

4D construction learning environment

virtual tour making

5. Image processing

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Table of contents

1	Preliminaries	3
1.1	Node images	3
1.2	Folder structure and naming conventions.....	4
2	Stitch and render node panoramas	6
2.1	Apply overall setting preferences	6
2.1.1	General tab:	6
2.1.2	Image tab:	6
2.1.3	Detection tab:	6
2.1.4	Optimization Tab.....	7
2.1.5	Panorama Tab	7
2.1.6	Render Tab.....	7
2.2	Process the images	8
2.2.1	Import image folders/files for the panorama(s).....	8
2.2.2	Check image info, quality and group settings.....	8
2.2.3	Save the workspace	9
2.2.4	Launch detection.....	9
2.2.5	Check assembly quality in Panorama editor.....	9
2.2.6	Save all panoramas	12
2.2.7	Launch final render	12
3	Render survey virtual tours.....	13
3.1	Start PanoTour	13
3.1.1	Open a new project.....	13
3.1.2	Import all the panorama files for the survey	13
3.2	Set Project and Scene properties in the Tour tab.....	13
3.2.1	Project Properties	14
	4D construction learning environment	1

3.2.2	Scene Properties (for each panorama).....	14
3.2.3	HotSpot editor	14
3.3	Set properties on the Build Tab.....	15
3.4	Launch 'Build'	15
3.5	Save the project	15
3.6	Transfer tour data to UQ.....	15

1 Preliminaries

This guide is for project teams who are producing virtual tour surveys of a construction site that is to be included in the suite of online UQ 4D construction learning environment (4Dcle) sites. The overall goal of a 4Dcle project is to document the construction (or refurbishment) process of a selected building for (online) use in teaching and learning activities by educators and students of professions related to the construction industry.

The aim of this guide is to provide a practical, illustrated reference for the project team to quickly and easily 1) stitch and render the 360° panoramas that comprise the node survey virtual tours and 2) assemble these panoramas (using PanoTour) into survey virtual tours to supply to the 4Dcle.

Separate guides cover the processes for a) establishing camera positions (nodes) on and around the site; b) photography and c) assembling an inventory of other resources.

Download from <http://4dconstruction.architecture.uq.edu.au/>

1.1 Node images

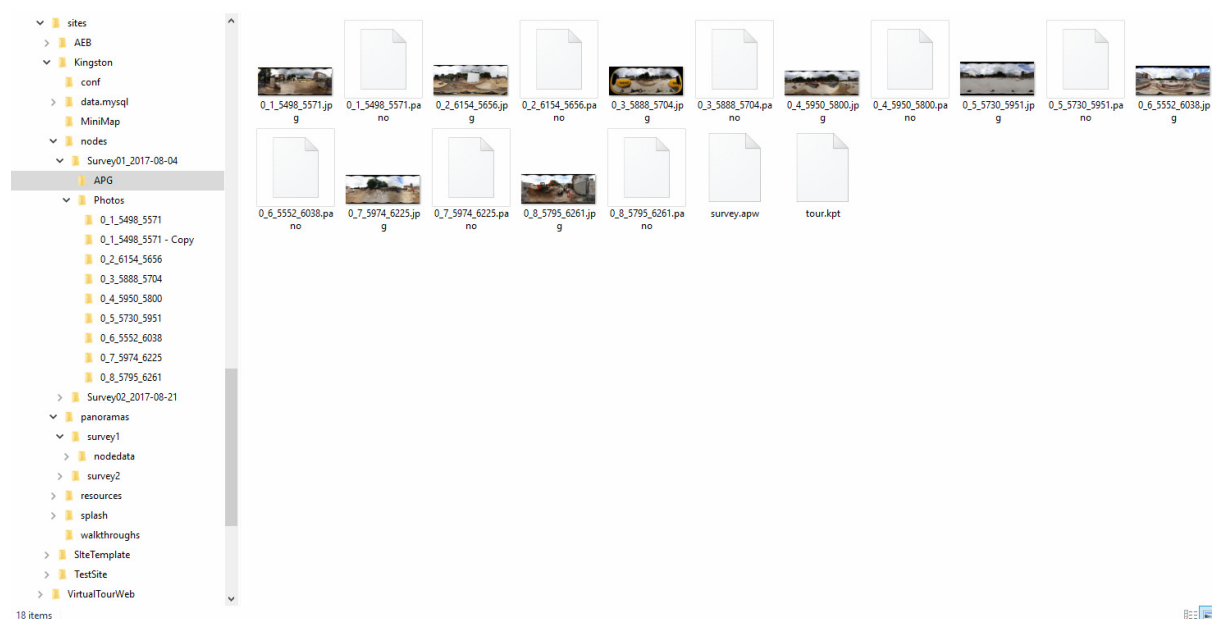
The photographs taken at each node during a survey need to be adequate in:

