Stellarium Panorama (Landscape) Tutorial

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Software:

- Stellarium: 25.2 or later from https://stellarium.org
- Hugin: 2023.0 or later from https://hugin.sourceforge.io/download/
- GIMP: 3.0 or later from https://www.gimp.org/
- Optional: FSPViewer https://www.fsoft.it/FSPViewer/
- Mentioned: Horizon 0.13c from http://agksmith.net/horizon/
- Mentioned: Google Earth Pro Desktop: https://www.google.com/earth/about/versions/

Hugin

The free and open-source panorama stitcher has been around since about 2005. We use it to combine a set of perspective images taken from one view location into an equirectangular image.

Photos from digital cameras come with EXIF metadata which should contain lens parameters, esp. focal length and crop factor (related to full 35mm film frame). APS-C cameras usually have crop factor 1.4 ... 1.6. If you convert images to different pixel format (make them smaller), you may need to rescale parameters. The pictures from my camera have original size 6000x4000 pixels and were reduced to 1080 lines (i.e. 1620x1080) for faster processing. When Hugin shows a dialog asking for field of view, start with v=60 degrees and crop factor 1.6, we will optimize v later. On the other hand, cropped input images will still not work.

After first launch, activate Menu:Interface:Expert.

Adding images

Press button “Add images...”. Select all required images. Hugin will read EXIF lens information or may ask for focal length and crop factor, or horizontal field of view. Images are presented in a table. Select some “central” image as anchor (both exposure and orientation).

If image orientation is known (in case of synthetic images), you can enter the data manually. Else we now use Hugin’s central operations.

Control points

Create control points automatically. These are mutually common points in two adjacent (overlapping) images. After creation, it is wise to go through the image pairs in the “Control Points” tab. When images *n, n+1, n+2* have high overlap, you may identify common points in images *n* and *n+2*. Delete those! Use Ctrl-RightMouseButton to select and delete all points inside a box inside one of the image.

Likewise, delete all control points in the clouds and water surfaces, and of course on moving targets (birds, planes, ships, cars, cattle, humans, ...).

You can add control points along truly vertical features (building edges) by setting the same image in both sides of the Control Points tab, then click near top and bottom of the linear feature. This helps defining verticality/fight camera rotation (wave effect).

Optimisation

We start finding image orientations with the Optimise/Geometric:Positions (incremental, starting from anchor):Calculate button. This tries to arrange the images based on minimizing the control point distances. The photographic imaging system (lens) may have a few distortions which can be modelled away in successively adding more variables to optimise.

Our most crucial line to match usually is the actual landscape horizon. If you have taken the panorama out of your free hand, delete control points in the grassy/rocky foreground and optionally add more along the horizon.

It is advisable to optimize the horizon row using a different "lens" than the bottom row(s). First, find a principal match of only the horizon row with as little error as possible. Use the preview dialog: Click in the image to set center, right-click to influence camera rotation (fight "image wave", make flat row). In the Optimise settings (bottom of "Photos" tab), apply geometric settings in sequence, from the first to "everything without translation".

Then match lower rows as well. If only grass, it is only important to match with the "above" image, and you can ignore/delete control points in laterally adjacent images. Check the preview if the panorama looks OK.

Finally, we want to adjust against a DTM-based panorama created from my Google Earth workflow[1] or from Andrew Smith's Horizon. Load this as new image, lens type equirectangular, field of view 360°. This image is already georeferenced by design, so no distortions are allowed. In the Optimiser selection at bottom, now set "Custom parameters". A new tab "Optimiser" appears. Prevent any changes to this already 'perfect' landscape image: Image orientation and Lens settings must remain frozen. Now find common points manually, e.g. faraway mountain tops. Don't forget to allow changes in the anchor image. Now run the optimizer again. The photo-based pano should be shifted to join the "Horizon horizon". A few pixels difference can hardly be avoided though when aligning real terrain images to SRTM 30m DTM based model renderings.

