

## NEANIAS Underwater Mapping Service

The NEANIAS UW-MOS service (U2 - Seafloor mosaicking from optical data), developed by Coronis Computing S.L., deals with optical mapping in underwater environments. UW-MOS provides an operational solution for large area representation of the seafloor addressing also visibility limitations from the underwater medium. UW-MOS is composed of several sub-services or tasks to deal with the underwater mapping problem from images:

- Camera calibration
- Image undistortion
- Image enhancement
- Image data quality check
- 2D image mosaicking
- 3D reconstruction

The service is based on Coronis in-house solutions and some other commonly used open source libraries from the Computer Vision community (OpenCV, OpenMVG, OpenMVS, ...). The user is allowed to launch more than one task at the same time, also the service can be used with a REST API based on OpenAPI v3.0.2 specifications.

The UW-MOS service is the first service that provides an end-to-end solution for building large scale maps from underwater optical images, using either 2D mosaicking or 3D reconstruction techniques freely on the cloud, without requiring any local software installation. The service adapts to the degree of expertise of the user. Therefore, a non-expert user may just upload a set of images and obtain a map, while an expert user will find tools suited for mastering the mapping process and obtaining the best results. Within these tools, the data quality check and the underwater image enhancement methods are specifically devised for our service and, consequently, they are not present in any non-commercial nor commercial desktop solutions solving this same problem.

### **1. Input data**

The service requires input data to generate mosaics or 3D reconstructions. These input files correspond to a set of images collected during a survey mission, in common formats such as tiff, jpeg, png, ... Optionally, navigation data can be provided for georeferencing the resulting 2D or 3D maps.

Moreover, the input data may be stored and managed using NEANIAS Data storage/sharing core service (Nextcloud), and sample data for demonstration purposes is provided for each task from the web.

### **2. Output**

The result of the UW-MOS service can be a 2D mosaic (a 2D image-composite of the scene) or a 3D mosaic (as a textured surface triangle mesh).

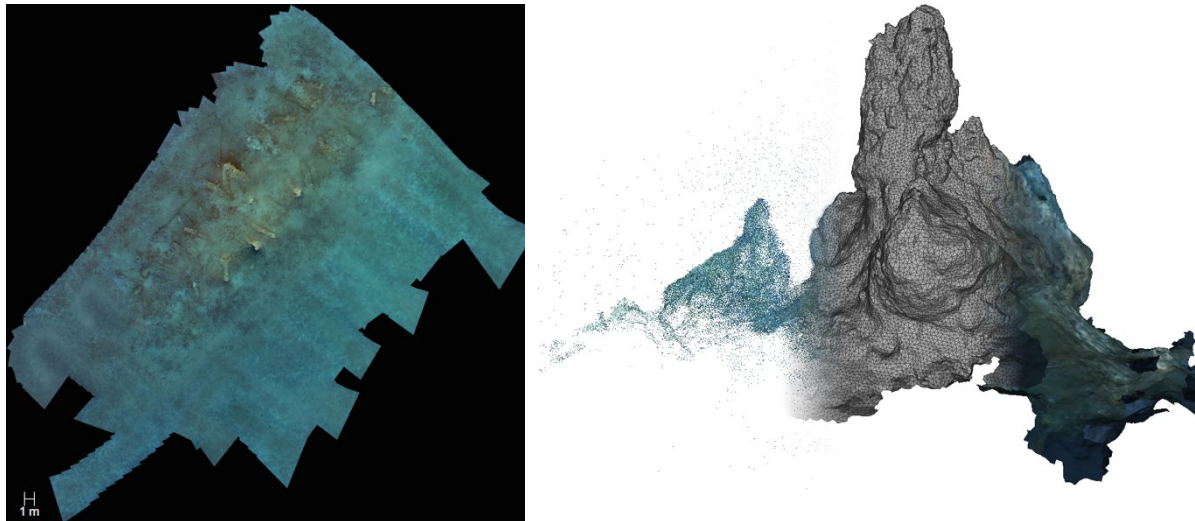


Figure 1: Sample results. 2D mosaic (left) and 3D map (right).

### 3. How to use it

- 1) First access the web service using this link (<https://uw-mos.neanias.eu> )
- 2) Log in using the NEANIAS AAI.
- 3) To start a new task, choose one of the options listed either in the landing page or in the left-side menu (as presented in Figure 2). The user may consult the status of the execution of the task, as well as retrieve the results of a task, from within the “My Tasks” option from the menu.