1. number (e.g. 6 horizontal with minimum of 10 degrees overlap) and sequence, 1st centred on North, remaining (5) taken clockwise (at 60° intervals) to create the panorama and that camera- related (EXIF) data are available
2. quality
 - a. camera settings are suitable for light conditions (see 4D learning environment Photography Guide V2.pdf). Chromatic Aberration is a common problem with Fisheye lens and should be corrected either in camera (download application to camera for automatic correction at time of shooting) OR use pre-assembly application like LightRoom, to edit before loading into panorama editor)
 - b. if shot in RAW or TIFF16-bit format, check and correct images, using photo editor of your choice, (useful tips at <https://www.panoramic-photo-guide.com/virtual-tour-360-photography/edits-virtual-tour.html>) for
 - i. vignetting
 - ii. artefacts like dust grains, sun halos, other annoying objects
 - iii. colour balancing
 - iv. convert to sRGB
 - v. if necessary redefine (down) size in pixels, especially height
 1. Image size calculation should be based on a) screen resolution required for the virtual tour e.g. full screen (1024x768 pixels or higher) and b) degree of zoom required (finished panorama of 8000 pixels width almost no zoom, whereas >12000 pixels provides some) e.g. 6 images at 4000 pixels width will stitch to panorama of approx 16800 pixels width. Processing time and storage use will be more for larger image sizes

2. Dpi doesn't matter for screens but keep at or below 96 to reduce file size
3. Keep proportional and use bilinear interpolation when changing either the above
 - vi. Save as JPG quality 12
3. uploaded to appropriately structured and named folders.

1.2 Folder structure and naming conventions

The 4D build scripts rely on a specific folder structure and folder and file naming conventions as detailed below. There should be no punctuation marks other underscore or hyphen (in positions indicated in name templates) and no spaces in any file or folder name.



There are two key folders utilised by the image processing softwares: 'nodes' and 'panoramas'. 'nodes' is the main folder for pre-PanoTour image processing, holding sub-directories for each Survey named and ordered as detailed below:

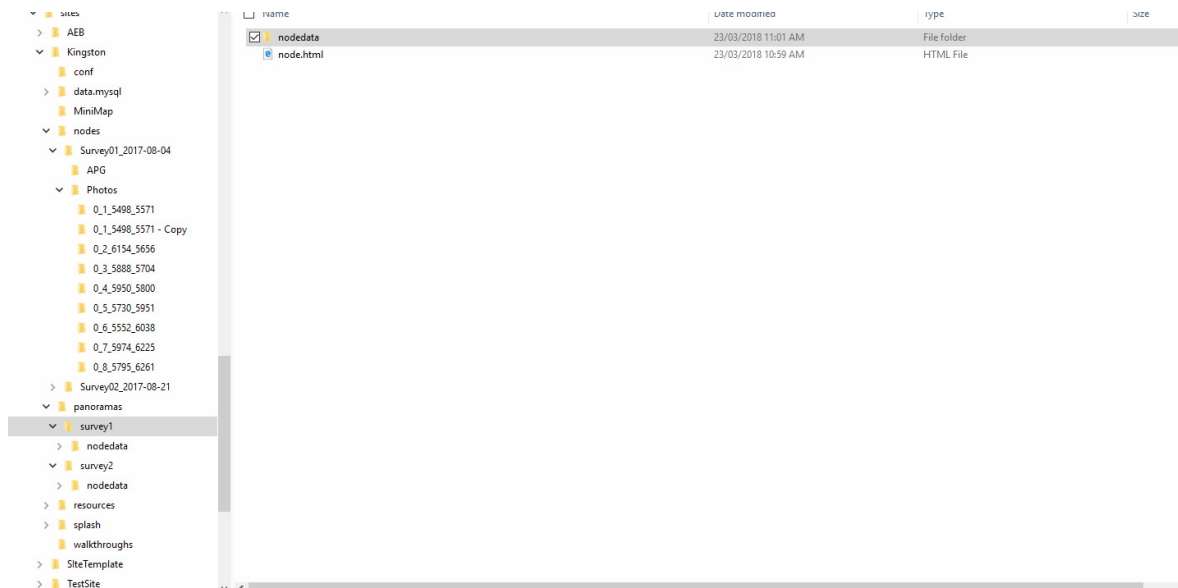
/nodes:

