Guidelines for image acquisition of structures with drones

1 CONTENTS

2 SUMMARY

This document provides general guidelines for photo acquisition of structures with drones for 3D model reconstruction in EasyInspect Cloud.

More specific guidelines for structures of interest like wind turbines or houses, can be found in the appendix of this document.

3 CAMERA

3.1 SUPPORTED CAMERA MODELS

Photos taken by all types of ordinary digital cameras are supported, e.g. by:

- DJI X3/X5/X4S/X5S/P3/P4/Mavic
- Smartphone cameras
- Compact cameras
- Semi-professional and professional SLR cameras

The following camera types are **not** supported:

- Linear push broom cameras
- Rolling shutter cameras under fast motion

3.2 FILE FORMATS

3.2.1 Images

The image file formats should be JPEG files. Do not edit the images before uploading as EXIF data may be lost. If editing is needed before upload, keep the original EXIF data and image size. Do not crop the images.

3.2.2 Videos

It is not possible to use video files as source for 3D reconstruction.

3.3 CAMERA/LENS CONFIGURATIONS

It is strongly recommended to use lenses with fixed focal length, that is without zoom. If the photo acquisition is done with lenses with variable zoom, it is recommended to choose proper zoom prior to the photo-session and fix it in this position (e.g. with piece of tape) for the duration of the photo session.

In addition to lenses with ordinary focal lengths the system supports wide-view fish-eye lenses. Extreme lens distortion can be identified by the system. We recommend lenses with little distortion.

If the camera model is not recognized by the system, the camera sensor size will be guessed and may lead to wrong calculations and reconstructions.

In general, higher resolution camera sensors are better as they ensure more details for the reconstruction process in the images of the structure of interest.

3.4 CAMERA SETUP

3.4.1 General

Using optical and digital image stabilization functions in the camera is not recommended for the 3D reconstruction purposes and should be avoided.

The auto-rotate feature in the camera should be deactivated.

3.4.2 Focus and focal length

The structure of interest in the images should always be in focus. Images with the structure of interest not being in focus can significantly affect the quality of the 3D reconstruction results.

Fixed focal length (no zooming) is strongly recommended during entire photo session. If needed, images can be taken in groups with fixed zoom settings across each group. The 3D reconstruction process can automatically distinguish and group images with different focal lengths. Digitally zoomed images must not be used in the reconstruction process, and thus, this camera feature should not be used.

3.4.3 Light and Exposure

Try to ensure constant and homogeneous lighting whenever possible. The ideal case is when the structure of interests has sufficiently strong constant uniform light on all the surfaces without shadows on them.

Under- and over-exposure should be avoided as they significantly affect the reconstruction process. Exposure settings should be chosen such that no motion blur occur in the images. Automatic exposure can be used to facilitate correct exposure. With sufficient skills in photography and stable uniform lightning conditions, manual exposure control is recommended to reduce color discrepancies.

Ambient constant lighting is significantly better for the reconstruction purposes than direct and/or variable lighting as this can easily cause overexposure and underexposure. Therefore, the best weather for outdoors photo-shooting of structures for 3D reconstruction is during the days with full cloud cover and no rain. These weather conditions provide most homogeneous light on the object, no strong reflections and no contrast shadows.

If photos must be taken on a sunny day, take them around noon to minimize shadow areas. Correctly exposed shadows do not affect the result quality of the 3D reconstruction process, but the shadows will appear in the texture map of the generated 3D model.

Using flash light should be avoided.

3.4.4 Positioning

GPS position tags are supported and extracted automatically from photo EXIF metadata, if provided. However, GPS position tags do not have to be present in all the images and the 3D reconstruction process can succeed. Incomplete GPS tags are ignored and proper scaling of the 3D model of the structure should not be expected if there are less than 3-4 photos with correct GPS position tags.

