4D construction learning environment

virtual tour making

4. Photography

Team leader:

Dr Chris Landorf

Contributors:

Calum Prasser
Jayesh Naran
Bram Chapman
Rick Hill
Lorinne du Toit

Edited by:

Rick Hill
Lorinne du Toit

Requests and inquiries concerning these rights should be addressed to:

Dr Chris Landorf
School of Architecture
The University of Queensland
Brisbane Queensland 4072

Table of contents

1 Overview

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 finished quality of a virtual tour is entirely constrained by the quality of the original photographic images. While some problems on images can be edited before assembly (e.g. in a photo editing software), this adds a considerable burden of time and cost, even if the team has access to high-level editing skills.

The aim of this guide is to provide a practical, illustrated reference for the photography team, with the objective of consistently producing enough good quality images at each node (camera position) survey, irrespective of photographer, to quickly and easily stitch and render the 360° panoramas that comprise the node survey virtual tours.

Separate guides cover the processes for a) establishing camera positions (nodes) on and around the site; b) stitching node images and rendering the panoramas; and c) assembling the panoramas (using PanoTour) into virtual tours. Download from http://4dconstruction.architecture.uq.edu.au/

Advice is included here on equipment preparation, camera settings and other points on spherical panoramic photography relevant to 4D VT survey production using Canon Fisheye on APS-C sensor but applies generically for alternative kit. Refer to specific manuals for equivalent detail.

A separate 'Quick start' workflow guide can be printed and kept with equipment.

2 Preliminaries

This guide assumes that initial project preparations have set up:

1. The focus of surveys at each stage of the construction process (outline story board)

2. A preliminary plan and survey site map, with the construction management team/site manager involvement, concerning:

- likely camera positions (nodes around which the images rotate for 360˚ panorama)

- frequency of surveys

- access issues including

    o valid construction induction cards (a White construction card in Australia)

    o full personal protection equipment (PPE) (construction helmet, protective glasses, gloves, high visibility long sleeve shirt, long trousers and steel-cap boots)

    o site induction and sign-on register procedures

3. Access to the photographic equipment and image processing software required:

- Fisheye 8-15 mm eg Canon or Nikkor

- 20-25 MPixel sensor in light-medium weight camera body

- Tripod with levelling base (integrated or mountable)

- Panorama head with at least 360° click stop rotator on horizontal plane

    o with crop frame sensor, the head package should include zenith adaptor

    o with full frame sensor, a tiltable head may avert need for zenith shot

- SD memory card (min 32-64 GB with read speed of around 95Mb/s)

- Image processing software

    o Stitching panoramas (equivalent to Autopano Pro)

    o Virtual tour linking (required PanoTour)

3 Pre-Survey preparations

Since planned camera positions may become unavailable for a period or disappear altogether over time it is important that measures are in place before survey photography starts regarding:

- procedures for documenting planned and unplanned camera positions

- a spreadsheet/database structure for linking camera positions (nodes) to surveys, to track

   o shifts in X and Y coordinates of existing nodes

   o irregular surveys from any individual node

   o new camera positions (you will need this data when downloading photos into node folders)

- Folder structure using project naming conventions for nodes, surveys and the applicable images (see Appendix for detail).

Allocate enough time in advance of live survey shooting for photographic team training on camera equipment, recognition of source image quality requirements, the administrative procedures above and using the panorama stitching and virtual tour rendering software.

3.1 Set up and test the camera equipment

Overall processing time is minimised when the camera and lens are set up to avoid parallax problems (rotational point on panorama head), as well as issues with exposure levels (luminosity), vignetting and white balance. Regular lens inspection and appropriate cleaning (check lens manual) will avoid artefacts in the images like dust specks and finger-prints.

You will need to establish, via field testing

- the rotational point of the kit when mounted on the tripod/ panorama head

- the 'best' average focal length (8mm-15mm) for the site

- settings for the camera (both outdoors and indoors).

3.1.1 Lens and sensor basics

The Canon EF 8-15mm f4 L F/Eye on the APS-C (22.5 x 15 mm) sensor, set at a focal length of 10 mm and shot in portrait, can provide a sufficient angle or field of view for a 6 shot panorama on the horizontal plane with reasonable zoom in finished virtual tour (VT). On a full frame sensor, using a tiltable panorama head, a focal length of 8mm may create a usable panorama in 4 shots. However, the images will suffer vignetting and need cropping, further depleting the depth of view in the resulting panorama.

