

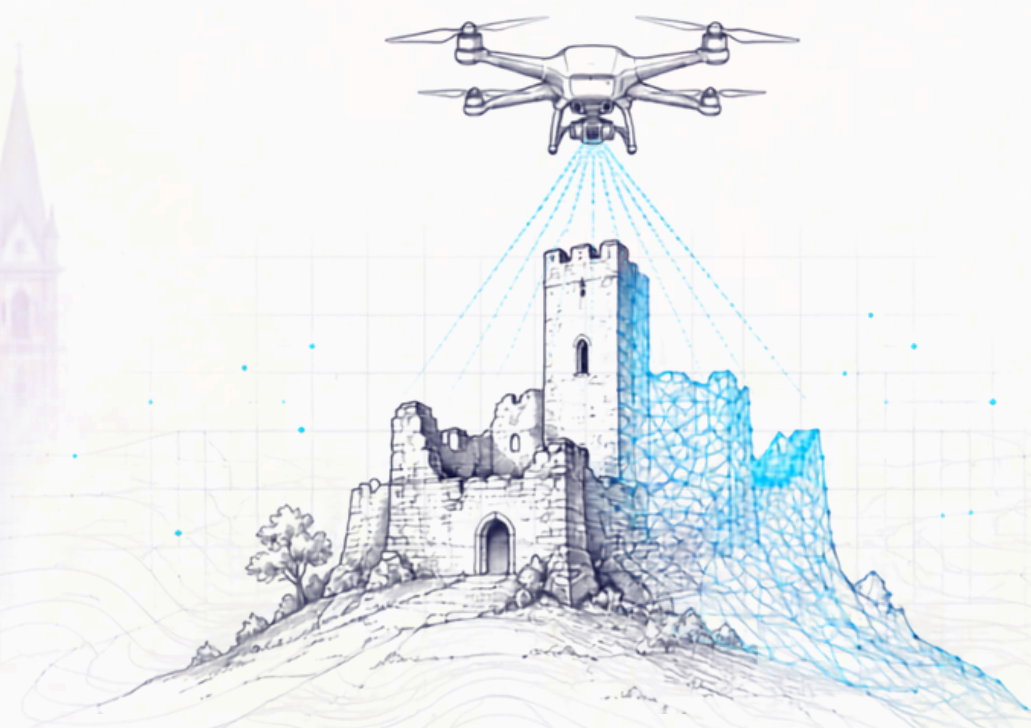


Co-funded by
the European Union

MODULE 02

PHOTOGRAMMETRY AND 3D SCANNING

DIGITAL RURAL EUROPEAN ART
AND MEMORY



Project partners



Project DREAM
Digital Rural European Art and Memory
2025-1-SK01-KA210-ADU-000360122



Co-funded by
the European Union

Project information:

DREAM - Digital Rural European Art and Memory
2025-1-SK01-KA210-ADU-000360122

Funded by the European Union. However, the views and positions expressed are those of the author(s) only and do not necessarily reflect those of the European Union or SAAIC. Neither the European Union nor the granting authority can be held responsible for them.



How to use this E-book

You can read this material before, during or after the session. Each section introduces one concept, explains the basic theory behind it and connects it with a practical decision that learners may need to make in a real project.

The activities are designed to help learners observe, compare, make decisions and practise with criteria. They do not require advanced equipment. In many cases, a smartphone, a simple object and a careful observation exercise are enough to understand the principle.



*Traditional wooden architecture
in Podbiel, Slovakia*

MODULE INFORMATION

 Module number 02	 Level Beginner
 Topic Practical introduction to photogrammetry, drones, WebODM and 3D scanning	 Format Hybrid learning
 Duration 3 hours	 Main output Heritage 3D Documentation Plan

About this module

This ebook accompanies the DREAM module dedicated to photogrammetry and 3D scanning. Its purpose is to help learners understand how photographs, drone images and 3D capture techniques can be used to document objects, buildings, landscapes and cultural heritage sites in digital form.

Photogrammetry is a measurement technique that uses overlapping photographs to reconstruct the shape, position and visual appearance of a real object or space. When photographs are processed with specialised software, they can generate point clouds, textured 3D models, orthophotos, elevation models and technical reports. These outputs can support education, conservation, interpretation, virtual exhibitions and community memory projects. In this module we use WebODM as the main photogrammetry tool. WebODM is an open-source platform that allows users to upload image datasets, process them and review the resulting 2D and 3D outputs through a web interface. For learners, it is especially valuable because it makes the full workflow visible: dataset, processing task, outputs, report, review and export. Drones are included because they are widely used to capture images for photogrammetry. They can document roofs, facades, monuments, archaeological areas and cultural landscapes from positions that are difficult or unsafe to reach from the ground. Drone work also introduces important responsibilities: flight planning, safety, permissions, privacy, weather and respect for heritage restrictions. Learners do not need to master every technical detail, but they should understand when each method is useful and what limitations it has.



Learning Objectives

- Understand what photogrammetry is and how it transforms overlapping photographs into digital 3D outputs.
- Explain, at a basic level, feature matching, camera position estimation, point clouds, meshes, textures and orthophotos.
- Identify practical uses of photogrammetry and 3D scanning in education, culture, heritage and community projects.
- Recognise the role of drones in capturing images for buildings, landscapes and cultural heritage documentation.
- Understand the basic principles of good image capture: overlap, coverage, lighting, sharpness, camera angles and texture.
- Plan a simple image capture workflow for an object, building or outdoor heritage space.
- Use WebODM at a basic level to understand the processing workflow from images to outputs.
- Apply safety, privacy, legal and ethical considerations when drones or heritage sites are involved.
- Analyse common errors in photogrammetry results and propose practical improvements.
- Document a simple heritage capture project with clear metadata, file organisation and purpose.

Index

0. Before You Begin: My Starting Point	3
1. What is Photogrammetry	4
2. Real Uses of Photogrammetry and 3D Scanning	8
3. Photogrammetry, Drones and Local Heritage.....	12
4. Basic Technologies: Photogrammetry and 3D Scanning.....	16
5. Capture Equipment: Cameras, Smartphones, Drones and Scanners	20
6. Image Datasets and Flight Planning	23
7. Safety, Permissions and Preparation of the Site.....	27
8. From Photographs to a 3D Model	30
9. WebODM: Projects, Processing and Outputs	34
10. Quality, accuracy and common reconstruction errors	38
11. Working with point clouds, orthophotos and 3D models	41
12. Basic data management and documentation	43
13. Introduction to drone-based photogrammetry workflows	46
14. Final Activity: Heritage 3D Documentation Plan	50
15. Digital Wellbeing Tip	52
16. Basic glossary	53
16. Module closing.....	55

0. Before You Begin: My Starting Point

Before starting the module, rate each statement from 1 to 5. Use 1 when you cannot do the task yet and 5 when you can do it independently. This is not a test. It is a way to notice your starting point and later recognise your progress.

- I can explain how photographs can be used to create a 3D model.
- I can plan how to take overlapping photographs of an object, building or heritage place.
- I can choose an appropriate capture method, such as a smartphone, camera, drone or 3D scanner.
- I can identify basic safety, privacy and permission issues before documenting a place or object.
- I can explain the basic process from collecting photographs to reviewing photogrammetry outputs.

Keep your ratings. You will return to the same statements at the end of the module.

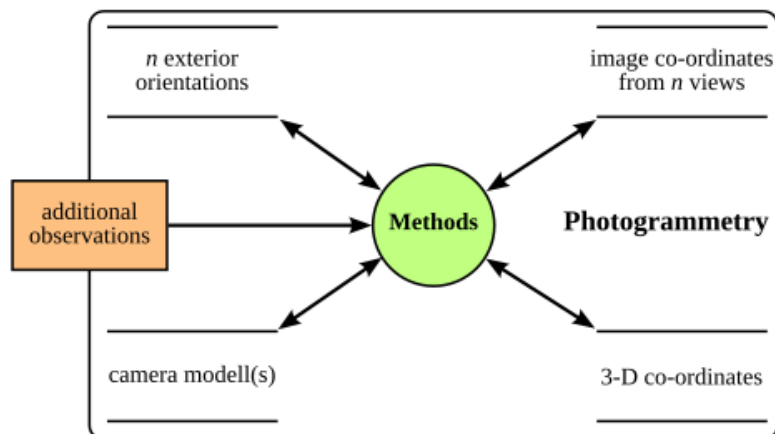
1. What is Photogrammetry

Photogrammetry is a technique that creates measurements, maps or 3D models from photographs. The basic idea is simple: if the same point appears in several images taken from different positions, software can compare those images and calculate where that point is located in space. This calculation is based on **triangulation**. When two or more camera positions observe the same feature, the software estimates the lines of sight from each camera and finds where they meet in three-dimensional space. A single photograph is flat, but a set of overlapping photographs can contain spatial information.