Export

Final image size

We will always create equirectangular panoramas in TIFF format. If we want eye resolution, we should have a panorama with arcminute-sized pixels along the horizon, i.e., 360x60=21600 pixels wide. Many graphic subsystems are challenged by this. In earlier years, and still with some systems (Raspberry Pi), maximal texture size was 2048^2, and generally using textures in sizes of powers of two (2^n) was important. Modern desktop systems can nowadays use maximum textures with 8192^2, 16384^2 or even 32768^2 pixels. Some software titles are limited in output image size (e.g. Photoshop PSD: 30.000 pixels wide). TIFF is limited to 4GB in file size (unless using BigTIFF extension).

Only in rare cases images larger than 16384 are ever needed. If you really need an image larger than 16384, create an old_style panorama: make equirectangular e.g. 32768 TIFF, but then split that into 4 or 8 sub-images along the horizon, plus a bottom image. Or, to come close to the 21600 arcminutes

[1] https://homepage.univie.ac.at/georg.zotti/, side menu "Stellarium", then follow link near bottom.

mentioned above, use 5*4096=20480 and split into 5 parts. Splitting up can be done automatically with ImageMagick's convert tool, and Hugin can help you creating the bottom image, but it is beyond this tutorial.

Cropping

Let us make a pano of base size 8192x4096 ("Canvas Size"). We can remove the sky and maybe unrecorded nadir area to save texture memory, but have to provide the limiting altitudes in landscape.ini.

Simple computations:

Altitude (maptex_top/maptex_bottom)	Crop from top
45°	1024
33.75°	1024+256=1280
22.5°	1024+512=1536
11.25°	1024+512+256=1792
5.625°	1024+512+256+128=1920
-11.25°	2048+256=2304
-22.5°	2048+512=2560
-45°	2048+1024=3072
-50.625°	2048+1024+128=3200
-56.25°	2048+1024+256=3328

Now export as TIF image.

GIMP

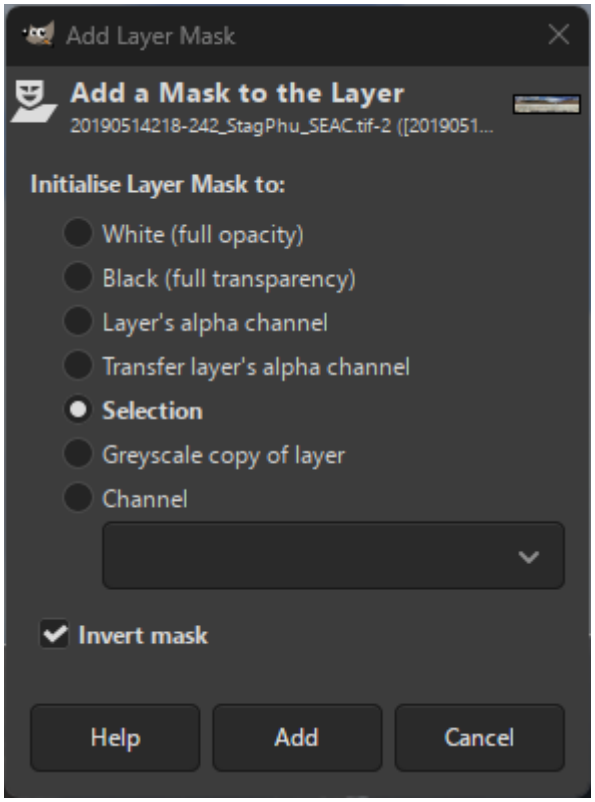
We need to set the sky transparent for Stellarium, i.e., get rid of the blue sky and clouds. GIMP is a free and open-source layered image editor similar to Photoshop.

After first launch, GIMP's menu is scattered all over the screen. For more concentrated working, enable a gray background via Windows->Single Window Mode.