The figure below shows how different focal lengths (e.g. on the Canon EF 8-15mm f4 L F/Eye Zoom) map to a full frame (35.9 x 24 mm) versus a x1.6 crop frame (22.5 x 15 mm) sensor.

Figure 1 Mapping of focal length to alternate sensors
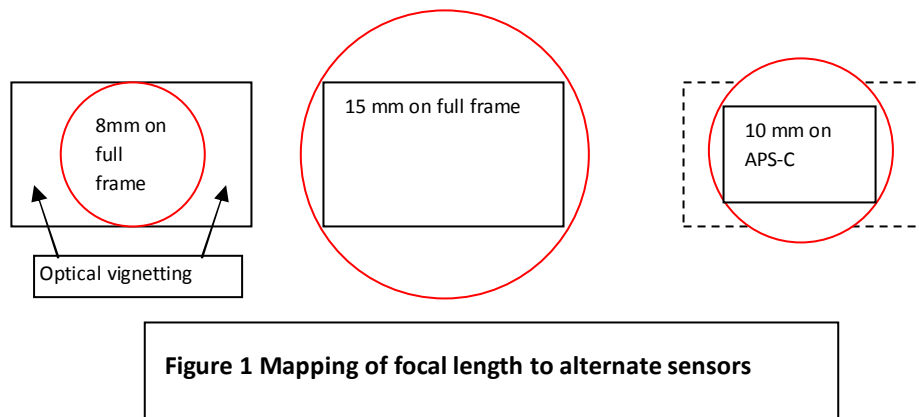
In general, to achieve a reasonable quality zoom capacity in a virtual tour viewed on a PC monitor (e.g. 1280×720 pixels), the stitched panorama image needs to be 12-17,000 pixels wide. The Canon APS-C sensor provides a maximum resolution of 5472 × 3648 pixels. The standard full frame (35.9 x 24 mm) provides resolutions up to 6240 x 4160 pixels.

Once the most appropriate focal length for the site has been established, this will be 'fixed' for project duration. The aperture setting (e.g. f/4-f/16), established on survey day, is fixed for the survey. The remaining variables, shutter speed and ISO, may need to be varied according to light conditions between nodes, and in interior shoots may need to take account of light conditions at openings (doors, windows, etc). Bear in mind that the sharpness of the image can suffer at higher ISO values, although built-in software in the Canon can reduce 'noise' up to ISO 1600.

Download and install lens correction firmware, if available, to provide in-camera correction of lens issues like peripheral illumination and chromatic aberration and reduce post-shoot editing.

3.1.2 Set up and level the tripod and panorama head

The position of the lens above ground/ floor level needs to stay constant throughout a survey and, if possible, the entire project.

So, on the first occasion, referring to manufacturer instructions (manuals):

- set up the tripod on a level surface
- adjust level using levelling base or equivalent
- attach the panorama head
- mount the camera and lens
- adjust the tripod to a comfortable or, at worst, average height, taking account of height differences among photographers, such that all can view setting displays
- using a tape, measure and note the height, from an appropriate marker e.g. middle of lens or top of camera, above ground level

- field test this at several nodes around the site and adjust as necessary

- include tape and height instruction in photographers' equipment bag

3.1.3 Locate no-parallax point (NPP) for Lens and focal lengths

Fasten the camera vertically (portrait position) on your panoramic head. Move the lateral sliding stage, if any, so that the centre of the lens seen frontally is placed just above the rotary axis of the head. The setting must be made as accurately as possible.

Use the rails to position the entrance pupil of the lens/ focal length (if Zoom) vertically and horizontally above axis of the panorama head rotator, shown in photos to right (sourced from Arnaud Frich). As the camera rotates, the lens entrance pupil should stay in the same spot, avoiding parallax issues i.e. no gap between the fore and background on rotation.

The ideal rotation point is always the same on a panorama head for a given camera, lens and focal length (as well as degree of tilt if any). There is a standard method for discovering the NPP. The following short video explains the basics (https://www.youtube.com/watch?v=k0HaRZi-FWs). A more detailed article found at http://www.johnhpanos.com/epcalib.htm has advice relating to cameras mounted on Nodal Ninja heads as well as discovering the Least Parallax Point (LPP) for Fisheye lenses.

Due to the optical qualities of Fisheye lenses there is only an LPP, which varies according to the intended rotation angle (number and type of shots in the panorama) as well as focal length. Adding tilt changes the LPP. See figure 2 for illustration.

Test using trial method, taking and stitching at least two shots at each likely position. Adjust rail as necessary. Do this for each focal length and rotation degree on horizontal plane.