Modern photogrammetry software uses a process often called **Structure from Motion**. It searches for feature points, matches them across images, estimates camera positions and creates an initial sparse point cloud. This sparse point cloud is not the final model; it is the first geometric skeleton of the scene. For this to work, the photographs must overlap and they must contain recognizable **texture**. Stone, wood, painted surfaces, soil and brick usually work well because they contain visible details. Glass, shiny metal, water, plain white walls or moving vegetation are harder because the software cannot reliably identify stable points.

Figure 1

Data Model of Photogrammetry



Note. Diagram illustrating the geometric parameters of 3D photogrammetry. From *Photogrammetry Wiora EN* [Vector graphic], by G. Wiora, 2005, Wikimedia Commons (https://commons.wikimedia.org/wiki/File:Photogrammetry_Wiora_EN.svg). CC BY-SA 3.0.

Photogrammetry connects the real world with digital representation. First, there is an object, building, monument or landscape. Then, a planned set of photographs is captured. Finally, software such as WebODM processes those photographs and generates outputs that can be viewed, measured, shared or reused.



Key Concepts

Photograph: A digital image captured with a camera, smartphone or drone. In photogrammetry, several photographs of the same object or place are used together to create spatial information.

Overlap: The part of a scene that appears in two or more photographs.

Feature point: A clearly recognisable detail in an image, such as a corner, mark, crack or texture pattern, that the software can identify in several photographs.

Triangulation: A method of calculating the position of a point in three-dimensional space by comparing where that point appears in photographs taken from different positions.

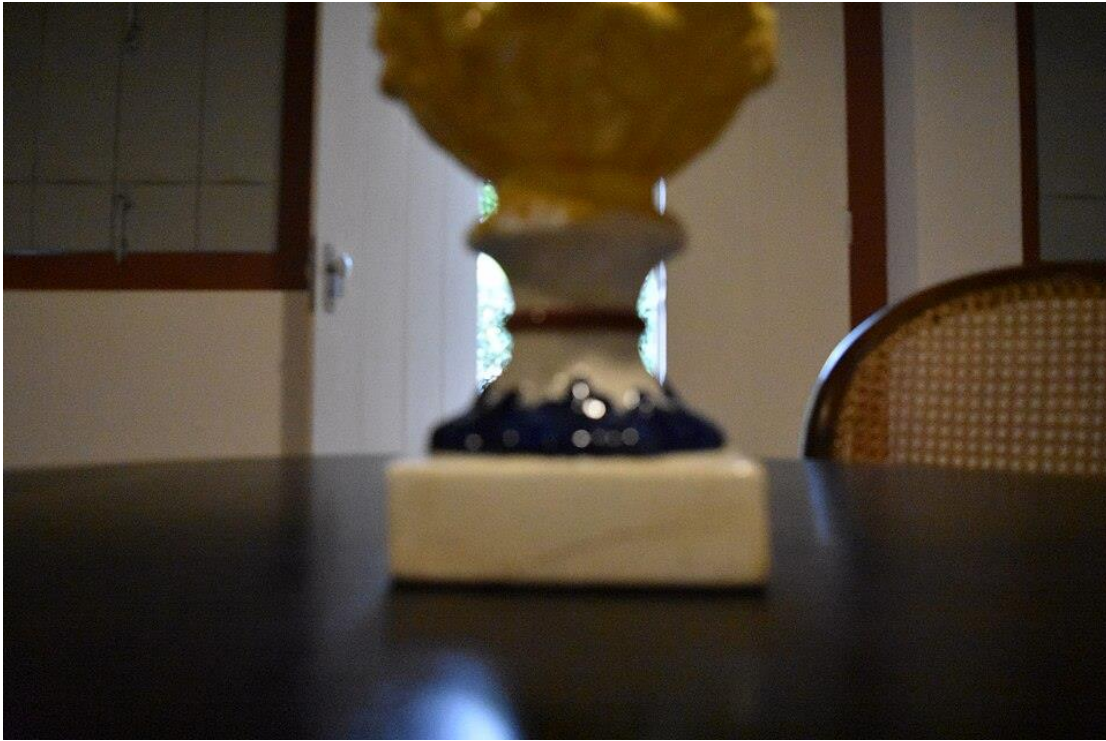
Structure from Motion (SfM): A photogrammetry process in which software compares overlapping photographs, identifies matching features and estimates the positions of the cameras and the basic 3D structure of the scene.

Sparse point cloud: The first simple 3D representation created during photogrammetry processing, containing a limited number of points that show the approximate shape and structure of the photographed object or place.

Texture: The visible surface details of an object, such as colours, patterns, cracks or roughness.

Figure 2

Photograph of Detail for Photogrammetry Exercise



Note. Image of a decorative pine cone sculpture at Fazenda do Pinhal. From *Foto para exercício de fotogrametria - Pinha (56)*, N.ELAC [Photograph], by N.ELAC, 2019a, Wikimedia Commons ([https://commons.wikimedia.org/wiki/File:Foto_para_exerc%C3%ADcio_de_fotogrametria_-_Pinha\(56\),_N.ELAC.jpg](https://commons.wikimedia.org/wiki/File:Foto_para_exerc%C3%ADcio_de_fotogrametria_-_Pinha(56),_N.ELAC.jpg)). CC BY-SA 4.0.



Practical Task

Choose an object and imagine that you want to create a 3D model of it using photographs.

Which sides of the object would you need to photograph?

Where would you place the camera?

Which parts might be difficult to capture?

Does the object have enough texture?

Would the lighting help or make the capture harder?

How to take the photos or collect the data

For this activity, learners should practice a simple close-range photogrammetry capture. The aim is to collect a clean, overlapping image set that could later be processed in WebODM.

Things to keep in mind

- Choose an object with visible texture and avoid shiny, transparent or plain surfaces.
- Use soft, stable light; avoid strong shadows and reflections.
- Keep the object still and move the camera around it.
- Take overlapping photos from several angles; do not skip the back or sides.
- Keep the camera steady and avoid blur.
- Include a ruler, scale bar or known measurement if size matters.

Step by step

1. Place the object in a stable position with enough space around it.
2. Take one test photo and check sharpness, light and framing.
3. Move around the object in a circle, taking one photo every small step.
4. Capture a second ring from a slightly higher angle.
5. Capture details or hidden areas that the first pass missed.
6. Review all photos and retake blurry or poorly lit images.
7. Save the dataset in a clearly named folder for WebODM or later review.

Mini tip: Before thinking about software, think about images. A strong dataset makes the processing much easier.

2. Real Uses of Photogrammetry and 3D Scanning

Photogrammetry and 3D scanning are used in many contexts. In cultural heritage, they can help document monuments, archaeological remains, historic buildings, objects, artworks, tools, landscapes and spaces connected to local memory. In education, 3D documentation allows learners to explore objects and places that may be far away, fragile, restricted or difficult to access. A 3D model can be used in a classroom, a virtual exhibition, a website, a presentation or a local heritage project. In conservation and monitoring, digital models can support comparison over time. If a building, sculpture or site is documented today and again in the future, changes can be observed more clearly. This does not replace expert conservation work, but it can provide useful visual and spatial records. In community projects, photogrammetry can help people document objects or places that are meaningful for local identity. The technology becomes a way to tell stories, preserve memories and create accessible digital materials.



Key Concepts

Digital documentation: Using digital tools to record and preserve information about an object, place or heritage site.

Conservation monitoring: Documenting an object or place over time to observe changes or damage.

Virtual exhibition: A digital space where objects, places or stories can be presented and explored online.