4 PHOTO SESSION

Each part of the structure of interest that is required to be reconstructed in a 3D model should be photographed from at least three distinct viewpoints. These viewpoints should neither be very similar

nor radically different, but rather progressively varying from one to another. In rough numbers, this corresponds to 30-50 images of the structure of interest evenly spaced all 360° around it, see Figure 1. In addition to the requirement of minimum three images of each point of the scene, each point must be captured in at least two adjacent photos. Try not to get too much horizon or distant objects in the images if possible.

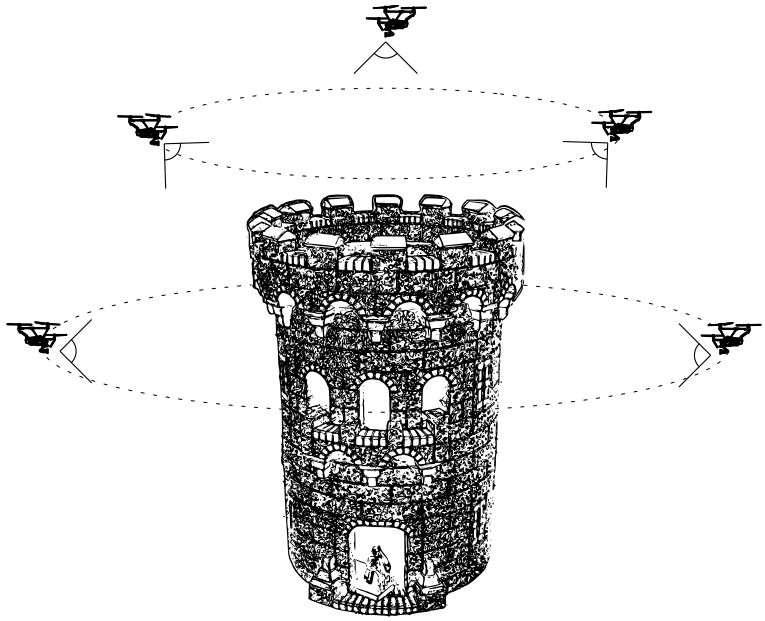

Figure 1 Example of drone position orbits during a photo-session for 3D reconstruction of a tower building

Generally, the overlap between two consecutive images should be not less than around 2/3 or 60% in terms of the image content. At the same time, two consecutive images should not be more than 15° apart in the sense of camera view direction.

It is typically desired to obtain uniform resolution for the textures of the reconstructed 3D structure of interest. To achieve that, all the images should be taken from approximately the same distance from the structure.

If higher resolution is desired for certain regions of the structure, it is recommended to take close-up images in such a way that the transition from the original distance to the close-up distance is taken in a smooth progressive manner with a reasonable number of images at intermediate distances from the structure of interest.

For aerial photography (land mapping), a longitudinal overlap of 80% and lateral overlap of 50% or more in terms of photo content are recommended.

It is very important to note that to obtain proper height levels of the reconstructed 3D model it is necessary to take at least one image just before the drone take-off and one image just after the drone has landed. The content of these images is not very important, it is the altitude sensor readings that are of the main interest.

To ensure that all required photos will be taken during a photo session, it is generally a very good idea to make a plan of the photo-session before commencing it, e.g. by using the DJI Ground Station Pro App for autonomous flight and flight planning.

More specific guidelines for particular type of structures of interest like wind turbine or house, can be found in the appendix of this document.

5 PHOTO EDITING

The 3D reconstruction system requires strictly **original** photo images with original EXIF meta-data. Do not manipulate photos by resizing, cropping, rotating, denoising, sharpening or adjusting brightness, contrast, saturation or hue prior to inputting the photos! In addition, photo editors typically compress images and remove the EXIF data which significantly reduces the quality of the 3D reconstruction.

Stitched panoramic photographs are also not supported.