- **/Survey{number}_{date}**
 - a folder for each survey named to include number and survey date in the format: Survey00_YYYY-MM-DD
 - each contains two sub-folders called "Photos" and "APG"
 - **/Photos**
 - contains additional sub-folders for each node in the survey named to show floor level, node number, x and y coordinates in metres
 - **/{floor-level_num}_{node_num}_{x_coord*10}_{y_coord*10}**

- E.g. a node named 2_4_740_84 is node number 4 on floor-level 2 positioned $x=74m$, $y=8.4m$ from the point of origin for the site
 - contains all images (JPG files) from that node to be used in stitching the node panorama.
- **/APG**
 - contains
 - the saved workspace file (**apw** in APG), which allows all nodes to be easily opened if restitching needed
 - **pano** file for each node in survey, saving stitching settings
 - stitched **JPG** panoramas, main output from stitching software
 - the **PTP workspace file (.kpt)** which allows the tour to be opened and re-exported easily if need be (i.e. adding hotspots etc).

/panoramas:

- **/surveyX**
 - contains the PTP output files for each survey (X = survey number)
 - NB from PTP always export to filename '**node**'. No need to worry about naming any other files here as it's all done automatically.



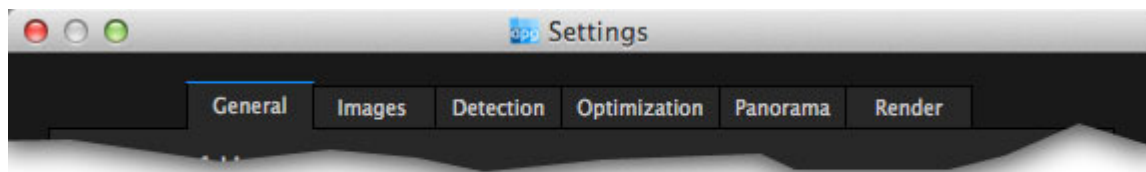
2 Stitch and render node panoramas

This process is illustrated with reference to AutoPano Giga/Pro (APG). However, the main steps in the process apply to other stitching software. Most of the key functions referred to are also generic although the name and location in other software will differ from APG.

2.1 Apply overall setting preferences

Preferences can be manually changed or tweaked as required to improve performance and time. In the case of regular batch processing like the 4Dcle surveys, there are some preferences that should be applied on first starting the software. These settings reduce the number of manual steps and possible errors in the workflow. If there is no 'Apply' button, you may need to 'Quit/Exit' the software and re-open it to save the new settings.

For APG, on a Mac locate via AutoPano/Preferences, in Windows go to Edit/Settings.



2.1.1 General tab:

Most options can be left at default but those worth reviewing:

- Temporary Directory.
 - best if possible to place this in a separate partition on a (fast access) hard drive that does not contain any installed programs, especially APG
- Select 'Multicore' and number of processors if you have better than monocore
- Use the check function for the GPU (graphics processor). If available, enable processing using it
- If you are working on an older computer (especially the GPU) or with limited RAM, lower the display quality of the panorama editor if this option is available.


2.1.2 Image tab:

If the program can't locate EXIF data (OR if using the same value for all image groups) you can set the default focal length here.

Review RAW decoding section, if shooting in RAW format.