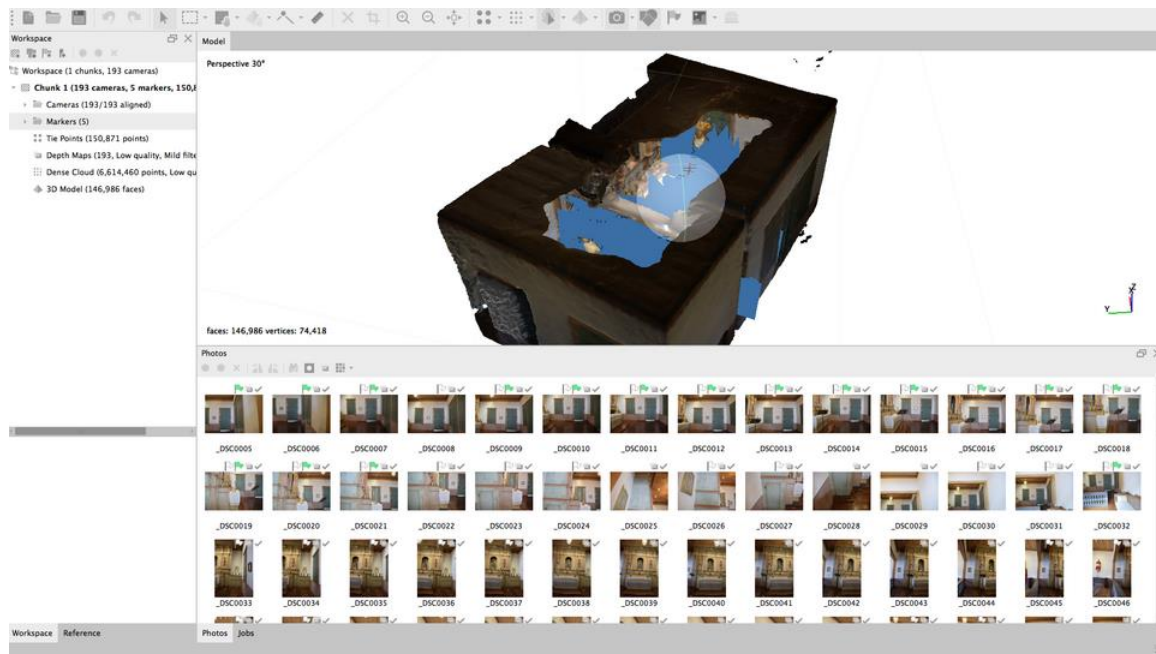
Accessibility: Making heritage and information easier for different people to access and use.

Community memory: Shared stories, traditions, places and experiences that help a community remember its past.

The purpose of the model is important. A model for a museum website may prioritise visual quality and storytelling. A model for conservation may require scale, metadata, careful documentation and repeatable capture conditions. The same technology can serve different goals, but the project must define its goal before capture begins.

Figure 3

Architectural Photogrammetry



Note. External facade of the Fazenda do Pinhal main house. From *Sede da Fazenda do Pinhal (143)*, N.ELAC [Photograph], by N.ELAC, 2019b, Wikimedia Commons (https://commons.wikimedia.org/wiki/File:Sede_da_Fazenda_do_Pinhal_%28143%29,_N.ELAC.png). CC BY-SA 4.0.



Practical Task

Choose one real object, building or place from your community.
Describe one possible use for a digital 3D version of it.

Who would use the model?

What would the model help them understand?

Would the output need to be visually attractive, measurable, or both?

How to take the photos or collect the data

For this activity, learners should practise a simple close-range photogrammetry capture. The aim is to collect a clean, overlapping image set that could later be processed in WebODM.

Things to keep in mind

- Choose an object with visible texture and avoid shiny, transparent or plain surfaces.
- Use soft, stable light; avoid strong shadows and reflections.
- Keep the object still and move the camera around it.
- Take overlapping photos from several angles; do not skip the back or sides.
- Keep the camera steady and avoid blur.
- Include a ruler, scale bar or known measurement if size matters.

Step by step

1. Place the object in a stable position with enough space around it.
2. Take one test photo and check sharpness, light and framing.
3. Move around the object in a circle, taking one photo every small step.
4. Capture a second ring from a slightly higher angle.
5. Capture details or hidden areas that the first pass missed.
6. Review all photos and retake blurry or poorly lit images.
7. Save the dataset in a clearly named folder for WebODM or later review.

Mini tip: A 3D model is more useful when it is connected to a clear purpose: who will use it, why, and what story it helps explain.

3. Photogrammetry, Drones and Local Heritage

In DREAM, photogrammetry is not presented only as a technical process. It is also a way to look at local heritage with attention. A square, a rural building, a traditional tool, a monument, a wall, a path, a fountain or a small object can become the starting point for a digital documentation activity.

Drones expand what can be documented. They can capture roofs, towers, facades, archaeological areas, large buildings and landscapes from above. This is especially useful when ground photography cannot provide enough coverage. A drone is not just a flying camera. In photogrammetry, it is part of a planned capture system. The route, altitude, camera angle, overlap and lighting must support reconstruction. Random aerial photographs may look attractive but may not contain enough systematic overlap for 3D processing.

Figure 4

4K drone in action



Note. From *DJI Phantom 4K drone in action* [Photograph], by S. Dwivedi, 2019, Wikimedia Commons (https://commons.wikimedia.org/wiki/File:DJI_Photom_4K_drone_in_action.jpg). CC BY-SA 4.0.



Key Concepts

Drone imagery: Photographs captured from the air using a drone.

Nadir image: A photograph taken with the camera pointing straight down toward the ground.

Oblique image: A photograph taken at an angle, useful for capturing façades, roofs and vertical structures.

Coverage: The amount of an object or area that is captured across the complete set of photographs.

Heritage context: The historical, cultural or community meaning connected to an object, place or site.

However, not every project needs a drone. Small objects can be documented with a phone or camera. A facade may need ground and oblique images. A landscape may benefit from a planned drone flight. The right tool depends on the object, the site, the objective and the available permissions.

Heritage work also requires interpretation. The digital model should not capture only geometry. It should help explain why the place or object matters, what context surrounds it, and how the community understands its value.

Figure 5

A quadcopter camera drone



Note. From *Quadcopter camera drone in flight* [Photograph], by J. Sorenson, 2018, Wikimedia Commons (https://commons.wikimedia.org/wiki/File:Quadcopter_camera_drone_in_flight.jpg). In the public domain.



Reflection

Think of a local heritage place, building or monument. Consider how it could be documented and whether using a drone would add useful information.

Could the heritage element be documented from the ground?

Would a drone improve the documentation?

What permissions might be needed?

What parts of the site should not be captured?

How could the digital result help explain its value?

How to take the photos or collect the data

For this activity, learners should think like a capture team before thinking like software users. The drone or camera route must be planned so that the site is covered systematically, safely and legally. **Mini tip:** When working with heritage, do not capture only the shape. Capture the context, the meaning and the reason why the place or object matters.

Things to keep in mind

- Confirm that drone use is allowed at the location and that privacy restrictions are respected.
- Check weather, wind, light, battery, storage, obstacles and people nearby.
- Use nadir photos for map-like outputs and oblique photos for facades, walls, roofs or vertical structures.
- Keep a consistent altitude and camera angle when possible.
- Aim for strong overlap between neighbouring images; avoid isolated or random photos.
- Review the images before leaving the site and repeat missing or blurry areas.

Step by step

1. Define the output: orthophoto, 3D model, facade documentation or simple visual record.
2. Draw the capture area and mark safe take-off, landing and observation points.
3. Plan the route: parallel lines for mapping, circular or oblique passes for vertical elements.
4. Take a first test photo and check exposure, sharpness and framing.
5. Capture the full route slowly and systematically, keeping overlap between photos.
6. Review the dataset immediately: remove obvious failures and identify gaps.
7. Organise the images in a clearly named folder before uploading them to WebODM.

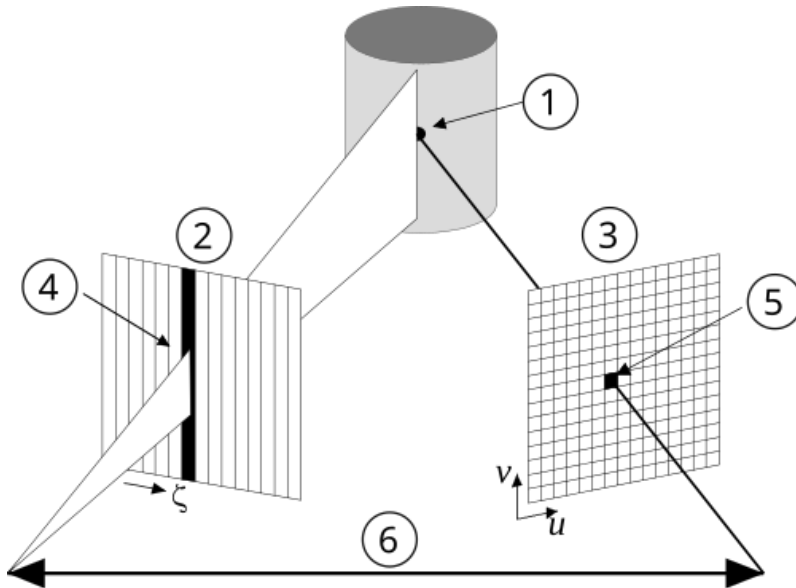
4. Basic Technologies: Photogrammetry and 3D Scanning

Photogrammetry and 3D scanning both create digital representations of real objects or spaces, but they do it in different ways. **Photogrammetry** uses photographs and existing light. For this reason, it is often described as a passive technique. Photogrammetry is often more accessible for beginners because it can be done with a camera, smartphone or drone. It is effective for objects, buildings, facades and outdoor areas when there is enough texture and good image overlap.