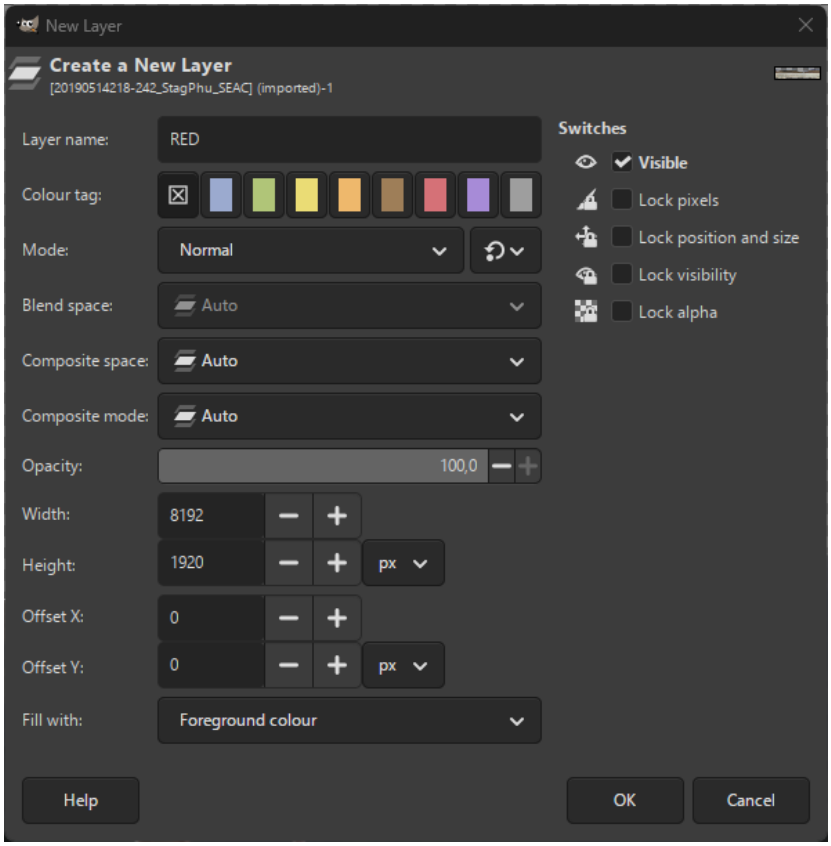
Open TIF image in GIMP. When you have cropped the image earlier, GIMP shows the original size (8192x4096) but highlights the final size as dotted box. To reduce actual image size, press Image->Fit Canvas to Layers.

Now use Magic Wand tool (stick with star) to successively select blue sky and clouds. Use Ctrl-Mousewheel to zoom. Shift-click to add, Ctrl-Click to remove area (The mouse cursor icon shows plus/minus hints). Fine-tune Magic Wand selection threshold.

Sometimes it cannot be avoided to select grey mountains and grey clouds. Try to select as good as possible, then do not just delete selected pixels, but create a transparency mask: Bottom-right corner, press the icon that looks like a theater mask. Select "Selection" and "Invert mask" to actually hide the clouds.



To detect leftover stray pixels, we can use a strikingly colorful single-color background, deep red or blue will do. Create layer is another button in bottom right:



Lock this layer (to prevent drawing in it). Put it below the landscape (drag layer). Now you see some remaining clouds, or the red shines through some (formerly) gray mountains that had been selected.

Activate (click on) the mask of the image layer to edit the mask, not the image. With Pencil tool and drawing color black, remove clouds, with color white, "reactivate" mountains. Manually draw difficult horizon borders.

Save this image in GIMP's own XCF format for later refinement. Then, export a PNG.

Stellarium

Stellarium's user data are stored in the user's personal folder. By default, programs use a hidden folder, on Windows: C:\Users\YOU\AppData\Roaming\Stellarium. In addition, Windows may be set to "hide known file name extensions". Therefore, in Windows Explorer, make sure to

1) Do not hide filename extensions for known file types
2) Display hidden elements

If your system drive (C:) is small (e.g., on systems with small system SSD plus large spinning harddisk), you can use a directory of your own choice by setting an environment variable STEL_USERDIR that names your actual directory.

landscape folder

Place the PNG file into a new subdirectory of your Stellarium User Data Directory (usually a hidden folder), on Windows: C:\Users\YOU\AppData\Roaming\Stellarium\landscapes\SEACtutorial, on Linux: ~/.stellarium/landscapes/SEACtutorial

Create landscape.ini

The landscape.ini is the configuration file required by Stellarium to load landscape and location (location is optional, but highly recommended). Create a new text file, rename it to landscape.ini (confirm the warning about type change – it's NOT landscape.ini.txt or landscape.txt.ini!)

