Photogrammetry Image Capture

User Guide & Production Tips

Mortimer Sotom
B313794

Contents

1.0 Overview 3
2.0 Image Capture Process 3
2.1 Equipment 3
2.2 Camera Settings – photo quality 4
2.3 Object Requirements 4
2.4 Capturing Scenes 4
2.5 Lighting 5
3.0 Troubleshoot 6
3.1 General 6
3.2 Editing of Photographs 6
3.3 Lens Distortion 6
3.4 Specular Amount / Shininess 6
3.5 Texture & Patterns 7
3.6 Lighting Setup 7
4.0 Software Workflow 8
4.1 Create a 3D Model 8
4.2 Summary 10
References 11

1.0 Overview

Close range photogrammetry is a technique used to obtain geometric information (position of surface points) of any object from a set of photographs. A number of image-based 3D modelling softwares employ this technique to reconstruct objects. Photogrammetry is a powerful tool to produce accurate models if the photographs meet certain requirements.

This user guide details the main principles of shooting and selecting suitable images for highly accurate 3D mesh model generation and describes the workflow process for creating such model with ReMake version 17.25.2.1 by Autodesk. Potential issues which can be encountered during image capture are covered and include solutions to approach those problems. Once all photos have been taken with consideration to these requirements, they should still be inspected before being inputted into the photogrammetric software.

Photographs can be taken with any digital camera as long as all guidelines explained below are followed. Some of the camera settings provided are for users with digital cameras where settings can be changed manually and hence can be ignored by smartphone users. The camera settings suggested are to render very high quality 3D mesh models but the use of a smartphone camera is much more time efficient and nevertheless yields accurate results.

The entire process to obtain a digitised model of a real item can be summarised by following these simple steps:

1. Take 50+ photographs of an object
    a. Ensure all photo and object requirements detailed below are met
2. Load photos into the photogrammetric software
3. Check with the software the quality of the images
4. Start the model reconstruction process
5. Download the model
6. Edit the model if needed and export it into the desired format

2.0 Image Capture Process

2.1 Equipment

The quality of the digitised model is strongly dependant on the resolution of the camera. Any digital camera with a resolution of at least 5 megapixels (MP) is recommended or 12 MP for professional results. No special photogrammetric equipment is, a digital consumer level camera or smartphone camera will have a sufficient resolution (e.g.: Samsung Galaxy smartphones have a camera resolution between 8 to 16 MP and iPhone models have a camera resolution between 8 to 12 MP). [1-2]

- Camera resolution of 5 MP or more.
- Smartphone cameras should be set to high dynamic range (HDR) mode.
- Prime/fixed lenses are preferable. If a zoom lens is used, the camera's focal length should be set to minimum or maximum for more stable results.
- Do not use ultra-wide angle and fisheye lenses as these will distort the images.
- It is recommended to choose a lens with 50mm focal length.
- If available, a tripod will prevent motion blur.

2.2 Camera Settings – photo quality

It is important to set the camera settings correctly to control exposure levels and capture photos at maximum resolution. [3-4]

- ISO values should be kept as low as possible. Higher ISO values increase the exposure but introduce noise in the form of a granule effect on the image.
  ISO = ~ 100 – 250
- Aperture values should sufficiently high for a deep depth of field to obtain sharp, non-blurry images. A small aperture or high f-stop value is recommended for small objects.
  F-stop = ~ f/8 – f/18
- Shutter speed should be fast to prevent images from being blurry but does not necessarily have to be extremely quick since it is to shoot a still object. A tripod will prevent any motion blur allowing the shutter speed to be reduced.
  Shutter speed = ~ 1/50 seconds or faster
- RAW image formats should be selected when possible. Data from RAW files can be losslessly converted to TIFF files while JPEG compression usually induces unwanted noise to images.

2.3 Object Requirements

Some object characteristics confuse the algorithm of photogrammetric softwares and therefore cannot be correctly analysed. This results in inaccurate renders in the form geometrical distortions and discoloured textures.