3D scanning normally uses active sensors, such as lasers, structured light, depth cameras or LiDAR, to capture geometry more directly. The scanner sends or receives depth information and produces a point cloud or mesh from that sensor data. 3D scanning can be very useful for detailed objects, sculptures, small artefacts or complex surfaces. Depending on the scanner, it may capture geometry with high precision. However, scanners can be more expensive and may require controlled conditions.

Figure 6

Fringe Projection in 3D Scanning



Note. From *Principle of 3d fringe projection numbered* [Vector graphic], by Dr. Schorsch, 2010, Wikimedia Commons (https://commons.wikimedia.org/wiki/File:Principle_of_3d_fringe_projection_numbered.svg). CC BY-SA 2.5.



Key Concepts

Passive sensor: A sensor that records information using existing light or energy instead of sending out its own signal.

Active sensor: A sensor that sends out a signal, such as light or laser pulses, and measures how it returns.

LiDAR: A scanning technology that uses laser pulses to measure distance and create a detailed 3D representation of an object or space.

Structured light: A scanning method that projects a known light pattern onto an object and measures how the pattern changes across its surface.

Depth camera: A camera that measures the distance between the camera and points in the scene to capture 3D information.

Mesh: A digital 3D surface made from many connected polygons that represent the shape of an object.

In practice, both techniques can complement each other. A drone survey can document a large site, while a scanner or close-range photogrammetry can capture smaller objects or details. The best method is the one that fits the object, the purpose, the budget and the required level of detail.



Practical Task

Classify these cases as better suited for photogrammetry, 3D scanning or both:

- a stone facade
- a small ceramic object
- a large archaeological site
- a shiny metal tool
- a rural building
- a sculpture with detailed texture

Explain your decision for each case.

How to take the photos or collect the data

For this activity, learners should practise a simple close-range photogrammetry capture. The aim is to collect a clean, overlapping image set that could later be processed in WebODM.

Things to keep in mind

- Choose an object with visible texture and avoid shiny, transparent or plain surfaces.
- Use soft, stable light; avoid strong shadows and reflections.
- Keep the object still and move the camera around it.
- Take overlapping photos from several angles; do not skip the back or sides.
- Keep the camera steady and avoid blur.
- Include a ruler, scale bar or known measurement if size matters.

Step by step

1. Place the object in a stable position with enough space around it.
2. Take one test photo and check sharpness, light and framing.
3. Move around the object in a circle, taking one photo every small step.
4. Capture a second ring from a slightly higher angle.
5. Capture details or hidden areas that the first pass missed.
6. Review all photos and retake blurry or poorly lit images.
7. Save the dataset in a clearly named folder for WebODM or later review.

Mini tip: Choose the technique according to the object, not according to what sounds more advanced.

5. Capture Equipment: Cameras, Smartphones, Drones and Scanners

Different tools can be used to capture data for photogrammetry and 3D scanning. A **smartphone** can be enough for a simple object. A **camera** can provide better control and image quality. A **drone** can capture aerial images of buildings and landscapes. A **3D scanner** can capture geometry directly when available. The most important factor is not always the price of the equipment. A clear capture strategy matters more. Blurry images, poor overlap or bad lighting can produce weak results even with good equipment.

Figure 7

RGB-D Stereo Depth Camera Setup



Note. Intel RealSense D435 depth camera used for spatial mapping, tracking, and close-range photogrammetry. From *Intel Realsense depth camera D435* [Photograph], by M. Auledas, 2021, Wikimedia Commons (https://commons.wikimedia.org/wiki/File:Intel_Realsense_depth_camera_D435.jpg). CC BY-SA 4.0.

For photogrammetry, image consistency is important. A fixed focal length, stable focus, low ISO and good exposure help the software compare images. Sudden changes in zoom, focus or lighting can make image matching more difficult. For drone-based work, the pilot must plan the flight path and capture enough overlapping images. For ground-

based work, the photographer must move around the object or site in a systematic way. For scanning, the operator must keep the object and scanner conditions stable.

Scale is another important issue. Photogrammetry can create a model with correct relative proportions, but it may need a known measurement, scale bar or ground control point to connect the model to real-world dimensions.



Key Concepts

Scanner: A device that captures the shape and dimensions of a real object or space to create digital 3D data.

Scale reference: An object or known measurement included during capture to help connect the digital model to real-world size.

Ground control point: A clearly marked point with known real-world coordinates used to improve the position and accuracy of a photogrammetry model.



Practical Task

What equipment is available for a simple class activity?

What are its strengths?

What are its limitations?

How could you include a scale reference?

What settings or conditions should remain stable?

How to take the photos or collect the data

For this activity, learners should think like a capture team before thinking like software users. The drone or camera route must be planned so that the site is covered systematically, safely and legally.

Things to keep in mind

- Confirm that drone use is allowed at the location and that privacy restrictions are respected.
- Check weather, wind, light, battery, storage, obstacles and people nearby.
- Use nadir photos for map-like outputs and oblique photos for facades, walls, roofs or vertical structures.
- Keep a consistent altitude and camera angle when possible.
- Aim for strong overlap between neighbouring images; avoid isolated or random photos.
- Review the images before leaving the site and repeat missing or blurry areas.

Step by step

1. Define the output: orthophoto, 3D model, facade documentation or simple visual record.
2. Draw the capture area and mark safe take-off, landing and observation points.
3. Plan the route: parallel lines for mapping, circular or oblique passes for vertical elements.
4. Take a first test photo and check exposure, sharpness and framing.
5. Capture the full route slowly and systematically, keeping overlap between photos.
6. Review the dataset immediately: remove obvious failures and identify gaps.
7. Organise the images in a clearly named folder before uploading them to WebODM.

6. Image Datasets and Flight Planning

A photogrammetry dataset is not just a collection of photographs. It is a planned set of images that together cover the object or site from enough positions. Each image should connect with neighbouring images through visible overlap. Overlap means that the same parts of the scene appear in several images. Forward overlap connects images taken one after another. Side overlap connects images from neighbouring rows or positions. Without overlap, the software cannot connect the photographs into a coherent model.

For drone projects, flight planning helps keep altitude, route and camera angle consistent. Parallel flight lines are useful for mapping and orthophotos. Oblique images are useful for vertical structures such as facades, towers and walls.



Key Concepts

Dataset: An organised collection of photographs captured for processing together in a photogrammetry project.

Forward overlap: The shared area between photographs taken one after another along the same route.

Side overlap: The shared area between photographs taken on neighbouring rows or flight paths.

Flight line: A planned path followed by a drone while capturing a sequence of photographs.

Oblique image: A photograph taken at an angle rather than straight down, useful for façades, roofs and vertical structures.

Ground Sample Distance (GSD): The real-world size represented by one pixel in an image; a smaller GSD usually means more visible detail.

Ground Sample Distance, or GSD, is the real-world size represented by one image pixel. A lower GSD means more detail, but it usually requires flying lower or using a better camera. For beginner projects, learners do not need complex calculations, but they should understand that altitude and image resolution affect detail.

A good dataset should be checked before leaving the site. Blurry images, missing sides, large shadows, moving objects or gaps in coverage can cause processing problems later.



Practical Task

Draw a simple capture plan for an object or small building.

Where should the first image be taken?

How would you move around the object?

Where could coverage gaps appear?

What would you check before processing?

How to take the photos or collect the data

For this activity, learners should think like a capture team before thinking like software users. The drone or camera route must be planned so that the site is covered systematically, safely and legally.

Things to keep in mind

- Confirm that drone use is allowed at the location and that privacy restrictions are respected.
- Check weather, wind, light, battery, storage, obstacles and people nearby.
- Use nadir photos for map-like outputs and oblique photos for facades, walls, roofs or vertical structures.
- Keep a consistent altitude and camera angle when possible.
- Aim for strong overlap between neighbouring images; avoid isolated or random photos.
- Review the images before leaving the site and repeat missing or blurry areas.

Step by step

1. Define the output: orthophoto, 3D model, facade documentation or simple visual record.
2. Draw the capture area and mark safe take-off, landing and observation points.
3. Plan the route: parallel lines for mapping, circular or oblique passes for vertical elements.
4. Take a first test photo and check exposure, sharpness and framing.

5. Capture the full route slowly and systematically, keeping overlap between photos.
6. Review the dataset immediately: remove obvious failures and identify gaps.
7. Organise the images in a clearly named folder before uploading them to WebODM.

Mini tip: Beautiful images are not always useful images. Photogrammetry needs systematic coverage.

7. Safety, Permissions and Preparation of the Site

Technical planning is not enough. A photogrammetry or drone project must also be safe, legal and respectful. This is especially important in heritage contexts, where places may be fragile, restricted, sacred, private or located near people. Drone use must follow the relevant regulations. In Europe, EASA rules organise drone operations into categories and require pilots to consider risk, location, altitude, people nearby, airspace restrictions and the type of drone used. Privacy is also part of preparation. Capturing a building, square or landscape may accidentally capture people, license plates, private homes or sensitive areas. A responsible project plans how to avoid or manage this before capture.