Figure 2 Canon Fisheye on FF sensor set at 8mm for 4 shot 360° tilt

Once you have established the focal length, and camera position for the project, use a more permanent mark on the rails.
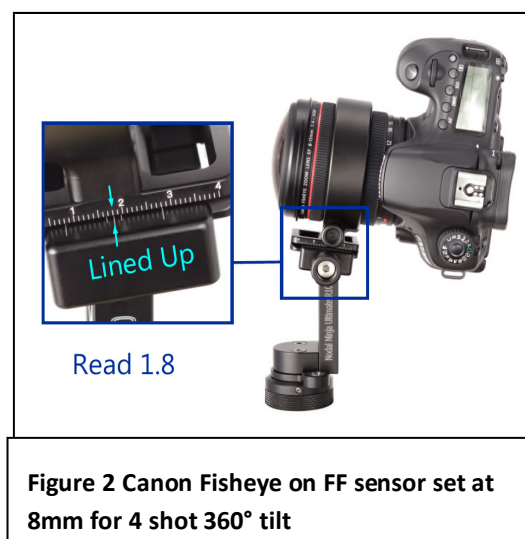
Figure 3 provides an indication of where the LPP can be found for each focal length on the Canon 8-15 mm Fisheye.

Figure 3 Approximate LLP for each focal length

3.1.4 Decide focal length for site

The aim here is to get best depth of field while retaining sufficient width to ensure around 25-30 % overlap (overlap can range from 10% minimum to 35%) of images. Focal length for the site needs to be established during the testing phase i.e. when establishing likely 'nodes' on the site (and site plan). An 8mm setting may not be suitable although this provides greatest width, partly because it may not give the best depth for use (zooming into detail) in the finished virtual tour. It is likely that 15mm will not provide adequate coverage.

A mid-range 10-11mm on a crop frame sensor or around 14mm on a full frame sensor is likely to work for most sites. Test each focal depth setting with a range of aperture (f-stop) settings. Take the 7 shots (6 horizontal and 1 zenith) with each combination of settings and create a panorama using your stitching program. Note all the camera settings for each test run and check the individual image information provided by the stitching program against this as well as final panorama quality. Look carefully at the image size (in pixels). More pixels give more data but file size increases so a balance needs to be struck. However, the image size should be in the ratio of 2 (height) to 1 (width) minimum and the panorama should yield a minimum of around 12,000 pixels.

3.1.5 Hyperfocal adjustments

The aim here is to achieve sharp focus throughout the image i.e. no blurring anywhere. The focus distance setting on the EF 8-15mm f4 L F/Eye is sensitive to very small adjustments (rotation) with the manual setting ring as well as to (extreme) temperature change. Results from manual setting of the 1-infinity scale require testing as the hyperfocal point may vary from lens to lens. The rotation distance across the 1-infinity scale is very small (1.5 mm) and a crisp focus achieved with very small adjustments. For greater discussion, see http://michel.thoby.free.fr/Canon_8-15mm/8-15mm_review.html

3.2 Exposure settings

Aperture controls the size of the hole through which light passes. The **shutter speed** controls how long the hole is open. And **ISO** speed controls the light sensitivity of the film or sensor. By adjusting these settings to different light conditions, photographers can get the clearest and sharpest shots.

Bear in mind that all images in the panorama (at the node) should be shot at the same exposure. Interior panoramas that include views of windows, doors and other openings need a different approach. This is usually 2 or more photos, with exposure adjustments, before rotating to new position and previous node settings. See link below for advice:

https://www.panoramic-photo-guide.co.uk/virtual-tour-360-photography/measurement-of-the-light-360-photography.html.

3.2.1 Camera light metering

In most digital cameras, when you press the shutter button halfway, the f-stop (aperture), shutter speed, and ISO speed appear in the viewfinder, the Shooting Settings display and LCD panel. With the Canon in Live View mode, the exposure data also appears at the bottom of the monitor and takes a form similar to that in the viewfinder.

Try out the different metering modes of the built in light meter. Evaluative (in Canon) or Matrix (in Nikon) metering is particularly useful for averaging light across a scene but there are draw backs as well, see link below for useful details

https://digital-photography-school.com/understand-camera-light-meter-desired-exposure/

Learn how to interpret and use the exposure histogram (in Live View or from test photo of scene).

The main steps for establishing exposure settings at a node are:

- Measure the average quantity of light shining on the scene or in the room. Avoid measuring the zones that are obviously more or less lit than the whole of the scene because this could deceive both the exposure metre in the camera and the sensor.