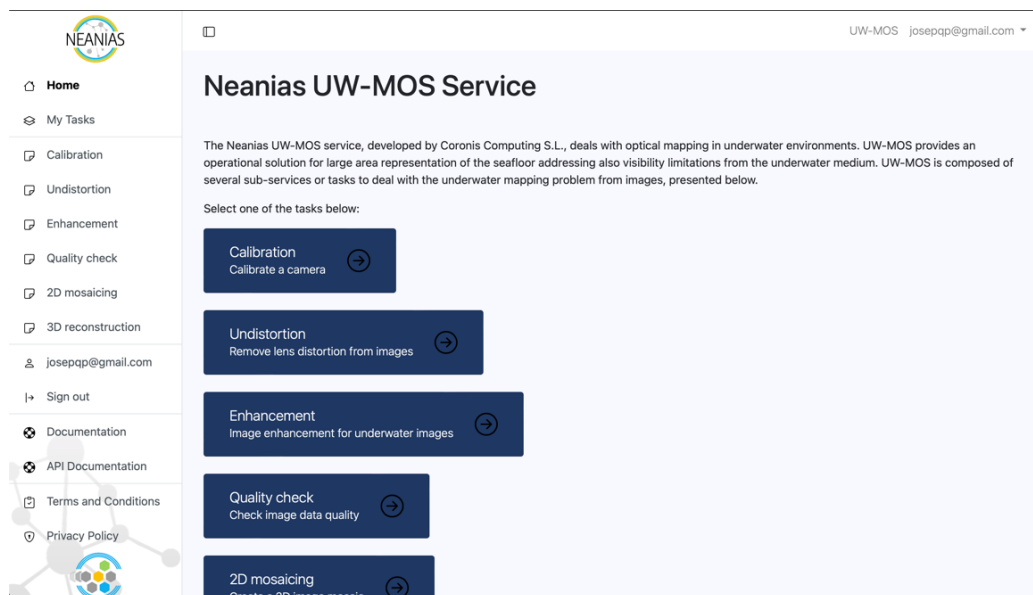


Figure 1: Initiate a new task in UW-MOS service.

- 4) The configuration of the different tasks follows a similar pipeline. For each task:
  - a) First, select the set input images (local storage or NEANIAS Data Sharing service – includes demo data).
  - b) Then, set task-specific parameters (more information on their meaning can be found in the documentation of the service).
  - c) Finally, submit the task. In case of using local data, it will start upload the images to the service before starting the task execution. Otherwise, the task will start executing directly.