Site preparation includes checking access, weather, lighting, batteries, storage, obstacles and emergency procedures. For heritage sites, it may also include contacting site managers, obtaining permission and agreeing on what can be photographed.



Key Concepts

Permission: Official approval or consent needed before photographing, scanning or flying a drone at a particular site.

Privacy: Protecting people and private information from being captured or shared without an appropriate reason or consent.

EASA: The European Union Aviation Safety Agency, which establishes common aviation safety rules for drone operations in Europe.

Geo zone: An area where drone flights may be restricted or subject to specific conditions.

Risk assessment: Identifying possible dangers before an activity and deciding how to reduce them.

Pre-flight check: A set of safety and equipment checks completed before a drone takes off.

Remember: *A technically perfect model is not a successful project if the capture was unsafe, illegal or disrespectful. Good documentation combines technical quality with ethical practice.*



Reflection

*What risks could exist at the site?
Who might need to give permission?
Could people or private spaces appear in the images?
What weather conditions would stop the activity?
What should be checked before starting?*

How to take the photos or collect the data

For this activity, learners should think like a capture team before thinking like software users. The drone or camera route must be planned so that the site is covered systematically, safely and legally.

Things to keep in mind

- Confirm that drone use is allowed at the location and that privacy restrictions are respected.
- Check weather, wind, light, battery, storage, obstacles and people nearby.
- Use nadir photos for map-like outputs and oblique photos for facades, walls, roofs or vertical structures.

- Keep a consistent altitude and camera angle when possible.
- Aim for strong overlap between neighbouring images; avoid isolated or random photos.
- Review the images before leaving the site and repeat missing or blurry areas.

Step by step

1. Define the output: orthophoto, 3D model, facade documentation or simple visual record.
2. Draw the capture area and mark safe take-off, landing and observation points.
3. Plan the route: parallel lines for mapping, circular or oblique passes for vertical elements.
4. Take a first test photo and check exposure, sharpness and framing.
5. Capture the full route slowly and systematically, keeping overlap between photos.
6. Review the dataset immediately: remove obvious failures and identify gaps.
7. Organise the images in a clearly named folder before uploading them to WebODM.

Mini tip: If the legal or ethical conditions are not clear, pause the capture. Documentation should protect heritage, not create new problems.

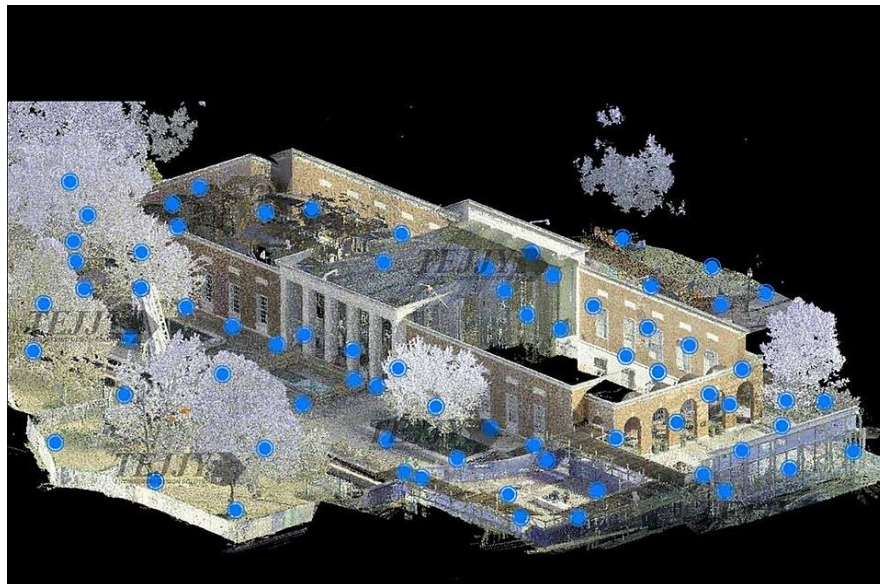
8. From Photographs to a 3D Model

The transformation from photographs to a 3D model happens in several stages. First, the software analyses the photographs and detects feature points. Then, it matches those points across different images. During **alignment**, the software estimates where each camera was when each photograph was taken. This stage creates a **sparse point cloud** and shows whether the dataset is connected. If many images fail to align, the dataset probably has problems with overlap, blur, texture or lighting.

After alignment, the software can generate a **dense point cloud**. This stage adds many more points and gives the scene more detail. The dense cloud can then be converted into a mesh, which is a surface made from connected polygons. The texture stage projects visual information from the original photographs onto the mesh. This makes the model look realistic. For mapping projects, the software may also create an orthophoto or elevation model.

Figure 8

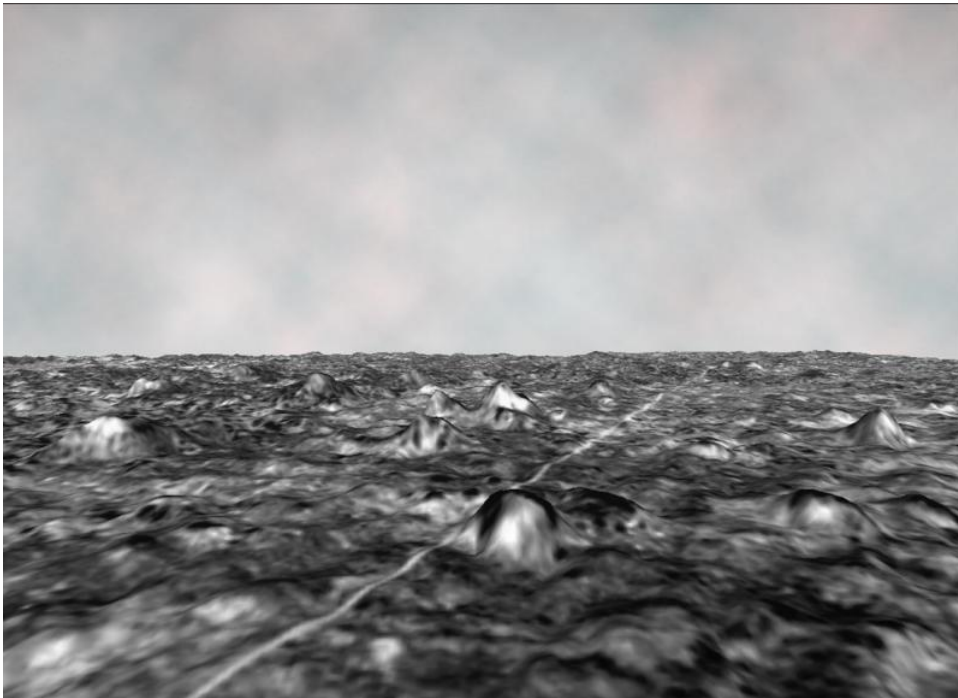
Point Cloud Visualization of a building



Note. From *3D Point Cloud Overview of Milton S. Eisenhower Library, Johns Hopkins University* [Digital image], by Matthewadams66, 2025, Wikimedia Commons ([https://commons.wikimedia.org/wiki/File:3D_Point_Cloud_Overview_of_Milton_S._Eisenhower_Library, Johns Hopkins University.jpg](https://commons.wikimedia.org/wiki/File:3D_Point_Cloud_Overview_of_Milton_S._Eisenhower_Library,_Johns_Hopkins_University.jpg)). In the public domain.

Figure 9

Example of an Orthophoto



Note. From *Chun-airsar-dem-orthophoto* [Digital image], by Hixson, D. R., 2007, Wikimedia Commons (<https://commons.wikimedia.org/wiki/File:Chun-airsar-dem-orthophoto.jpg>). In the public domain.



Key Concepts

Alignment: The stage where software matches photographs and estimates the position of each camera.

Sparse point cloud: The first basic set of 3D points created from matched photographs.

Dense point cloud: A more detailed set of 3D points generated after the initial alignment.

Orthophoto: An image corrected for perspective so it can be used like a map or elevation drawing.

Remember: *Processing cannot invent missing information. If the dataset does not include the back of an object, the software cannot reconstruct it correctly. If the images are blurry, the model will usually be weak.*



Practical Task

Put the workflow stages in order:

- What does each stage produce?
- Which stage would reveal that many images failed?
- Which output is best for visual display?
- Which output is useful for map-like interpretation?

How to take the photos or collect the data

For this activity, the photographs should be treated as input data for WebODM. The goal is to understand how capture decisions affect alignment, point clouds, meshes and orthophotos.

Things to keep in mind

- Use sharp images with stable exposure and enough visible texture.
- Cover all sides of the object or site; missing views usually become holes in the model.