- Avoid non-textured, transparent, reflective or shiny objects.
- Avoid flat objects with little surface depth.
- Do not use moving objects as the subject and avoid including moving objects in the background.

2.4 Capturing Scenes

It is important that the photographs used to reconstruct a scene capture the entire objects from all angles. For a full 360^{o} sequence, each picture should be taken from the same height and distance from the object at 10^{o}-20^{o} intervals. This step should be repeated from at least three different heights as illustrated by figure 1. Close up shots should also be taken for detailed parts and areas with occlusions for the software to accurately recreate the shape of the object. It is better to have too many images than too few as this would distort the model. [2-4]

- Take 50 to 100 photos of an object depending on the size.
- Maintain the same camera orientation for all photos.
- The object of interest should fill most of the frame size.
- Avoid including any unnecessary foreground in the shots.
- A high contrast between the object and background is preferable.
- Ensure a minimum overlap of 60% between pictures. A higher percentage in overlap yields better results so an 80% overlap between images is recommended.
- Each small detail should be captured by at least three photos with close up shots (e.g.: around occlusions, detailed engravings).
- Minimise the number of ‘blind-zones’ or areas with occlusions. Photogrammetric softwares are only able to reconstruct geometry visible from a minimum of two images.

- For large objects or with close up shots, the entire object does not have to be in the image frame. It is not an issue if some parts are missing as long as they appear in other shots.
- Do not use blurry photographs due to out of focus or motion blur.

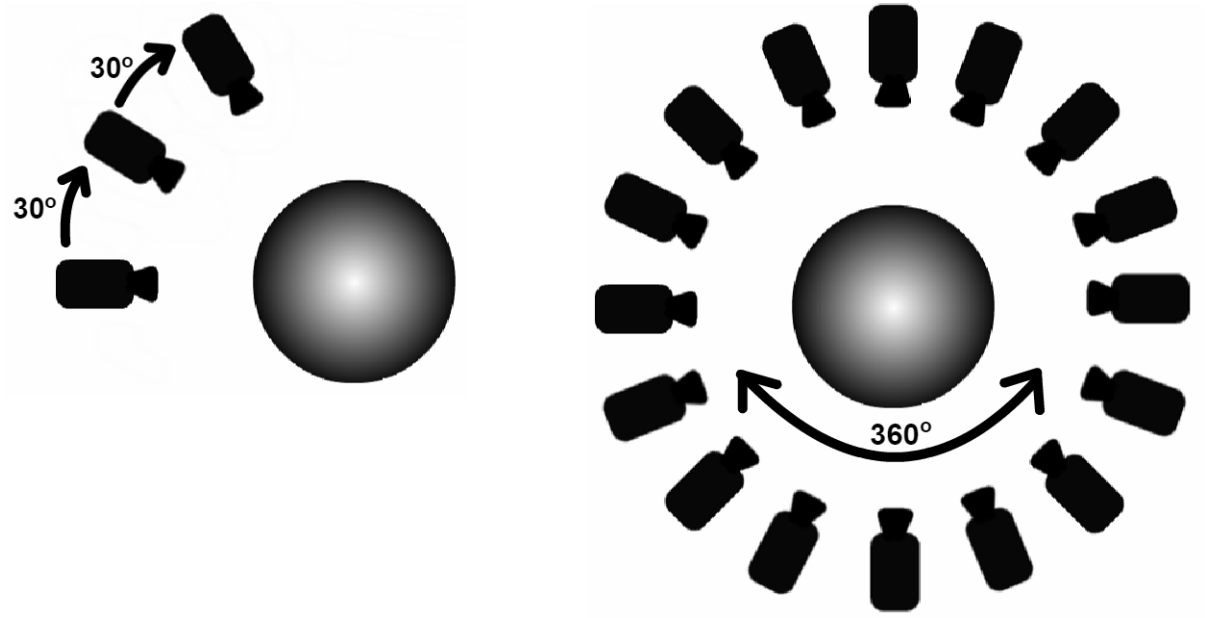

Figure 1: Object capture process

2.5 Lighting

Suitable lighting is required and must be correctly set up in some conditions to obtain high quality results. [5]

- Light sources in the camera's field of view should be removed where possible e.g.: background light sources or LEDs on the subject).
- Avoid using flash as this can alter the texture of the object.
- If shooting outside, a cloudy day provides the optimal lighting conditions (i.e.: uniform light distribution, no glare on cameras).