6 CONTROL POINTS

User-defined control points with accurately measured GPS locations can be input to facilitate the reconstruction process. Minimum three control points are required for accurate geo-referencing; however, it is recommended to establish five control points within the scene. Out of these five control points, the first four should be in the corners of the reconstructed scene and the last one in the center of the scene. This approach provides best results when geo-referencing.

If the reconstructed scene is significantly large so that long-range effects can be expected, a larger number of control points well-distributed across the scene is required.

7 LIMITATIONS

There are some limitations connected with the 3D reconstruction algorithm:

- Transparent or shiny parts cannot be properly reconstructed, e.g. glass, water, etc.
- Reconstruction quality of the structure parts with uniform texture (plain walls, uniform color surfaces, etc.) is typically low
- Reconstruction quality of the reflective, shiny or transparent structure parts is very low

8 APPENDIX A. IMAGE ACQUISITION OF PARTICULAR STRUCTURE TYPES

8.1 WIND TURBINE

For successful 3D model reconstruction of a wind turbine it is recommended to acquire photos of the wind turbine in several 360° orbits at the same distance from it with 15°-20° step between the adjacent photos in each orbit, see Figure 2. This configuration corresponds to approximately 18-24 images from a single orbit.

It is further recommended to fly three orbits around the wind turbine to provide three distinct view attitudes: -15°, 30° and 60° with respect to the horizon. In all images the camera should point approximately at the hub center, has the entire turbine in sight, and has sight of the ground for better reconstruction results, see Figure 3 for visual reference.

All in all, a full photo session around a wind turbine constitutes to around 54-60 images.