- Keep overlap between consecutive images; each area should appear in several photos.
- Avoid moving people, vehicles, vegetation, strong reflections and harsh shadows.
- Include a known measurement or scale reference if the model needs real-world dimensions.
- Keep original images unchanged and process copies when possible.

Step by step

1. Create a folder for the dataset and give it a clear name.
2. Take photos around the object or site in a logical route, not randomly.
3. Capture a second higher or lower ring of photos if the object has complex geometry.
4. Check the images for blur, missing angles and exposure problems.
5. Upload the dataset to WebODM and create a processing task.
6. Review the quality report, aligned images and outputs.
7. Write down what should be improved in a second capture attempt.

Mini tip: Processing is not a rescue operation. The best improvements usually happen before processing, during planning and capture.

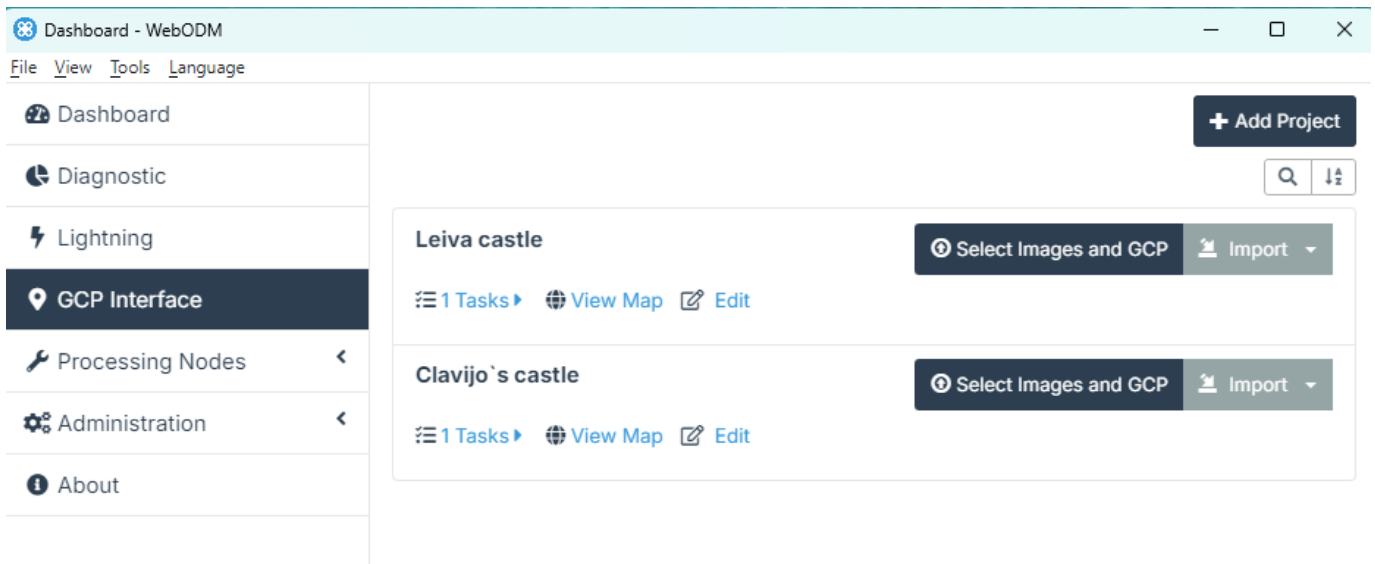
9. WebODM: Projects, Processing and Outputs

WebODM is the main tool used in this module. It provides a web interface for creating projects, uploading image datasets, launching processing tasks and reviewing outputs. This makes it suitable for learning because the workflow is visible and organised.

A project in WebODM can contain one or more tasks. A task usually corresponds to one dataset and one processing run. If learners change settings or improve the dataset, they can create a new task and compare the results. WebODM can produce several outputs: point clouds, textured models, orthophotos, digital surface models, digital terrain models and processing reports. Each output has a different use. A textured model is useful for visualisation, while an orthophoto is useful for map-like views.

Figure 10

Screenshot of WebODM workflow



Note. Screenshot of DREAM project training instance, created by the DREAM team, CC BY-SA 4.0

The processing report is important. It can show how many images were used, whether alignment was successful and whether the model has quality problems. Learners should not ignore the report just because the model looks good at first glance.



Key Concepts

Project: A workspace in WebODM that organises one or more photogrammetry processing tasks.

Task: One processing run in WebODM using a specific image dataset and selected settings.

Processing report: A summary showing how the images were processed and whether problems appeared during reconstruction.

DSM: Digital Surface Model; a model showing the height of visible surfaces such as buildings, trees and the ground.

DTM: Digital Terrain Model; a model that represents the ground surface without buildings or vegetation.

Export: Saving a WebODM result in a file format that can be downloaded, shared or used in other software.

Remember: *WebODM also helps learners understand that photogrammetry is an iterative process. A first result may show gaps, noise or distortions. The next step is to diagnose why this happened and improve capture or settings.*



Reflection

After processing your images, take a moment to look at the result and think about what it tells you about the quality of your dataset.

- What information would you check after processing?
- Did all images align?
- Which output would you use for a presentation?
- Which output would you use for a map-like document?
- What would you change if the model has holes?

How to take the photos or collect the data

For this activity, the photographs should be treated as input data for WebODM. The goal is to understand how capture decisions affect alignment, point clouds, meshes and orthophotos.

Things to keep in mind

- Use sharp images with stable exposure and enough visible texture.
- Cover all sides of the object or site; missing views usually become holes in the model.
- Keep overlap between consecutive images; each area should appear in several photos.
- Avoid moving people, vehicles, vegetation, strong reflections and harsh shadows.
- Include a known measurement or scale reference if the model needs real-world dimensions.
- Keep original images unchanged and process copies when possible.

Step by step

1. Create a folder for the dataset and give it a clear name.
2. Take photos around the object or site in a logical route, not randomly.
3. Capture a second higher or lower ring of photos if the object has complex geometry.
4. Check the images for blur, missing angles and exposure problems.
5. Upload the dataset to WebODM and create a processing task.
6. Review the quality report, aligned images and outputs.
7. Write down what should be improved in a second capture attempt.

Mini tip: The quality report is part of the learning process. Read it before deciding that the model is finished.

10. Quality, accuracy and common reconstruction errors

Quality in photogrammetry depends on several factors: image sharpness, overlap, lighting, texture, camera stability, complete coverage and the absence of moving elements. A model can look impressive but still contain errors. Accuracy means how close the model is to real-world dimensions or positions. Precision means how consistent measurements are inside the model. A visually attractive model is not automatically accurate, especially if no scale reference or control point was used.

Common reconstruction errors include holes, floating points, warped surfaces, duplicated geometry and weak textures. These errors often come from poor overlap, shiny surfaces, motion blur, repeated patterns, strong shadows or moving objects.



Key Concepts

Accuracy: How close the model or its measurements are to the real object, size or position.

Precision: How consistent measurements within the model are when repeated.

Noise: Incorrect or unwanted points or shapes that appear in a photogrammetry result.

Blur: Loss of sharpness in a photograph, often caused by movement or poor focus.

Coverage gap: An area of an object or site that was not photographed sufficiently and may therefore be missing from the model.

Reflective surface: A shiny surface, such as glass or metal, that reflects light and can make it difficult for the software to identify stable points.

RMSE (Root Mean Square Error): A numerical measure used to show the average amount of error in a model; a lower RMSE generally indicates greater accuracy.

Vegetation, water, glass and reflective metal are difficult because they change appearance between images or do not provide stable feature points. People and vehicles can also create noise because they move between photographs.

Improving quality usually means returning to the dataset: capture more images, increase overlap, change lighting, avoid blur, include missing angles or choose a more suitable capture method.



Practical Task

Look at a photogrammetry result with errors.

Where are the holes or distortions?

What could have caused them?

Would more overlap help?

Would different lighting help?

Would another technique be better?

How to take the photos or collect the data

For this activity, the photographs should be treated as input data for WebODM. The goal is to understand how capture decisions affect alignment, point clouds, meshes and orthophotos.

Things to keep in mind

- Use sharp images with stable exposure and enough visible texture.
- Cover all sides of the object or site; missing views usually become holes in the model.
- Keep overlap between consecutive images; each area should appear in several photos.
- Avoid moving people, vehicles, vegetation, strong reflections and harsh shadows.
- Include a known measurement or scale reference if the model needs real-world dimensions.
- Keep original images unchanged and process copies when possible.

Step by step

1. Create a folder for the dataset and give it a clear name.
2. Take photos around the object or site in a logical route, not randomly.
3. Capture a second higher or lower ring of photos if the object has complex geometry.
4. Check the images for blur, missing angles and exposure problems.
5. Upload the dataset to WebODM and create a processing task.
6. Review the quality report, aligned images and outputs.
7. Write down what should be improved in a second capture attempt.