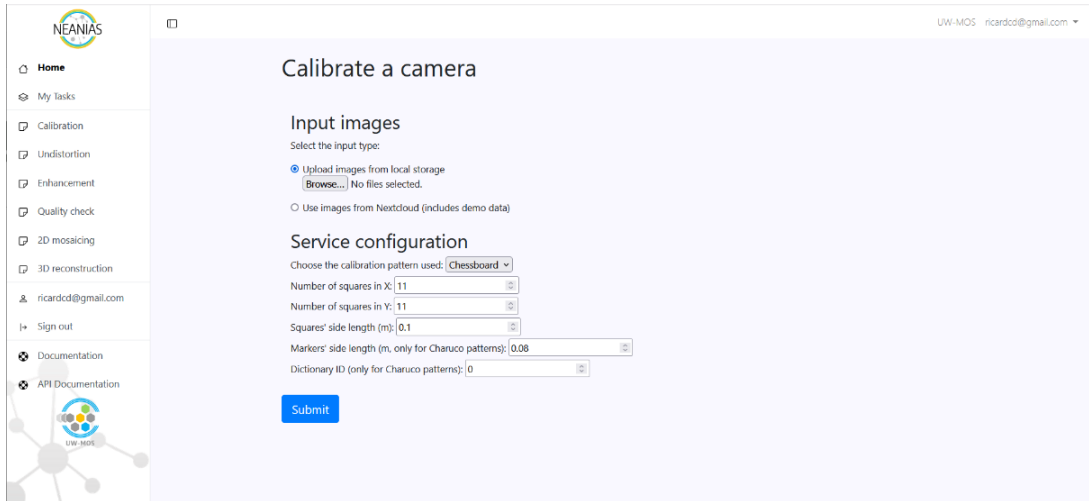


Figure 2: Task configuration page

- 5) After launching the task, you will be redirected to the “My Tasks” view, where you will be presented with your list of on-going and completed tasks. On this task list menu, you can:
  - a) View and/or Download results in different formats
  - b) View the input images, processed ones and input/processed side-by-side (these last two just for undistortion and image enhancement tasks).
  - c) Share the results of a task back to the user via the NEANIAS Data Sharing service.
  - d) A report of the execution, where the user can see the different steps executed and details of the execution progress. To promote repeatability, a complete list of software versions and the commands used for each pipeline is listed. Moreover, a summary of the task execution time and resources required for processing are also presented. The report can be consulted, in some cases, during task execution (to see the progress of the task) or downloaded at the end of the task as a PDF file.
  - e) Delete a task. Once the user has viewed/retrieved the results, he/she can remove the task and its associated data from the service.

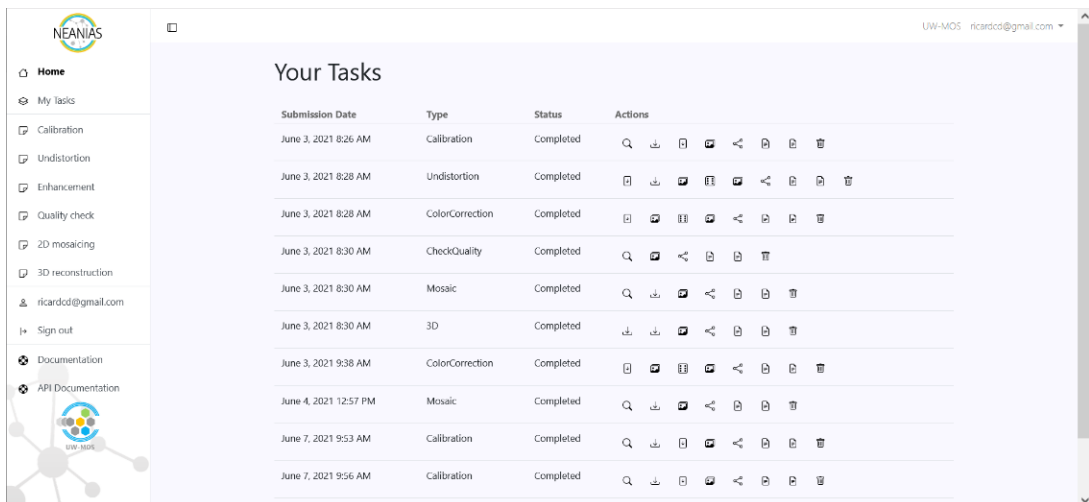


Figure 3: Task list

#### 4. UW-MOS: Camera Calibration Task

The camera calibration task of UW-MOS, responsible for obtaining the intrinsic parameters ruling the internal geometry of the camera, i.e., how a point from the world is projected onto the image plane.

This calibration is usually performed using a calibration pattern, from which some points belonging to a common known plane can be extracted. By means of a known planar pattern, and some user intervention, the 3D-2D relations can be established. Then, by means of the DLT algorithm and a non-linear optimization procedure, the parameters of the camera are recovered.