When you had created a pano with Andrew Smith's Horizon, you can use parts of that landscape (the polygonal horizon line) as well:

```
[landscape]
name = Stag Phu (SEAC2025)
author = Georg Zotti, from self-made photographs from May 14, 2019.
description = Stag Phu Nyi Thig platform, calibrated with pano from
HORIZON Version 0.13c (30-Jan-2020). (SEAC 2025 tutorial)
type = spherical
maptex = 20190514218-242_StagPhu_SEAC.png
maptex_top = 33.75
maptex_bottom = -50.625
bottom_cap_color = 0.5,0.5,0.5
angle_rotatez = 0 <adjust azimuth of left/right image edge.>
                  <0 is due east.>
polygonal_horizon_list = horizon.txt     <IF YOU HAVE SUCH LIST!>
polygonal_angle_rotatez = 0              <0 implies East=left edge.>
polygonal_horizon_list_mode = azDeg_altDeg

[location]
planet = Earth
```

```
latitude = +29d53'0"
longitude = +91d49'38"
altitude = 4102
light_pollution = 1
atmospheric_extinction_coefficient = 0.125
name = Stag Phu Nyi Thig
timezone = Asia/Shanghai
```

Another optional file, description.en.utf8, can contain a more extensive description. Details: See User Guide.

If you want a light pollution layer (not required at this site), add another layer to your GIMP image, draw the light situation, then export as MYSITE_light.png, and add in landscape.ini:

```
maptex_illum = MYSITE_light.png
maptex_illum_top = 33.75
maptex_illum_bottom = -50.625
```

Distribution

If the panorama is worth sharing, it is easiest to create a ZIP archive. You can email or host it for download, or even contact the Stellarium maintainers for hosting at https://stellarium.org/landscapes/. Make sure to add a license declaration! See User Guide.

A landscape packed in a ZIP file can also installed during runtime from the landscape dialog.

Rita's Notes:

- Depending on the system the maximum size of the image is different
- Stellarium in principle accepts one large image or several smaller pieces
    - We only look at one large image today
- Record in raw image format – is preferable because the images can be postprocessed later
- Special tripod head device to mount camera for panorama images when features are very near
- 1/3 of image should overlap for stitching of panoramas
- 2-3 rows of photographs and usually vertical: first for horizon, second turned to the ground (the "landscape" layout of the example images here were necessitated by use of a simple tripod where vertical setting would have caused parallax issues!)
- Hugin
    - Change to expert view mode
    - Import images
    - HFOV in Hugin: if dialog appears, use 60 degrees, focal length multiplier 1.6 (HFOV then adapted automatically)
    - Need to modify Yaw (azimuth) and Pitch (altitude) angles – Rotation should be close to 0 first (or 90 for vertical-mode images)
    - Change Yaw angle of one image to e.g. 70 to see the effect in the preview dialog: it is just displaced to the right.