If shooting inside, the goal is to obtain a dome light to replicate the luminosity of a summer cloudy day. An overhead light in a room can be sufficient but a three point light set up will highlight the definition of the object. The setup detailing the three point lighting is explained in section 3.6.

3.0 Troubleshoot

In some instances the software might not generate accurate models or cannot generate a model at all from a set of images. A list of potential reasons causing these issues with methods to rectify them are listed below. [5]

3.1 General

All elements within the scene to be reconstructed must be static for the software to use are reference points. Any moving object is likely to appear as blurry and will increase the time taken for the alignment process.

Limiting the amount of background in a photo will significantly decrease the alignment time.

The software will perform calculations faster if the photos are the order where each consecutive image overlap each other. Usually, these should already be in the order that the photos are taken except for close up shots.

Some softwares have an accuracy setting which can be set to low, medium or high. The alignment process can fail or take excessive amount of time if set on medium or high setting. It is recommend to complete the alignment process on low setting as it is only used to create the sparse point cloud. This has no significant impact in generating the dense point cloud on a higher accuracy setting.

3.2 Editing of Photographs

The EXIF-tag (Exchangeable Image File Format) associated with photographs contains important information, such as the camera type and focal length, accessible by most image processing softwares. Some photogrammetric programs exploit this information to estimate the field of view of each photo during the alignment process. [6]

Any modifications of photos such as geometrical transforms (ie: rotate or resize), editing with a software (e.g.: Photoshop) or cropping will alter the information stored in the EXIF-tag of the image. Processing of such photos is likely to cause alignment issues and result in inaccurate 3D mesh models as well as discoloured textures.

3.3 Lens Distortion

Every lens will have some sort of distortion but these are easily modelled and unnoticeable. Ultra-wide angle and fisheye lenses are hove more significant and complex distortions on the photos captured which consequently render them unusable for 3D model generation. Some softwares although very few, such as PhotoScan, use advanced distortion models to support fisheye lenses. However, these models still contain some inaccuracies which can be reflected in the resulting model.

3.4 Specular Amount / Shininess

Objects with specular properties will result in artefacts in the 3D mesh and texture as they reflect their surrounding environment and hence should be avoided. To reduce the shininess of an object, a small amount of talc powder can be applied to dull the surface without altering the colour considerably.

Shooting the object under cloudy conditions or with the three point lighting set up described will also reduce the specular amount.

3.5 Texture & Patterns

Smooth objects or with plain/monotonous textures are challenging to scan as they provide few reference points for the software which induces artefacts in the 3D mesh. Thus, surfaces should not be too reflective and have irregular intensity changes. A white plate with no pattern, a glass, shiny cars or chrome mechanical parts are problematic and unlikely to be reconstructed. This can disregarded if the object has distinct features such as dents, scratches or changes in hue. The software can use these as tracking points for the alignment process as it assumes the camera is moving instead of the object. Such objects can also be placed on a surface with many details such as a newspaper to aid the software.

3.6 Lighting Setup

As previously mentioned, if shooting inside, the goal is to obtain a dome light to replicate the luminosity of a summer cloudy day. If overhead lighting available in the room is not appropriate, a three point lighting set up is necessary. This can be achieved in two ways. The first method is by positioning the main light above the object and placing two fill lights on either side of the camera at a 45^{o} angle. All lights should have the same intensity to minimise projection shadows and evenly illuminate the object. The second and more standard method is to place the main or key light at an angle towards the object. The fill light is placed on the other side and a back light is positioned above and slightly behind the object to highlight its contours as illustrated in figure 2 below.