2.1.3 Detection tab:

- Detection quality: Standard
- Control points/ Image pair
 - No of points: 50

- Ransac model: Similarity
- Links
 - Layout: Free (unless using motorised panoramic head. In that case select 'Line')
 - Detect links in 'One stack level' (if this option is available. In later versions of APG, the default setting 'The reference level' is suitable)
- Project
 - Folder: use browse to navigate to .../APG for current survey
 - Filename: change to %R0 (where 0 is zero)
 - Click on the  icon for a description of the symbols that make up the models (syntax) of the file name
- Automate
 - Select 'Auto color correction'

2.1.4 Optimization Tab

- Optimization presets
 - Select 'Fisheye'
- Lens distortion correction
 - 'Enabled'

2.1.5 Panorama Tab

- Projection and crop
 - Default projection: Spherical

2.1.6 Render Tab

- Size: 100%
- Interpolator: Bicubic
- Blending Settings
 - Select 'Anti-ghost'
- Format
 - JPG/JPEG
 - Depth: Select '8 Bits'
 - Quality: 12 (maximum)
 - DPI: 72
- Exported data:
 - Data: Select 'Panorama'
 - Options: (none selected)
- Output
 - Folder: %p (Click the info button to check template)

To save these settings, Quit/Exit program. Re-start.

But NB Detection and Render Tabs will need to be re-visited each time the node images of a new survey are processed:

- The Detection Tab/ Project
 - Folder - Use browse button to navigate to /Survey.../APG folder
 - Filename – check (in APG this is still %R0) so that each node panorama is named automatically from the node folder name
- The Render Tab/Output
 - browse to /Survey.../APG folder if necessary

2.2 Process the images

The following steps are generic to all stitching softwares. However, the illustrations are from APG.

2.2.1 Import image folders/files for the panorama(s)


If possible (as in APG), drag and drop all node folders from the survey to be processed to the Groups window (or equivalent). Otherwise, use import option.

Group Creation criteria may need adjusting.

2.2.2 Check image info, quality and group settings

EXIF data on lens and focal settings as well as time is usually embedded in the image file and is displayed in side bar when each group is created. APG uses the time to sequence shots in the group. Check:

- details for selected individual images in group using **Image Info** button
 - if EXIF data not available you will need to open 'stitching/ detection preferences' from button on group menu and manually set
 - camera lens type (eg fisheye)
 - focal length and focal length multiplier (depending on sensor type)
- Image quality
 - Use **Circular crop tool** on fisheye images to clean edges, especially if vignetting or chromatic aberration is an issue
- 1st image in the group is the North shot with remainder in compass point sequence
- Detection and Render settings and make sure appropriate folders for Project and Output are selected.

In APG, each group is headed by a tool bar. To view settings dialogue use  . Check

Detection Tab

- Project /Folder
 - Should show current Survey.../APG but use browse button to navigate to /Survey.../APG if necessary
 - Filename should show the node folder name

Render Tab

- Output/Folder
 - browse to /Survey.../APG


2.2.3 Save the workspace

You should see this file (.apw for APG) in the /Survey.../APG folder.

2.2.4 Launch detection

This starts the image alignment/ control point creation function, which analyses all selected photos in a group producing as many control points as possible and displaying the resulting potential panorama in the Panorama window.

You can run the detection function individually for each group, or run (all groups) batch detection.

In APG, for individual group detection click run button  on tool bar at top of group. To process as a batch, click run button at bottom of (main) group window.



A batch processing dialogue will pop up showing groups included in the batch and the detection status of each during processing. Check node names are as expected and, if not, cancel and re-apply file name template (%R0) in Preferences/Detection Tab

2.2.5 Check assembly quality in Panorama editor

Examine the panorama previews for issues in stitching as well as image quality. You are looking for

- a continuous image, without visible stitching artefacts, such as abrupt lines or other misalignments
- reasonable photometric balance
- A Global RMS (average error in pixels) lower than 5, flagged green means less (but not no) need to edit
 - NB even with a low RMS, check for lens distortion.