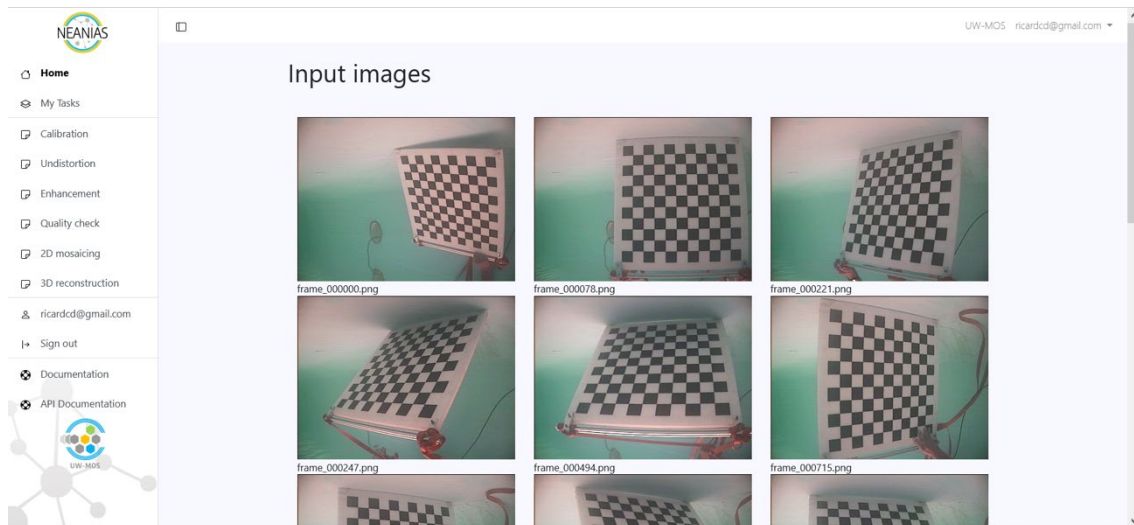


Figure 4: Input images for the camera calibration task.

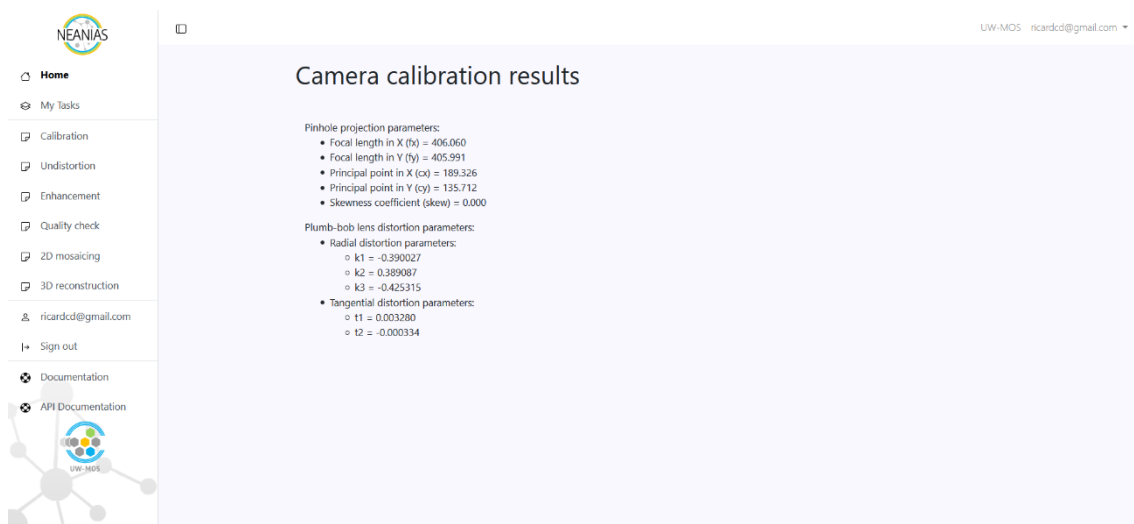


Figure 5: Sample result from the camera calibration task.

## 5. UW-MOS: Image Undistortion Task

Given the camera parameters obtained in the previous task, removes the distortions of the image caused by the camera lenses assuming the plumb-bob distortion model. The output of this task is a set of images without distortion. That is, straight lines in the world should remain straight in the image after correcting distortion.