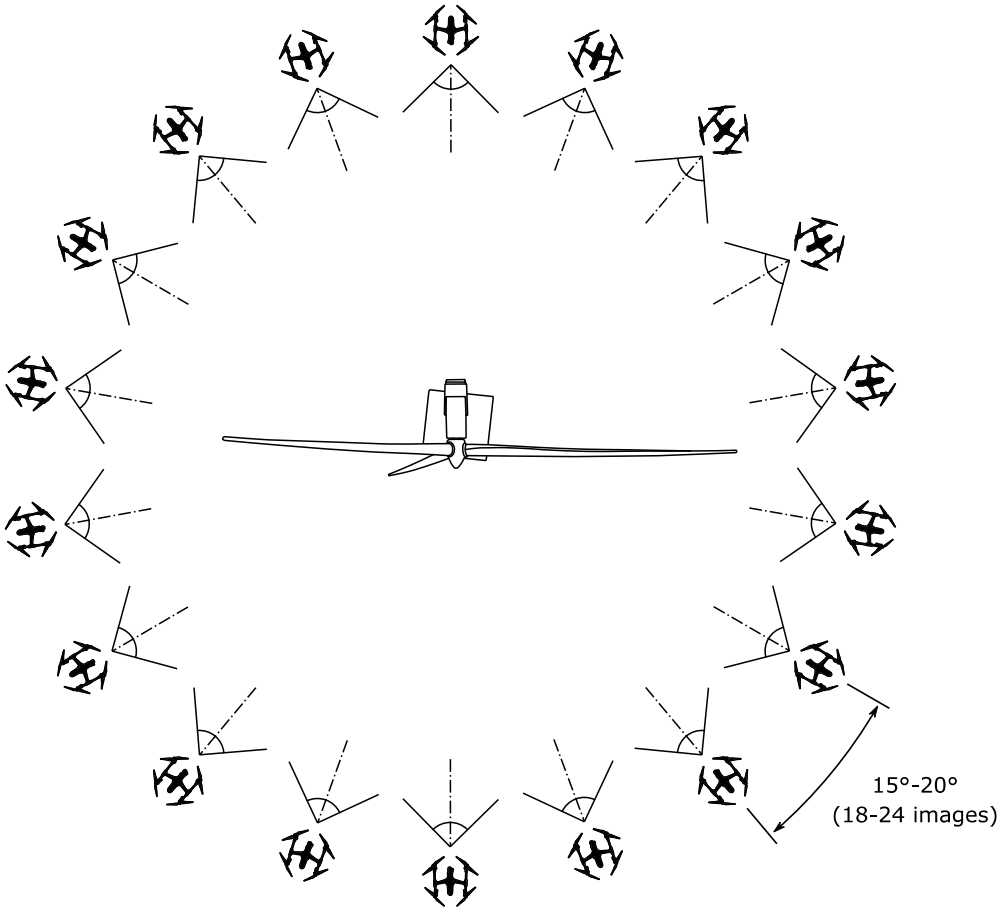

Figure 2 Recommended orbit pattern for photo acquisition of a wind turbine with drone for 3D reconstruction: Ca. 18-24 photos in a 360° orbit, that is a photo taken with a 15°-20° step.

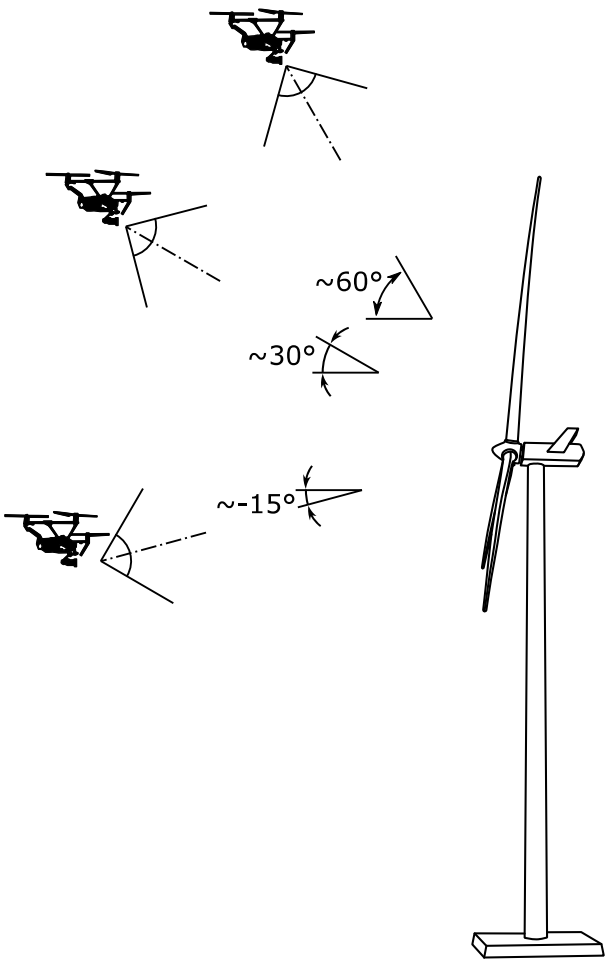

Figure 3 Three view attitudes recommended for photo acquisition of a wind turbine with drone for 3D reconstruction: Aiming approx. at the hub, -15°, 30°, and 60° to the horizon, entire turbine in sight, and sight of ground.

8.2 BUILDING

For successful 3D model reconstruction of a house it is recommended to acquire photos in several perimeter orbits at same distance from the house. The step between the adjacent photos in the perimeter orbit should be selected such that the rule of 60% overlap in the image content is fulfilled.

In addition, it is recommended to take two extra photos at each camera position along the walls and few intermediate photos around each sharp element, like corners. This will ensure good reconstruction quality for the entire building, see example in Figure 4. The amount of images for a single perimeter orbit will naturally depend on the building size, camera setup and amount of sharp parts that require more photos.

It is recommended to take images of a building in at least three perimeter orbits with distinct view attitudes: -15°, 30° and 60° with respect to the horizon, see Figure 5.

Example of the 3D reconstruction result for a house is given in Figure 6.