    - Feature matching – create control points
    - Optimize area – apply geometric corrections – chose Positions (incremental, starting from anchor) first, afterwards three columns have filled with different numbers
    - To regulate brightness – adjust “EV” value
    - Preview panorama view (the one of the two similar blue icons without GL)
        - Click on left mouse button – this is the new center
        - Click on right mouse button – the respective point is forced on the central line while keeping azimuth
    - Optimizer area choose next option: Positions and View (y, p, r, v) and press calculate
    - Open list of control points (“list” icon)
        - Click on line – then you see the control point in the image marked
        - Meaningless control points are in the clouds, in water, on people, close points in the foreground
        - To delete a point press Control key and the right mouse button to draw a rectangle around the respective point
    - Have to check all picture pairs!
    - Can switch between pictures by clicking on green arrows
    - After first round check between image 1 and 3, 2 and 4 etc. and delete all matching points
    - Optimizer area: choose Positions and Barrel Distortion (y, p, r, b)
- Go to GL Preview and press layout
    - You see coloured lines between images – red ones show bad matches
    - The GL preview can also be used to identify images by mouse-over
- Click on image numbers in the (non-GL) preview to deselect the lower images now
    - Run optimizer again
    - Run optimizer one more with option Everything without translation
- Identify mountain peaks and add a few more points along the far horizon – activate auto fine-tune, auto-estimate, auto add – move if it doesn’t fit properly and then click on Fine-tune
- Sometimes it happens that hugin tells you “no similar point found” – just grab it with the mouse button and shift it to the place where you think it should be
- Run optimizer again (currently maximum deviation is 2.8 px which is quite ok)

Add artificial panorama and identify matching points

- Load artificial horizon panorama prepared with Horizon: click add image
- Double click on respective image – Image variables open, degrees of view must be 360°, go to tab Photometrics and change value from 0 to 15 (or a value close to the EV of the photos)
- In Optimise section select Custom parameters, go on new tab Optimiser above – deselect that angles of artificial panorama can be changed and also of the Lens number the artificial panorama has – run optimizer again
- Now we have to add link points – identify peaks in photos and artificial image
- Control points – select the two images (4 and 18 in this case) – deactivate auto fine-tune and auto add – add points by clicking. It may help to increase zoom to 100%.
- In GL Preview dialog click Identify button – set matching points for other images (6 and 18 in this case)
- Run optimizer again with Custom parameters but select all photo images of the horizon again
- Switch off all angle buttons for top row and Lens 0 – the angles of the top row should not be changed further

- Switch on photos of the bottom row again and run Optimiser again
- To get rid of the brightness break disable the artificial horizon and in Optimiser area use the Photometric section and choose Low dynamic range and press Calculate
- Create final file – got to Stitcher tab and set canvas size to 8192, projection should be Equirectangular, field of view 360°, vertical 180°, set crop for top to 1024 (for cutting sky above 45° altitude) and for the bottom 3072 (check with your image), export in TIFF format with LZW compression – then click Stitch

Remove background sky with gimp

- Activate single window mode in tab "Window"
- Drag and drop the .tiff image into gimp and chose to keep all settings
- Chose in Image tab Fit canvas to layers
- Ctrl+P and zoom
- Chose from top left tool box the stick with star on top ("Magic Wand") and select first cloud, then click Shift key and select next cloud or sky until all the sky is selected
- Add layer mask (theatre mask) in the layer dialogue on the right to Selection and activate Invert mask, then click Add
- Then we have to paint into our selection mask to eliminate errors – select brush tool and paint in black the disturbing remaining clouds
- Paint in white and make the mountains visible again
- Paint in black with hard brush and make sky transparent in contact zone
- Save the file in gimp format (.xcf) and then export the file as .png

Load panorama into Stellarium

- In Explorer go to folder Users/yourAccountName/AppData, go to display menu and choose Show and activate show hidden elements and show file name extensions
    - In AppData you have a Roaming folder, go there and to the subfolder Stellarium/landscapes
    - Make a new subfolder and call it somehow (e.g. SEACTibet) – copy the .png file there
    - Copy horizon.txt and landscape.ini from your pre-existing "Horizon" horizon into the same folder
    - Adapt filename in landscape.ini to the name of the panorama and the location (if necessary), set maptex_top to 45 and maptex_bottom to -45 (because we have cropped away 45° of the panorama image on both sides). Add an entry for bottom_cap_color=0.5,0.5,0.5 to close the "hole in the ground".
- Open Stellarium, load new landscape
    - If horizon is pink, usually filename is spelled wrongly
    - An existing horizon polygon created by the Horizon program should be close to the photo horizon.
- Further Reading, all details: Stellarium User Guide, chapter 7.