If satisfactory

- SKIP to **2.2.6 Save all panoramas**

If not, try adjusting settings, control points, alignment and color anchors until satisfactory:

1. Global RMS is high and flagged orange or red (because of poor image quality, parallax errors or other issues), control points need to be edited and / or set up manually.
2. Check that optimization configuration (open **Preferences**, click on **Optimization** tab) is correctly configured for the image group. For 4D app
 - a. Select **Fisheye**
 - b. Lens distortion correction should be **Enabled**
3. Open **Control Point editor** (or equivalent function in other software to edit/ set up control points manually – the process is generic):
 - a. select two neighbouring images that are supposed to link together
 - b. click on an element in one image that is identical with an item visible in the 2nd image (i.e. a shared element)
 - c. then click on same detail in the 2nd image to create the control point
 - d. make sure there are a minimum of 5, and preferably more than 10, control points with good RMS values between these two images before moving on to the next image pairing
 - e. Repeat for each image pairing in the whole panorama sequence
 - f. Once you have enough good control points for the whole sequence, remove (edit out) any that are poorly aligned
 - i. From APG v4 this is done automatically during Quick or Full optimization if this setting has been selected (usually set to On by default but look at this when setting preferences)
 - ii. In other software, you may have to delete manually
 - g. Start **Optimize image** position function
 - i. after changes via Control point editor
 - ii. there are two (Quick and Full) optimize buttons in APG. **Quick** will optimize (locally) just for the immediate changes. **Full** will re-optimize the whole panorama.
 - h. Return to Panorama editor, when satisfied.
 - i. NB In APG,
 - i. there are a variety of tools to help optimize control points (access some via Contextual Menu – right click in window) further details at http://www.kolor.com/wiki-en/action/view/Autopano_-_Panorama_Editor_-_Control_Points_Editor
 - ii. Extra help for difficult cases at http://www.kolor.com/wiki-en/action/view/Autopano_-_

[Common cases that don't stitch automatically - Repetitive patterns](#)

- iii. If the GPU calculation option in Preferences of the software is enabled, use "**Quick Preview**" function in Panorama Editor to view results after any changes and prior to final rendering
4. **Layers editor** icon in APG Panorama Editor opens tools for working with double or triple exposure (or in-camera HDR shots) 'bracketing' i.e. overlaying several shoots of same image close in time in order to combine best or different parts of photos into final image, such as through window/ door shots. Needs some skill in e.g. Photoshop layer work
5. **Layer mask** tool (only in AP Giga) can be used to edit objects in or out of the overlap zone. Useful where some object/subject has moved between shots e.g. vehicle/ pedestrian/ bird etc
6. **Align** the panorama if necessary – In APG Panorama editor there are icons for **Horizontal** and **Vertical**
 - a. Vertical alignment is only available with Spherical and Rectilinear projections
 - i. Check **Geometric Projection** is set to Spherical in Info area (use icon in Panorama Editor toolbar to change if necessary)
 - b. If final render is launched from Main Window 'automatic alignment' is applied but may not be successful. Best to view and edit alignment from Panorama Editor and later launch Render from there after using Quick Preview to check for any remaining flaws.
7. Open **Colour Editor** to start photometric optimization function
 - a. This looks at exposure and white balance across all images in panorama and equalizes imbalances
 - b. In APG to do this
 - i. click on "**Edit color anchors**" icon, this will open a new menu (None, Auto, HDR). Some general options are available. Make sure Vignette and Gradient are activated. Select all items under Properties to preview re-optimized result after any edits to colour anchors
 - ii. Select **Auto** to start function. Colour anchors will appear on each image. The reference anchor is in yellow. You can change this to another position or add extra reference anchors, if really required. Contrast can be modified for a selected (full) photo or luminosity (white/black balance) at threshold only. Colour (white balance) can also be adjusted.

Preview results to this point, if okay, move on to next process (2.2.6 Save all panoramas).