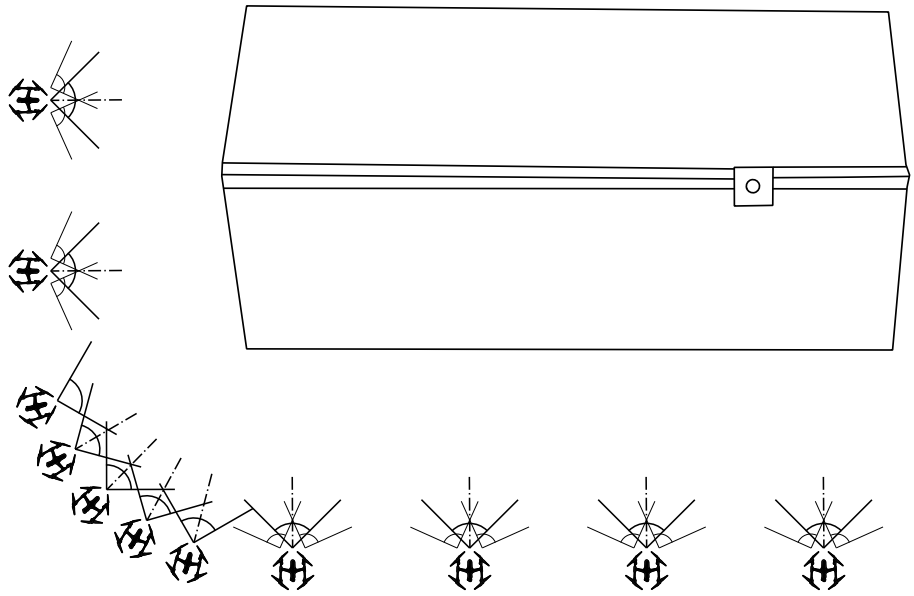

Figure 4 Recommended perimeter orbit pattern for photo acquisition of a house with drone for 3D reconstruction: Two extra photos at each drone position along the walls, and generally more photos of sharp parts like corners.

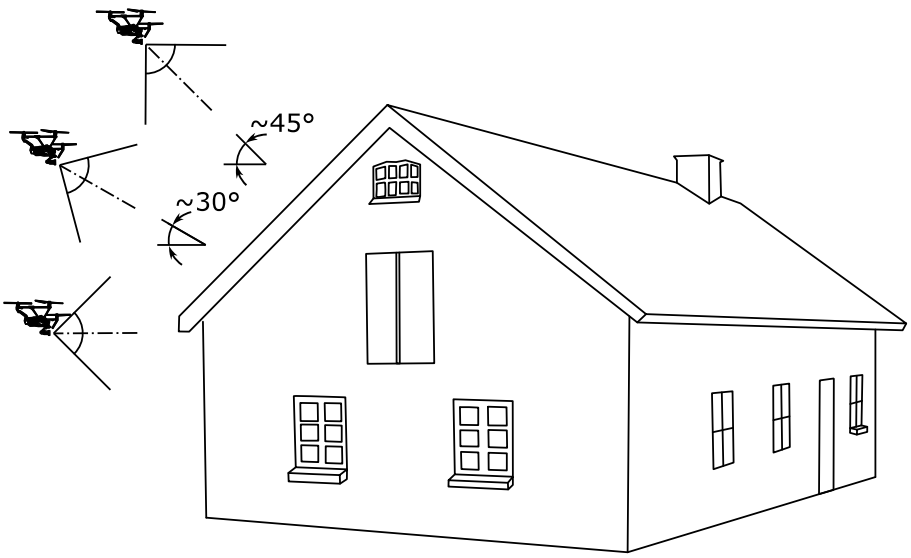

Figure 5 Perimeter orbit attitudes recommended for photo acquisition of a house with drone for 3D reconstruction: 0°, 30°, and 45° to the horizon.

Figure 6 Result of house 3D reconstruction using drone for photo acquisition
Online model can be found at http://easyinspect.link/GQYb3