- Look at contrast differences between the different important parts of the panorama sphere to judge if the sensor dynamic will be sufficient

- If shooting inside, check differences between indoors and outdoors through the openings, to see if and where you have to change the exposure settings and perhaps duplicate the shot for layer merge/editing later (or use HDR if shooting in JPEG format).

Switch to manual setting for the white balance when working in JPEG and select an appropriate value from the menu.

3.2.2 Experiment with alternative settings

Select Aperture Priority mode and test different f-stops, noting camera suggestions for ISO and shutter speed.

Larger aperture numbers result in smaller opening and thus level of light but larger depth of field. Apertures like f/8, f/11, or f/16 help capture sharp details in both the foreground and background (especially useful for landscape shooting).

If the photo is too bright or dark at a particular aperture setting, adjust your shutter speed to compensate and/or raise ISO if sharp shutter speed limit is reached.

In reasonable daylight, low-sensitivity ISO 100 is normally adequate. ISO becomes more important in low-light conditions. If you raise the ISO, the increased sensitivity allows you to keep a fast shutter speed but may increase noise.

Compensate for exposure differences between nodes via ISO and shutter speed. Aperture corrections are likely to be required during a survey when some of the nodes are positioned indoors.

3.3 Select image format

A decision about whether to shoot in RAW (easier to fix several types of issue on image before converting) or JPEG (minimum touch up possibilities) format will need to be made before survey photography starts. Shoot a test panorama (of same scene) in both formats at several focal lengths to check for lens distortion, vignetting, white balance and other issues. Check what things can be fixed in each case. Decide then what suits the project best.

Tips

Use a wireless remote control (clicker) or even the self-timer set at 2 seconds to avoid camera shake at slow shutter speeds and photographer's feet showing.

Don't forget to set the rotator to the right number of notches you need.

4 Shooting the survey

Allow time for preparing equipment, entering site and confirming accessible nodes:

- Don protective clothing
- Set up tripod, mount pano head
- Check lens for correct focal length (set for project)
- Mount lens and camera at N/LP point. Check levels
- Follow site sign-in procedure
- Check with site manager for node availability
- Log node information

At 1st node:

- Adjust tripod to survey height, level and lock
- Set mode to Aperture Priority
- Scan site, noting exposure information
- Adjust
  - aperture to average light (set for survey)
  - ISO and shutter speed
- Switch to manual to maintain settings for all panorama images
- Fine-tune hyperfocal (1-∞)
- Position camera/lens to North (use compass), check all settings & levels

Shoot panorama images at each node according to Figure below
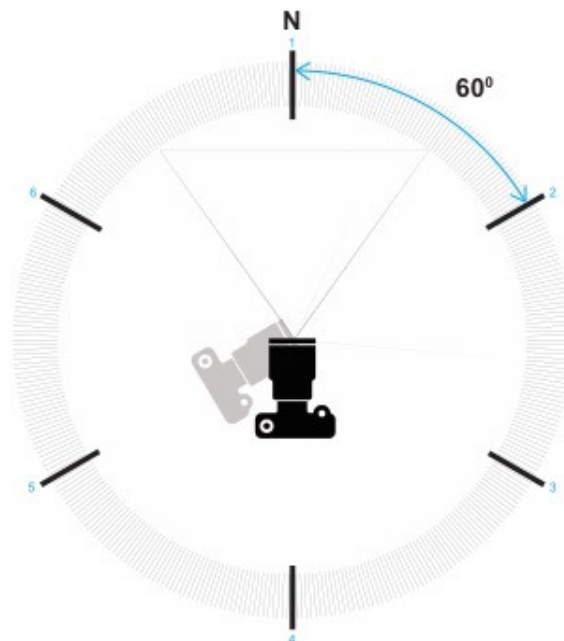
Optionally shoot zenith and/or nadir.

Check image quality. Repeat shoot if necessary

Move to next node.
- Note any node that must be skipped or which has coordinate changes, listing reasons for this.
- Level tripod.
- Check exposure settings.
- Adjust ISO and/ or shutter speed if needed

Repeat for all nodes in survey

Post survey:
- Add/copy any notes to node data table.
- Download images for processing to appropriate node folders as per 4D folder structure and naming convention: nodes\SurveyXX_YYYY-MM-DD\Photos\{floor-level}_{node_num}_{x}_{y}/*
- View images, edit as required

Proceed to image processing.

Appendix: Folder structure and filenames for images

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**
  - where X = survey number (1-n)
  - contains the PTP output files for each Survey
  - NB from PTP always export to filename '**node**'. No need to worry about naming any other files here as it's all done automatically.