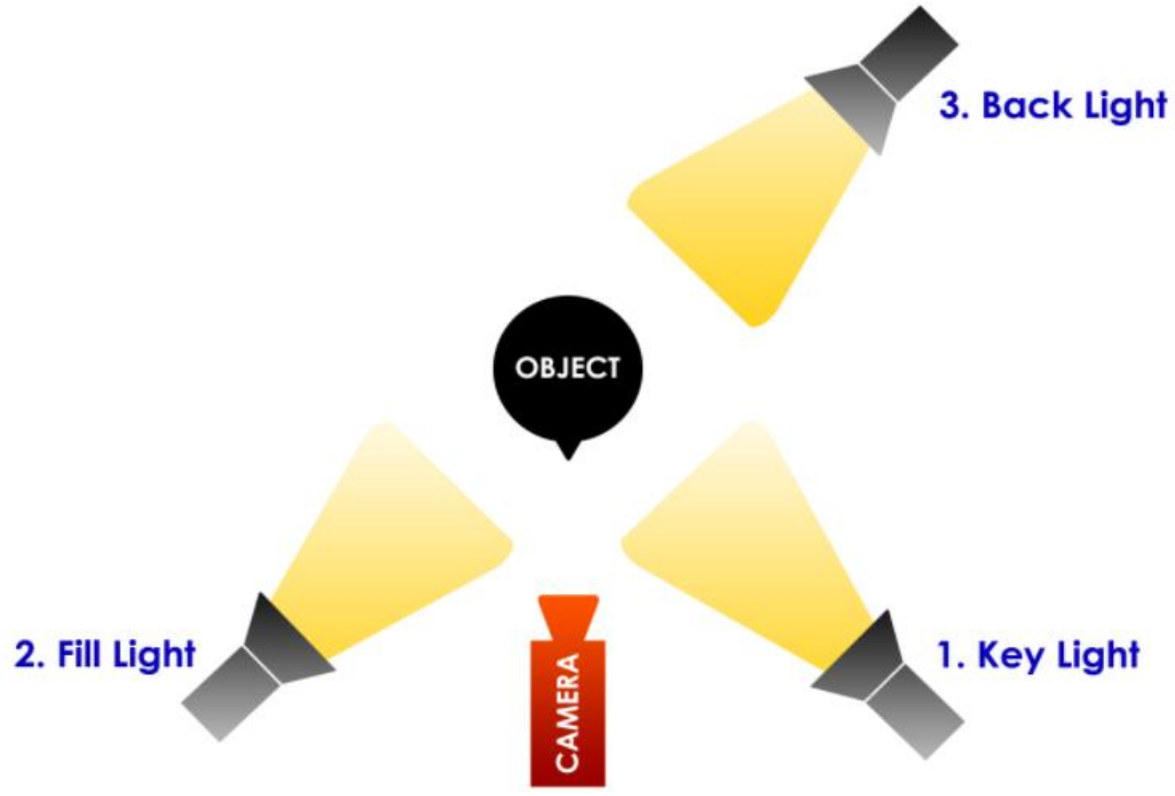

Figure 2: three point lighting set up [7]

4.0 Software Workflow

ReMake by Autodesk is a complete software for producing 3D models of real objects from photographs and editing the generated mesh to suit the user's requirements. 3D mesh models can be directly imported into the program for editing and optimisation and can then be exported into a range of different mesh file formats for compatibility with other softwares or applications. This section details the workflow process with version 17.25.2.1 for obtaining a 3D model of an object from a set of photographs. [8]

4.1 Create a 3D Model

Once installed, the main page of the software is the dashboard. From here the user can create new 3D models, import models already available and gains access to a Cloud drive to store projects.

To create a new model the user must select 'Create 3D' (1. of figure 2) at the top left of the dashboard. The user than has the option of constructing the mesh through online cloud servers (recommended) or locally on their personal computer (2. of figure 2).