If not, you can

- start again (recommended if learning 'how to' use software on practice node shoots – the value of impeccable photographic equipment set-up becomes clear)

- discard the node (recommended if remaining node panoramas are acceptable quality and this node makes no vital contribution to a specific learning activity)
- re-shoot the entire survey (recommended when remaining node photography is also marginal)

2.2.6 Save all panoramas


Check that each group is named for the appropriate node

Can save individually or in batch (all groups)

- to Survey00_YYYY-MM-DD /APG/{floor-level}_{node_num}_{x}_{y}.pano

2.2.7 Launch final render

Initiate stitching function to produce finalised panorama(s):

- In APG, click on the Render icon in the Panorama Editor to open the Render (settings) dialogue window.
- Check settings especially
 - Blending presets : anti-ghost
 - Format: JPG , 8 bit
 - Compression: 12
 - Exported data : Panorama (do NOT embed outputs)
 - Output:
 - Folder should point to /Survey.../APG
 - Filename (in APG: a%)
- Click on Render button on the Render settings dialogue to open batch processing dialogue window
- Check that each panorama is correctly named for the node as added to the queue
- Launch Render  from Batch dialogue tool menu bar.

When panoramas for all nodes in that survey are complete, continue to PanoTour process.

3 Render survey virtual tours

It is currently mandatory to use PanoTour (PTP) from Kolor (the 'light' version excluding a krpano licence is quite adequate) for the virtual tour render process. It is also mandatory to follow the folder structure and folder and file naming conventions outlined earlier in this guide.

During the stitching process, node and survey data is embedded (as EXIF data) in the final panorama JPG files. The format at this point is generic (for all stitching softwares) and incorporates meta-data derived from the original folder structure and names as well as node filenames. When rendering Survey virtual tours, the software draws on this meta-data to structure views, rotation, and other elements of the tour.

However, on exporting, the virtual tour formats (images, tiles, and associated meta-data tables) differ between softwares. The automated build scripts to create the 4D site have been designed to handle files and meta-data tables in the format produced by PanoTour. There is no plan to re-write the scripts to handle output formats of other softwares, at this time.

3.1 Start PanoTour

[http://www.kolor.com/wiki-en/action/view/Panotour - Interface overview#The Basics](http://www.kolor.com/wiki-en/action/view/Panotour%20-%20Interface%20overview#The%20Basics)

3.1.1 Open a new project

Each survey comprises a new project named for the survey being processed.

3.1.2 Import all the panorama files for the survey

Select, drag and drop or use import function.