Mini tip: Do not judge a model only by its first visual impression. Look for errors, missing areas and signs of weak reconstruction.

11. Working with point clouds, orthophotos and 3D models

Photogrammetry outputs are not all the same. A **point cloud** is a set of points in 3D space. It can show the shape of the object or site and may be useful for measurement, analysis or further processing. A **mesh** is a surface made of connected polygons. When texture is applied, it becomes easier to understand visually. Textured meshes are useful for presentations, virtual exhibitions and storytelling, but they may not always be the best output for precise measurement. An **orthophoto** or **orthomosaic** is an image corrected for perspective, so it can be used like a map or elevation drawing. In heritage work, orthophotos can help document facades, floors, walls, archaeological areas or landscape features.

Digital Surface Models include visible surfaces such as buildings, trees and structures. Digital Terrain Models try to represent the ground surface. Understanding this difference helps learners interpret landscape outputs correctly. The choice of output depends on the project purpose. A school exhibition may need a textured 3D model. A facade analysis may need an orthophoto. A landscape activity may use elevation models. A conservation workflow may require point clouds and metadata.



Practical Task

Match each output to a use case:

- **Point cloud**
- **Mesh**
- **Texture**
- **Orthophoto**
- **Orthomosaic**
- **DSM**
- **DTM**

Which output is best for visual storytelling?

Which output is best for map-like interpretation?

Which output might support measurement?

Which output would be easiest for learners to present?

How to take the photos or collect the data

For this activity, the photographs should be treated as input data for WebODM. The goal is to understand how capture decisions affect alignment, point clouds, meshes and orthophotos.

Things to keep in mind

- Use sharp images with stable exposure and enough visible texture.
- Cover all sides of the object or site; missing views usually become holes in the model.
- Keep overlap between consecutive images; each area should appear in several photos.
- Avoid moving people, vehicles, vegetation, strong reflections and harsh shadows.
- Include a known measurement or scale reference if the model needs real-world dimensions.
- Keep original images unchanged and process copies when possible.

Step by step

1. Create a folder for the dataset and give it a clear name.
2. Take photos around the object or site in a logical route, not randomly.
3. Capture a second higher or lower ring of photos if the object has complex geometry.
4. Check the images for blur, missing angles and exposure problems.
5. Upload the dataset to WebODM and create a processing task.
6. Review the quality report, aligned images and outputs.
7. Write down what should be improved in a second capture attempt.

Mini tip: The best output is not always the most visually attractive one. Choose the output that serves the project goal.

12. Basic data management and documentation

A photogrammetry project produces many files: original images, processed outputs, reports, exports, notes and sometimes permission documents. Without organisation, the project becomes difficult to understand or reuse. The original photographs are the primary record. They should be preserved because future software may be able to reprocess them better. Learners should avoid deleting or editing original images and should work from copies when needed. Good file naming helps. A dataset folder can include the date, location, object name and capture method. A simple metadata sheet can record who captured the images, what equipment was used, what permissions were obtained, and what the purpose of the project was.

Documentation is especially important for heritage. A digital model without context can become disconnected from the place or community it represents. Notes about meaning, location, authorship and ethical restrictions help keep the model useful and respectful. Backups and versioning are part of basic responsibility. If the dataset matters, it should not exist in only one place. If the model is revised, the old and new versions should be clearly labelled.



Key Concepts

Metadata: Information that describes a digital file or project, such as its date, location, creator, equipment and purpose.

Backup: An additional copy of important files stored separately in case the originals are lost or damaged.

Versioning: Keeping and clearly labelling different versions of a file or model as it is changed or improved.

Permission record: Documentation showing what permission was obtained to photograph, scan or use a site or object.

Processing notes: Short records of the settings, problems, decisions and results from a photogrammetry processing attempt.



Practical Task

Create a folder naming convention for a heritage capture project.

What metadata should be recorded?

Where would permissions be stored?

How would you label a second processing attempt?

What files should never be deleted?

How to take the photos or collect the data

For this activity, learners should capture and document at the same time. A good dataset is not only a group of images; it also includes notes that explain where the images came from and how they may be used.

Things to keep in mind

- Record date, location, object/site name, author and purpose.
- Keep original images in a protected folder.
- Create separate folders for raw images, processed outputs, reports and exports.
- Save permission notes or access restrictions with the project files.
- Use consistent file and folder names.
- Back up important datasets before editing or processing.

Step by step

1. Create the project folder before capture begins.
2. Write a short capture note with purpose, location and equipment.
3. Take the photos using a planned route and keep all originals.
4. Copy the selected images into a processing folder.
5. Save WebODM outputs in a separate results folder.
6. Add a short note explaining errors, limitations and possible improvements.
7. Back up the full project folder.

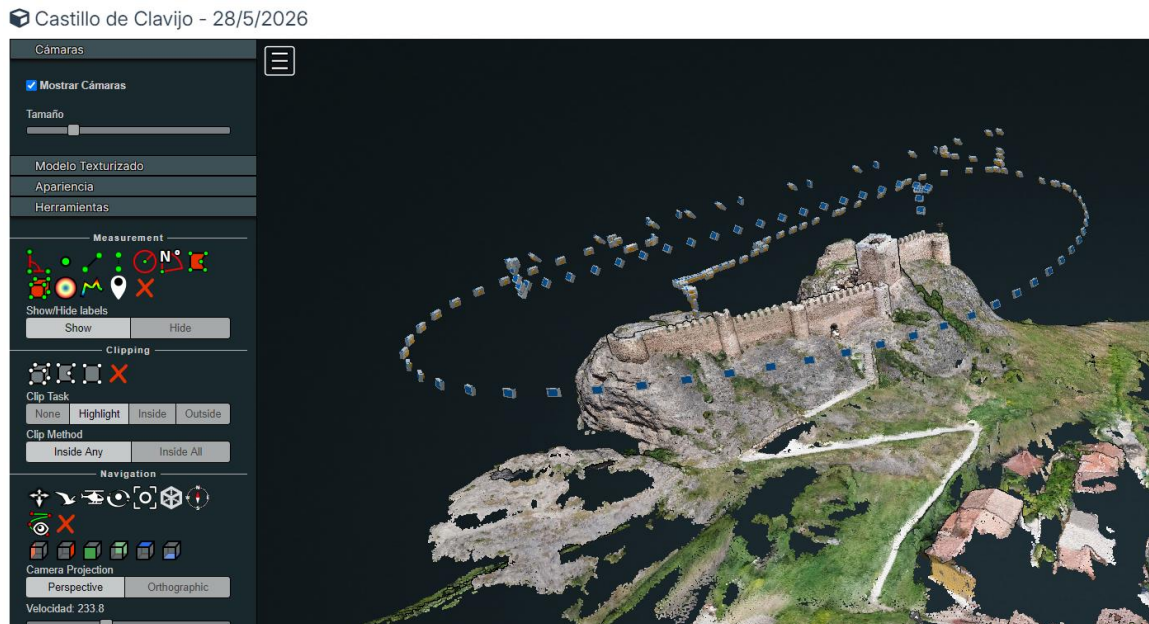
Mini tip: A model without notes is easy to lose, misunderstand or misuse. Document the process as well as the result.

13. Introduction to drone-based photogrammetry workflows

A drone-based photogrammetry workflow begins before the flight. The team defines the purpose, checks permissions, studies the site, plans the flight route and decides what outputs are needed. A mapping project and a facade project do not use exactly the same capture strategy. **Nadir images** are taken with the camera looking straight down. They are useful for maps, orthophotos and terrain-like surfaces. **Oblique images** are taken at an angle. They are useful for vertical structures such as facades, towers, roofs and walls.

Figure 11

Drone grid and circular capture path



Note. Software visualization of camera locations showing an oblique circular flight path, created by the DREAM team, CC BY-SA 4.0

Overlap is essential. A drone should capture images so that each part of the site appears in several photographs. Consistent altitude and speed help keep image scale and sharpness stable. Strong wind, low light or fast movement can create blur.

After the flight, the dataset should be reviewed before leaving the site. The team should check whether the images are sharp, whether the whole area is covered, whether there are exposure problems and whether any important angle is missing.

Remember: *Drone photogrammetry can be powerful, but it must be systematic. A set of attractive aerial images is not the same as a dataset prepared for reconstruction.*



Key Concepts

Flight path: The planned route a drone follows while capturing photographs over or around a site.

Post-flight review: Checking the photographs after a drone flight to make sure they are sharp, complete and suitable for processing.

No-fly zone: An area where drone flights are prohibited or highly restricted.



Practical Task

Plan a simple drone workflow for a small heritage building.

What output is needed?

Would nadir images be enough?

Would oblique images be required?

What safety checks are needed?

What should be reviewed after landing?

How to take the photos or collect the data

For this activity, learners should think like a capture team before thinking like software users. The drone or camera route must be planned so that the site is covered systematically, safely and legally.