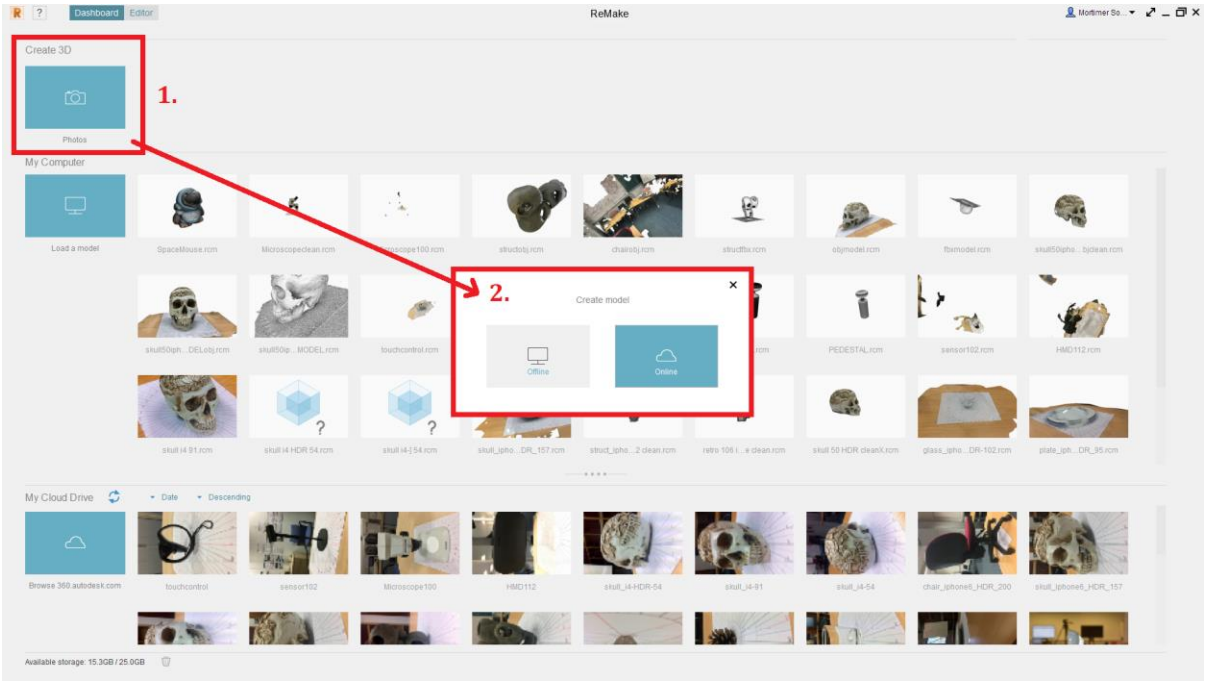

Figure 3: ReMake dashboard – creating a model

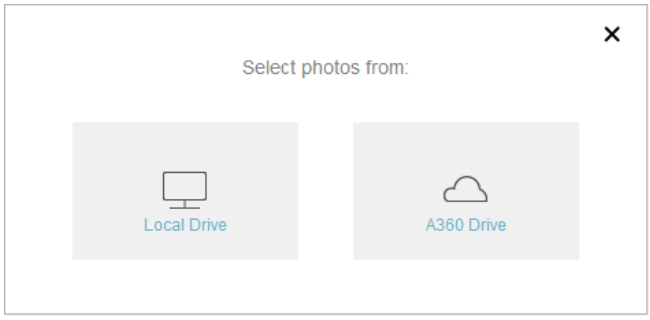

Figure 4: ReMake, photo upload source

Once the user decided whether to generate the mesh model through cloud computing or on a local machine, photos can be uploaded from a local drive or from the Cloud drive as show in figure 3.

