasions. If you are unlucky GtKam will fail to detect your camera. If this happens, you can go no further. There is an extensive list of options, but if yours is not there, you can only hope it will be added some day. Assuming your camera is successfully recognised, you should now proceed with setting up your camera for astronomical use.

Setting the Camera Preferences

The first thing to do is choose the camera mode you want using your camera's Mode dial. For astrophotography you will mostly require the Manual mode, but for other kinds of photography you may want to use something else and you are free to do so. Options governed by the Mode dial are not amenable to change using GtKam.

From the drop-down menu obtained when you right click on the camera's name in the left hand panel you can choose *View camera preferences*. This will open a menu panels allowing you to set the camera controls:
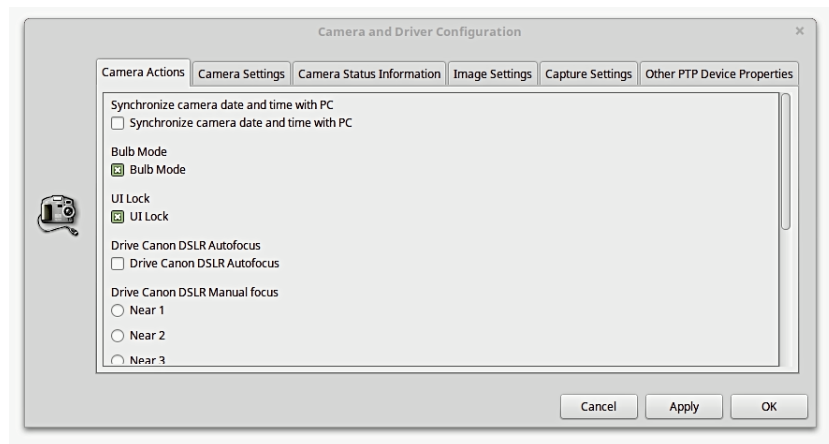
The Camera Preferences Panel

(This panel is also opened by the [Preferences] button on the *Capture* panel mentioned below.) Not all of the options shown will be actively available to you, since some are set exclusively by your camera mode dial, but things like exposure and shutter speed will be there for you to set. There are six sub-panels to look at:

    i. Camera Actions;
    ii. Camera Settings;
    iii. Camera Status Information;
    iv. Image Settings;
    v. Capture Settings; and
    vi. Other PTP Device Properties.

In practice you will probably spend most time interacting with sub-panels iv and v. Apart from that you must make one change, near the bottom of panel ii, to ensure that the photos are written to the camera's SD card and not the internal RAM. A tick box is available for this purpose.

Taking Pictures

Right click the camera name in GtKam's left hand panel and from the drop-down menu select the *Capture image...* option. What happens next depends on the camera you have and the mode you are using.

For example, in the case of my Nikon D40, which does not have *Live View*, a small panel opens showing three buttons, including one that allows you to take pictures [Capture], one that allows you access to the camera controls [Preferences], and one that closes the panel [Close]:
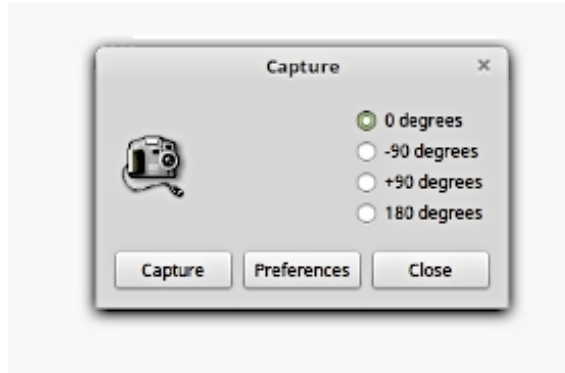
The Capture Panel (with no Live View)

Clicking on the [Capture] button takes the picture. There is no help here for focussing the shot - that has to be done through the viewfinder.