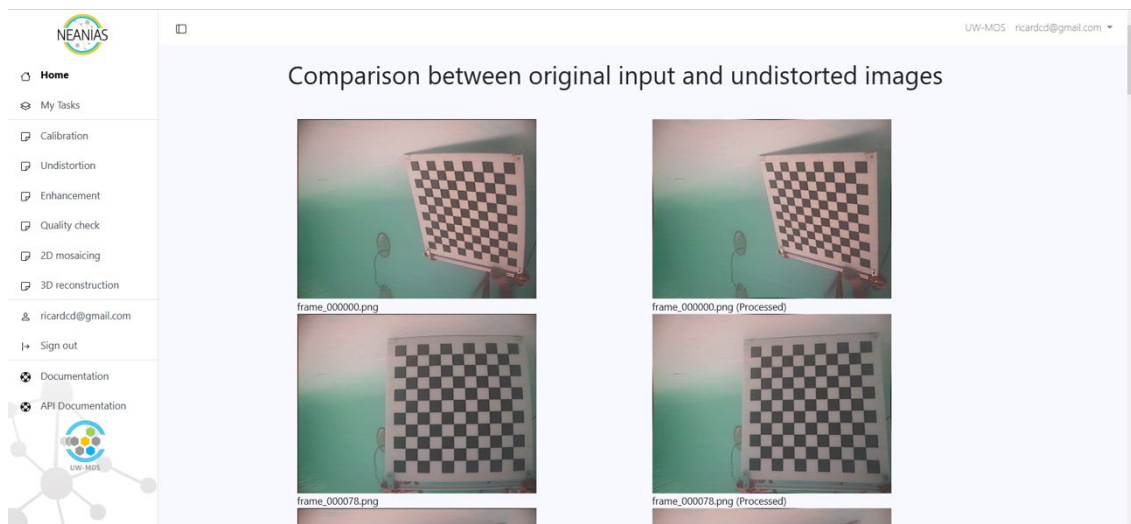


Figure 6: Output from the Image Undistortion Task, input images (left), and corrected images (right).

## 6. UW-MOS: Image Enhancement Task

Since underwater images suffer from lack of contrast and color shifting, we provide an image enhancement method suited for underwater data. The method implemented is the color correction method in Bianco2015<sup>1</sup>, with the optional Contrast Limited Adaptive Histogram Equalization (CLAHE) step.

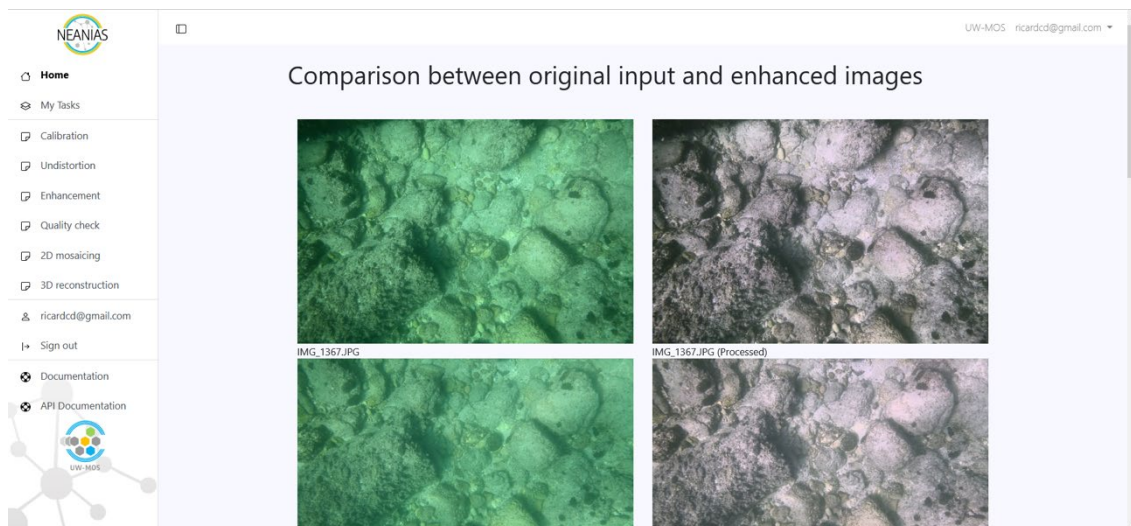


Figure 7: Output from Image enhancement task. Original images (left) and enhanced images (right).

## 7. UW-MOS: Data Quality Check Task

UW-MOS task checking the quality and suitability of a set of images for 2D mosaicing and/or 3D reconstruction.

The first step in both 2D mosaicing and 3D reconstruction tasks is to detect features on the images. These features are the base of the subsequent steps in both pipelines and, consequently, the input images must contain a relevant number of such features in order to obtain good results.

<sup>1</sup> Bianco, G., Muzzupappa, M., Bruno, F., Garcia, R., and Neumann, L. A New Color Correction Method for Underwater Imaging Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XL-5/W5, 25–32. 2015. <https://doi.org/10.5194/isprsarchives-XL-5-W5-25-2015>

This task computes the number of AKAZE2 features for each image of the input dataset. A minimum of 500 features is required to consider an image as suitable for mosaicing/reconstruction.