When all photos have been loaded into the project, the user should ‘Validate’ the photos (3. of figure 3). This option forces the software to check the overlap between all images and ensure the model will be correctly rendered. Once the validation is complete, the software will highlight all the photos which flagged an error and recommended the user to retake them for better results (see figure 6). After all photos are loaded and validated, the user can ‘Create model’ (4. of figure 3) which opens a window to name the project and select quality features (5. of figure 3).

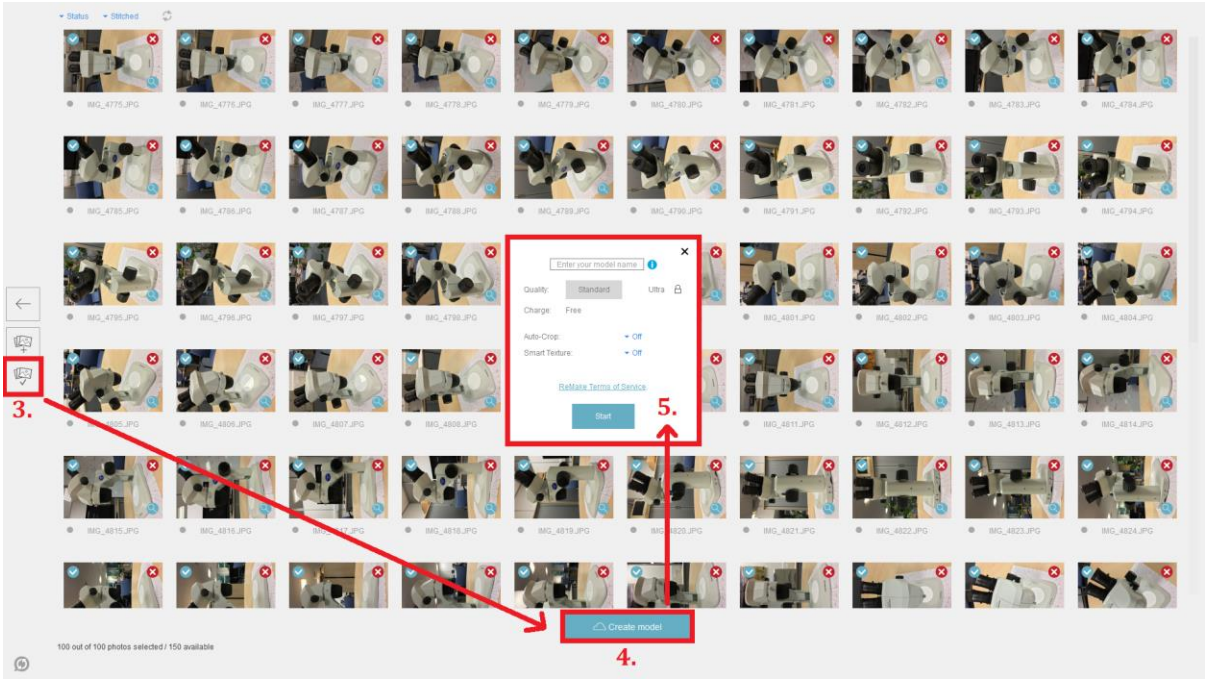

Figure 5: ReMake – loading photos to a project and begin constructing the model

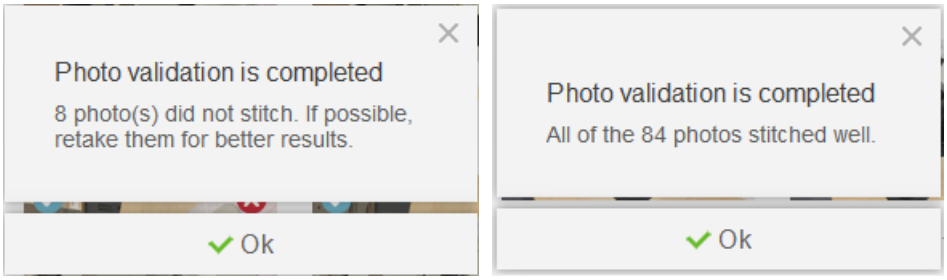

Figure 6: ReMake – ‘Photo validation’ message

Finally, the 3D model reconstruction process begins. If the project is done through cloud computing, the project will fist need to be uploaded to the online servers (see figure 7). For the upload and processing stage, a progress bar indicates the percentage completion. The entire workflow pipeline required to perform by any photogrammetric software is entirely automated and the user only has to download the finished model. The model can then be edited with ReMake or another modelling software and exported in the desired format.