In the case of my Canon 450D, which in Manual mode has live view, the Capture panel also has a screen showing the view through the camera, which can be very handy for manual focusing. Note however that the size of the live view screen cannot be reduced, and if your monitor screen is on the small side, you might not see the whole of the panel all at once, but you can see any chosen part by holding down the <Alt> key and, with a right click, dragging the screen around until you find what you want to see (such as the [Capture] button!) Ironically, is is possible to *increase* the size of the live view screen by mouse-dragging a corner.

The Capture Panel (with Live View)

Assuming that you can see the [Capture] button, click on it and the camera will take a picture.

The pictures you take will be stored on your camera's SD card and can be viewed on-screen, saved to the laptop/Pi, or deleted using GtKam. The viewing option is useful if your camera doesn't have live view. (You will want to know

immediately if your shots are not in focus!) These features of GtKam are described below.

Accessing Pictures on the Camera

Personally speaking, I find GtKam's methods for accessing and manipulating the camera's SD card a little buggy and for general processing of images I prefer to remove the SD card from the camera and copy the photos directly onto my working computer. However there *are* desirable functions you can access using GtKam, so it's worth trying it out. If GtKam crashes for any reason, just immediately start it up again. It is quick to restart and won't damage the photos on your camera.

You get access to the photos on your camera by left clicking on the bullet left of the camera's name in the left hand panel and descending through a directory tree to the SD card and the directories thereon. When you arrive at the directory containing the photos, left clicking on it will throw up a list of the photos in GtKam's right hand panel. The manner of access to the photos in directory takes a bit of getting used to. For example, if the photo directory was already open when you took a picture, you may find that have to left click again on the photo directory to make the picture show up. You may also find that repeatedly re-entering the directory results in multiple listings of the photos taken (the screen is not cleared between re-entries). The effect seems to be harmless, but it can be confusing when first encountered. Re-clicking on the directory name tidies things up, but sometimes it also crashes GtKam!

Note there is a *View Thumbnails* option above the left hand panel, which toggles the visibility of the thumbnail images of your photos. Clicking on it while the left panel has thumbnails on it makes things look a little untidy, but clicking on the directory name again will tidy things up a bit.

You can view any picture by right clicking on its name or thumbnail and selecting the '*View with…/Built-in viewer*' option. This is quite useful for a quick inspection of the shot. You can make the default size of the viewer bigger (but not smaller) by dragging the corners of the image with the mouse.
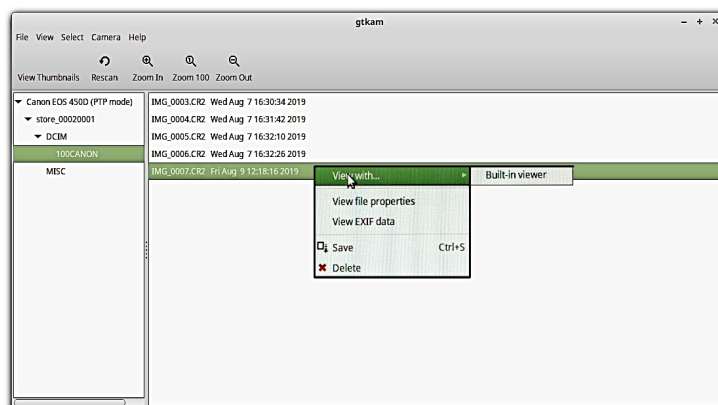
Selecting Photos to View On-screen

To save selected photos to your laptop/PI you first highlight them with a left click, then right click on them and select the *Save* option. You can highlight more than one photo and save them all at once - with options to use the camera-given names, names you specify using a prefix, or GtKam's own quirky file names. Note that if you initiate a *Save* without highlighting anything, nothing is saved. The *Save* operation may also be initiated through the *File* menu, where you have a choice to save *All* or *Selected* (i.e. highlighted) photos. Likewise you may delete photos via the *File* menu or using the highlighting method.

Using Live View for Focussing

For cameras that support live view, an obvious astronomical application is to use this for improving the image focus. This can certainly be done if the astronomical object in view is bright enough, such as the Moon, Jupiter, the Sun (with proper safety filtering), Venus and the brightest stars. You can also increase the ISO setting of your camera to improve visibility in live view. However, deep sky objects and faint star fields are not likely to be amenable for live view focussing.