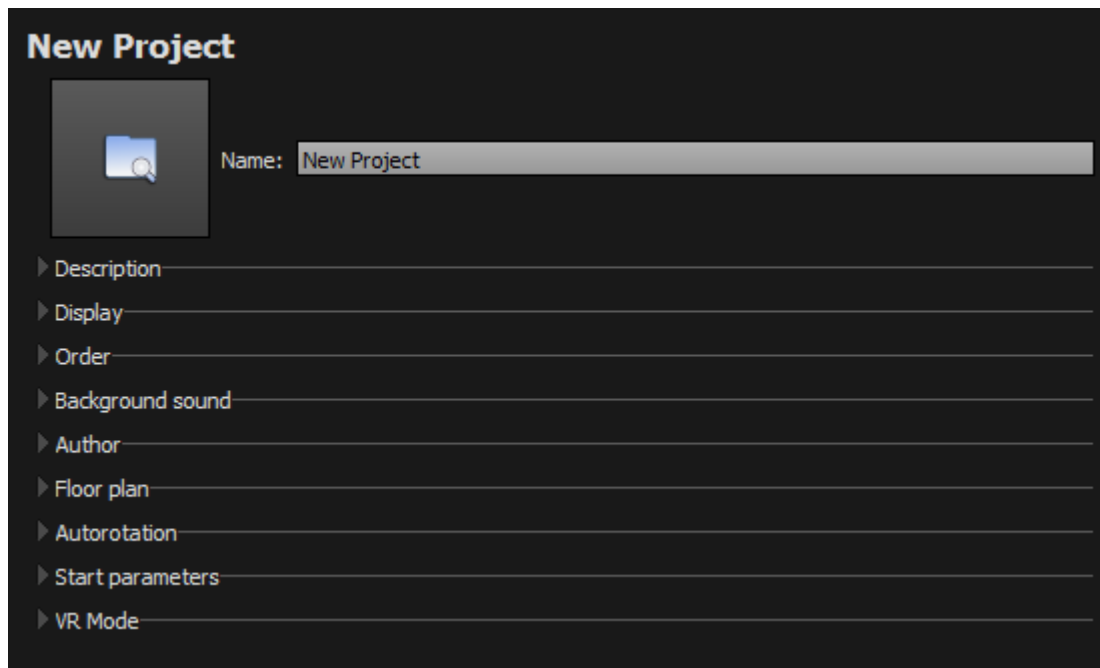
Panoramas must be

- of adequate viewing quality
- saved as JPG Files by node name and located in:
 - /nodes/Survey.../APG

3.2 Set Project and Scene properties in the Tour tab



3.2.1 Project Properties



Change Project name to SurveyX, where X is the survey number

Ensure all items in '**Start Parameters**' are unchecked.

3.2.2 Scene Properties (for each panorama)

Select a panorama (or some/all at once if property edits will be the same in each instance).

Ensure Output projection is spherical.

You can edit defaults for

- the point of view, the default angle, the maximum zoom-in and zoom-out
- if you want the whole image or to perform a partial reframing of a less interesting part

Click on  for info

Tour Directory: navigate to /panoramas/surveyx

[http://www.kolor.com/wiki-en/action/view/Panotour - Tour - Scene properties](http://www.kolor.com/wiki-en/action/view/Panotour%20-%20Tour%20-%20Scene%20properties)

3.2.3 HotSpot editor

Can use to

- limit the top (zenith) and bottom (nadir) view of panoramas without patches e.g. when view includes choppy edge at top (sky) and/or tripod legs, use the crop tool



. This does not actually crop the saved panorama image but limits the screen view on some devices

- add inter-node hotspots when you are developing an additional resource (tutorial) such as a ‘walkthrough’ of a specific section of a building. This provides a timed sequencing of views
- add equipment hotspots (polygonal). The URL should be set to ‘equipment’(name) and the URL path (relative) should point at a Folder and a ResourceInventory.xls Tab named HotSpots – see Resource Inventory guide.

3.3 Set properties on the Build Tab

<http://www.kolor.com/wiki-en/action/view/Panotour - Build tab>

Edit Output, Target and Tiles to show:

Output:

Folder: panoramas/surveyX
(X = survey number e.g. survey1)

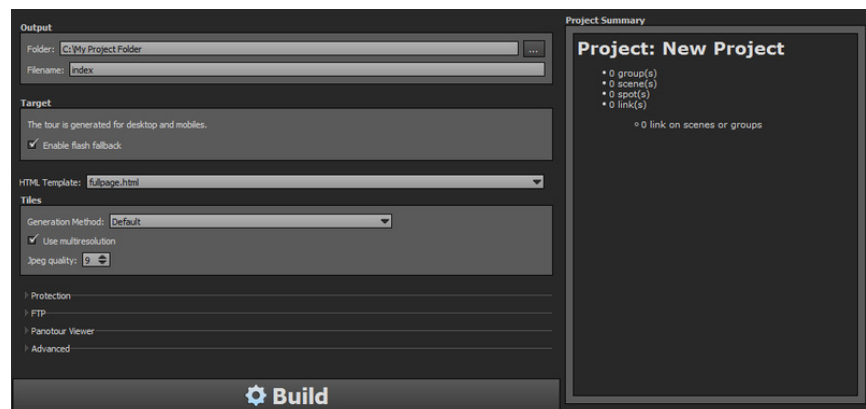
Filename: node

Target:

Uncheck ‘Enable flash fallback’

Tiles:

JPEG quality = 12



3.4 Launch ‘Build’

The rendered survey ‘virtual tour’ should save to **panoramas/survey{X}**. In this folder you should find one file called ‘node.html’ and a sub-folder called nodedata.

3.5 Save the project

In case you need to edit this tour later e.g. to add hotspots, save the PTP project to **APG/survey.kpt**

3.6 Transfer tour data to UQ

Zip the panoramas/survey{X} folder. Upload to Cloudstor and send to eLIPSE at agreed intervals (using pre-arranged voucher if not an AARNet member).