Things to keep in mind

- Confirm that drone use is allowed at the location and that privacy restrictions are respected.
- Check weather, wind, light, battery, storage, obstacles and people nearby.
- Use nadir photos for map-like outputs and oblique photos for facades, walls, roofs or vertical structures.
- Keep a consistent altitude and camera angle when possible.
- Aim for strong overlap between neighbouring images; avoid isolated or random photos.
- Review the images before leaving the site and repeat missing or blurry areas.

Step by step

1. Define the output: orthophoto, 3D model, facade documentation or simple visual record.
2. Draw the capture area and mark safe take-off, landing and observation points.
3. Plan the route: parallel lines for mapping, circular or oblique passes for vertical elements.
4. Take a first test photo and check exposure, sharpness and framing.
5. Capture the full route slowly and systematically, keeping overlap between photos.
6. Review the dataset immediately: remove obvious failures and identify gaps.
7. Organise the images in a clearly named folder before uploading them to WebODM.

Mini tip: Random beautiful drone photos are not data. Photogrammetry needs a planned dataset.

14. Final Activity: Heritage 3D Documentation Plan

The final activity brings the full workflow together. Learners choose a simple object, building detail or local heritage element and prepare a basic documentation plan. The goal is not to create a perfect professional model, but to understand the complete process with criteria. The activity starts with purpose. Learners must decide why the object or place should be documented. Possible purposes include education, exhibition, accessibility, conservation awareness, tourism interpretation or community memory.

Then learners plan capture. They decide whether to use a smartphone, camera, drone or scanner; how many sides need coverage; where images should be taken; what permissions are needed; and how the dataset will be organised.

If WebODM is available, learners process the dataset and review the outputs. If processing is not possible during the session, they can analyse an example dataset and discuss what the expected outputs would be.

The final presentation should include the object or site, the purpose, the capture plan, the main risks, the expected outputs and one improvement that would be made in a second attempt.



Practical Task

Work individually or in pairs. Choose one simple local heritage element, such as an object, building detail or monument. Use what you have learned in the module to prepare a basic plan for documenting it digitally.

1. Select a simple heritage element.
2. Define the purpose of the digital documentation.
3. Choose the capture method.
4. Plan the image positions.
5. Identify safety and permission issues.
6. Describe the expected WebODM outputs.
7. Present one lesson learned.

How to take the photos or collect the data

For this activity, learners should practise a simple close-range photogrammetry capture. The aim is to collect a clean, overlapping image set that could later be processed in WebODM.

Things to keep in mind

- Choose an object with visible texture and avoid shiny, transparent or plain surfaces.
- Use soft, stable light; avoid strong shadows and reflections.
- Keep the object still and move the camera around it.
- Take overlapping photos from several angles; do not skip the back or sides.
- Keep the camera steady and avoid blur.
- Include a ruler, scale bar or known measurement if size matters.

Step by step

1. Place the object in a stable position with enough space around it.
2. Take one test photo and check sharpness, light and framing.
3. Move around the object in a circle, taking one photo every small step.
4. Capture a second ring from a slightly higher angle.
5. Capture details or hidden areas that the first pass missed.
6. Review all photos and retake blurry or poorly lit images.
7. Save the dataset in a clearly named folder for WebODM or later review.

Mini tip: Start small. A simple object documented well teaches more than an ambitious site documented poorly.

15. Digital Wellbeing Tip



Digital Wellbeing Tip

Notice How Digital Use Makes You Feel

Not all screen time affects us in the same way. Some digital activities can leave us feeling informed, connected or creative, while others may make us feel distracted, tired or overwhelmed. Paying attention to this difference can help us use technology more intentionally.

Try this: After spending time online, briefly notice how you feel. If an activity regularly leaves you tense or drained, consider taking a break, changing how long you spend on it or choosing another activity.

Reflection question: Which digital activities usually leave you feeling better, and which ones tend to leave you feeling more tired or distracted?

16. Basic glossary

Accuracy: How close a model, measurement or position is to the real-world value.

Bundle adjustment: A mathematical optimisation process that improves estimated camera positions and 3D points.

Dense point cloud: A detailed set of 3D points generated after initial image alignment.

DSM: Digital Surface Model. It represents visible surfaces such as ground, buildings, vegetation and objects.

DTM: Digital Terrain Model. It aims to represent the ground surface without buildings or vegetation.

Feature point: A visual detail that software can recognise in several photographs.

Forward overlap: Shared image area between photographs taken one after another along a route.

GCP: Ground Control Point. A point with known coordinates used to improve georeferencing or accuracy.

GSD: Ground Sample Distance. The real-world size represented by one pixel in an image.

Mesh: A 3D surface made from connected polygons.

Nadir image: An image taken with the camera pointing straight down.

Oblique image: An image taken at an angle, useful for facades and vertical structures.

Orthophoto: An image corrected for perspective so it can be used like a map or elevation drawing.

Point cloud: A collection of 3D points representing the shape of an object or space.

Precision: How consistent measurements are when repeated, even if they are not perfectly accurate.

RMSE: Root Mean Square Error. A statistical indicator often used to describe measurement error.

Side overlap: Shared image area between neighbouring rows or flight lines.

Sparse point cloud: The first, lighter point cloud created during image alignment.

Structure from Motion: A photogrammetry process that estimates camera positions and initial 3D structure from overlapping images.

Texture: The visual surface information applied to a 3D mesh from the original photographs.

WebODM: An open-source web platform for processing drone and ground image datasets into photogrammetry outputs.

16. Module closing

Photogrammetry and 3D scanning are practical ways to connect real-world heritage with digital learning, documentation and interpretation. They allow learners to observe objects and places carefully, plan capture decisions and create digital outputs that can be shared and discussed.

The most important lesson is that good 3D documentation is not only a software task. It is a complete workflow: purpose, planning, permissions, capture, processing, quality review, documentation, archiving and communication. WebODM helps make this workflow visible. Drones expand what can be captured, but they also require responsibility. 3D scanning offers another route for capturing geometry, especially when objects or conditions make photogrammetry difficult. A successful project is not finished when the model looks good. It is finished when the dataset is organised, the process is documented, the ethical conditions are respected and the output helps people understand the value of the object or place.



Reflection

What part of the workflow seems most important for quality?

What part of the workflow seems most important for heritage interpretation?

When would you use a drone?

When would you avoid using a drone?

What would you improve in a second version of your project?

Bibliography

Auledas, M. (2021). *Intel Realsense depth camera D435* [Photograph]. Wikimedia Commons.

https://commons.wikimedia.org/wiki/File:Intel_Realsense_depth_camera_D435.jpg

Dr. Schorsch. (2010). *Principle of 3d fringe projection numbered* [Vector graphic]. Wikimedia Commons.

https://commons.wikimedia.org/wiki/File:Principle_of_3d_fringe_projection_numbered.svg

Dwivedi, S. (2019). *DJI Phantom 4K drone in action* [Photograph]. Wikimedia Commons.

https://commons.wikimedia.org/wiki/File:DJI_Phantom_4K_drone_in_action.jpg

Hixson, D. R. (2007). *Chun-air sar-dem-orthophoto* [Digital image]. Wikimedia Commons.

<https://commons.wikimedia.org/wiki/File:Chun-air sar-dem-orthophoto.jpg>

Matthewadams66. (2025). *3D Point Cloud Overview of Milton S. Eisenhower Library, Johns Hopkins University* [Digital image]. Wikimedia Commons.

https://commons.wikimedia.org/wiki/File:3D_Point_Cloud_Overview_of_Milton_S._Eisenhower_Library,_Johns_Hopkins_University.jpg

N.ELAC. (2019a). *Foto para exercício de fotogrametria - Pinha (56)*, N.ELAC [Photograph]. Wikimedia Commons.

[https://commons.wikimedia.org/wiki/File:Foto_para_exerc%C3%ADcio_de_fotogrametria_-_Pinha\(56\),_N.ELAC.jpg](https://commons.wikimedia.org/wiki/File:Foto_para_exerc%C3%ADcio_de_fotogrametria_-_Pinha(56),_N.ELAC.jpg)

N.ELAC. (2019b). *Sede da Fazenda do Pinhal (143)*, N.ELAC [Photograph]. Wikimedia Commons.

https://commons.wikimedia.org/wiki/File:Sede_da_Fazenda_do_Pinhal_%28143%29,_N.ELAC.png

Sorenson, J. (2018). *Quadcopter camera drone in flight* [Photograph]. Wikimedia Commons.

https://commons.wikimedia.org/wiki/File:Quadcopter_camera_drone_in_flight.jpg

Wiora, G. (2005). *Photogrammetry Wiora EN* [Vector graphic]. Wikimedia Commons.

https://commons.wikimedia.org/wiki/File:Photogrammetry_Wiora_EN.svg