For faint objects there's nothing to stop you initially focussing on a bright astronomical object using live view and then swinging the camera/telescope to what actually interests you to take a well-focussed shot. You may also make use of GtKam's *Built-in viewer* feature to inspect the long-exposure shot afterwards and make small adjustments to the focus in a trial-and-error fashion.

Using Gphoto2

Gphoto2 is the suite of utilities that underpins GtKam and it can be accessed through the command line - that is, by typing commands in a linux terminal window. Once again, remember to unmount the camera to give gphoto2 access.

The most obvious command to try first is

=> gphoto2 --help

which lists all the operations available through gphoto2. A briefer version of this extensive information is given by

=> gphoto2 --h

which prints the information in reduced format.

When taking photographs, the following commands are particularly useful.

=> gphoto2 --auto-detect

which detects the camera that is connected to your computer (if it recognises it).

If it doesn't report any cameras you can try

=> gphoto2 --list-cameras

which lists on-screen all the different cameras that gphoto2 can handle. If yours isn't listed, there's your problem!

The command

=> gphoto2 --capture-image

takes a photograph.

The command

=> gphoto2 --list-files (or alternatively => gphoto2 -L)

lists all the files on your camera (including photos).

Lastly, the command

=> gphoto2 –get-all-files (or alternatively => gphoto2 -P)

will download all the photographs into your current working directory.

These are enough for you to get started, but do look at the other commands to get a feeling for what else is possible.

Note that there is no visual access to the camera through the command line (that is the designated purpose of GtKam), but if you are content first to focus the shot through the camera's viewfinder, then the GtKam can do all the rest.

Using Scripts

One feature of linux that is particularly useful is *scripting* – storing sequences of commands into a file that you can execute. Before you do this however, I recommend that you ensure you have the latest stable version of gphoto2 on your computer, otherwise you may find (as I did) that things don't work quite as intended. To do this you need the updating script from GitHub. You can find this by googling for: *gphoto2-updater.sh* . When downloaded mark it as executable:

=> chmod +x gphoto2-updater.sh

Then run this from the command line to install the latest version of gphoto2:

=> ./gphoto2-updater.sh

As an example of a script consider the following. Type the following lines into a file named *shoot* using your favourite text editor, then save it:

```
#------------------------------------------------------------------------------------
#!/bin/bash
echo -n "Taking $1 "; echo "shots"
i=0
while [ $i -lt $1 ]
do
  gphoto2 --capture-image
  i=`expr $i + 1`
  sleep 2
done
echo "All shots taken"
#------------------------------------------------------------------------------------
```

Next run the command

=> chmod +x shoot

which marks *shoot* as *executable*.

Connect the camera to your computer, turn it on, and immediately unmount it. Set the camera's mode to *Auto* (just for this exercise), then type the command

=> ./shoot 1

and the camera should now take one shot. If it doesn't work, check the typing in the file *shoot* and correct if necessary.

Next try

=> ./shoot 5

and the camera should take 5 shots in succession. You now get the general idea, so experiment with the camera in different modes (e.g. Manual) and try changing the exposure, Iso and focussing *etc.* using GtKam to get used to things.

Scripts like *shoot* are useful. Once a shot has been set up using GtKam (i.e. in focus, with correct exposure and Iso) and the camera is set up so it tracks with the sky, you can use the script to take as many shots as you need of a chosen object for later stacking and image processing. You should not have to intervene until after the last shot is taken. By all means consider writing scripts for your own purposes.

Experienced linux users will store the *shoot* script in a suitable place, say a directory called *.myscripts* in their */home* directory. It can then be executed from any working directory with the command

=> ~/.myscripts/shoot n

where n is some integer number. Better still, a command alias or desktop launcher can be defined to do the same things more efficiently. It's up to you!

Conclusions

I hope this article has encouraged you to try linux with Gphoto2 and GtKam to operate your camera from your laptop or Raspberry Pi. I have found that once you get used to linux and have learned to live with the quirks of the software, it can be a great labour saving tool. The tedious nights being bent over the camera for long spells while shepherding your shots will be over.

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