Figure 7: ReMake dashboard – uploading and processing project

4.2 Summary

The workflow process with ReMake version 17.25.2.1 by Autodesk for creating a 3D model of an object from a set of images can be summarised with the following steps:

1. Select ‘Create 3D’ on the dashboard
2. Choose to create the model locally or through cloud computing
3. Choose to load photos locally or from the Cloud drive
4. Select all photos for the project
5. ‘Validate’ the photos
    a. Delete or retake invalid photos
6. Select ‘Create model’
7. Name the project, select the mesh quality and click on ‘Start’
8. Wait for the model to be generated
9. Download the model and edit or export it into the desired format

Supported export formats are: OBJ (triangular and quad meshes), FBX, STL, PLY, XYZ and PTS.

References

[1] C. Storm, H. Jacobs; “We pitted an iPhone camera against a point-and-shoot and a DSLR to see if there’s really any difference”, Business Insider UK, February 2015. Available at: http://uk.businessinsider.com/iphone-6-vs-dslr-and-point-and-shoot-2015-2/#e-verdict-in-every-instance-the-dslr-is-going-to-take-a-higher-quality-image-it-has-many-times-more-options-and-the-larger-file-sizes-which-allow-for-clearer-and-increased-detail-especially-when-enlarged-or-printed-but-for-everyday-shooting-and-sharing-of-photos-the-iphone-does-a-surprisingly-good-job-iphone-images-are-optimized-for-viewing-on-an-iphone-as-well-so-if-youre-taking-pictures-to-text-email-snapchat-or-upload-to-facebook-an-iphone-will-do-a-fine-job-26 Accessed on [16/04/2017]

[2] Agisoft; “Useful Tips on Image Capture: How to Get an Image Dataset that Meets PhotoScan Requirements?", Agisoft PhotoScan, July 2012. Available at: http://www.agisoft.com/pdf/tips_and_tricks/Image%20Capture%20Tips%20-%20Equipment%20and%20Shooting%20Scenarios.pdf Accessed on [18/04/2017]

[3] J. Harmer; “Aperture – Shutter Speed – ISO”, Improve Photography, January 2012. Available at: https://improvephotography.com/photography-basics/aperture-shutter-speed-and-iso/ Accessed on [01/03/2017]

[4] Agisoft LLC; “Agisoft PhotoScan User Manual”, Professional Edition, Version 1.3, 2017. Available at: http://www.agisoft.com/pdf/photoscan-pro_1_3_en.pdf Accessed on [13/03/2017]

[5] “Technical Guide and Production Tips For Agisoft Photoscan”, _blankRepository, February 2016. Available at: http://www.agisoft.com/pdf/tips_and_tricks/_blankRepository_Technical%20Guide%20and%20Productions%20Tips.pdf Accessed on [18/04/2017]

[6] “ARC3D User’s Guide”, ARC 3D Webservice – A Family of Web Tools for Remote 3D Reconstruction, July 2017. Available at: https://homes.esat.kuleuven.be/~visit3d/webservice/v2/manual3.php Accessed on [12/11/2016]

[7] Tangient LLC; “Lighting”, Auburn High Scool, August 2010. Available at: https://hscmsbs.wikispaces.com/Lighting Accessed on [28/04/2017]

[8] Autodesk; “Getting Started Guide”, Autodesk ReMake, v.01, May 2016. Available at: https://remake.autodesk.com/assets/Autodesk_ReMake_Guide_01.pdf Accessed on [13/11/2016]