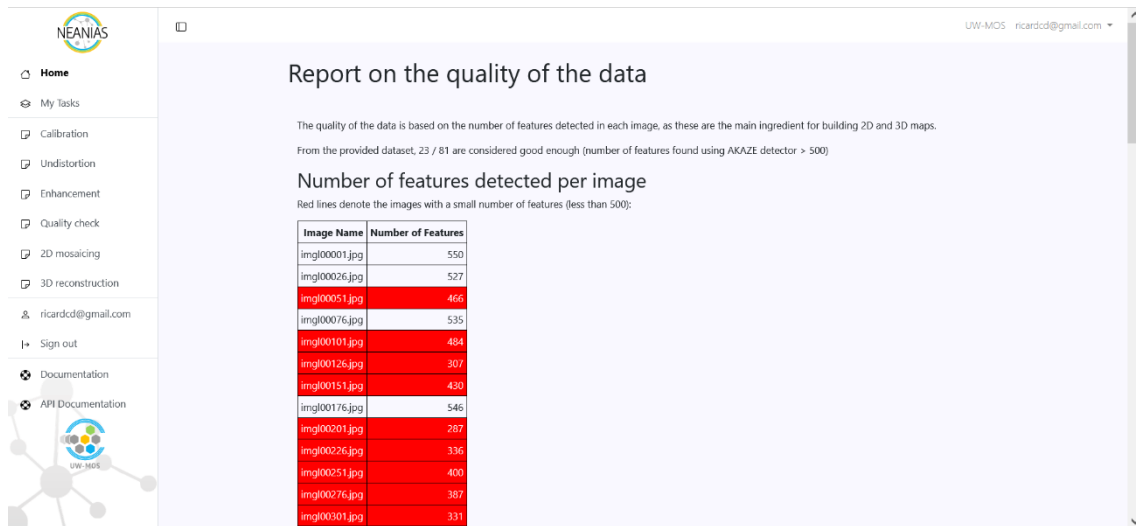


Figure 8: Example of a report for the check quality task.

## 8. UW-MOS: 2D Mosaicing Task

Performs all the steps of a 2D image mosaicing pipeline. The result is a composite of all the input images (an image mosaic).

This service assumes that the scene observed in the images is close to planar or, alternatively, that the effects of parallax are negligible. This corresponds to a typical use case for this service, which is a flyover of a downward-looking camera carried by an AUV/ROV surveying a given seabed area not having much 3D relief (or not relevant compared to the distance from the camera to the scene).

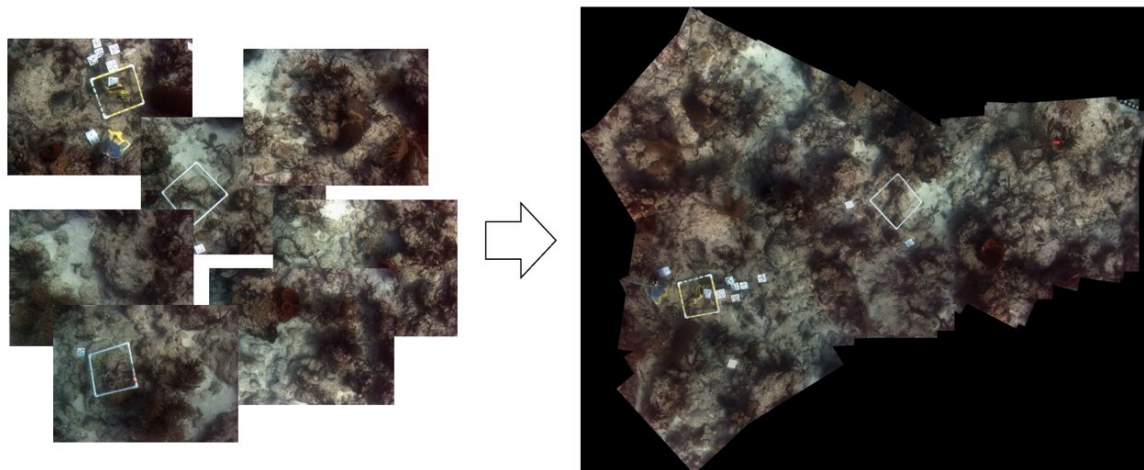


Figure 9: Example of 2D mosaicing task output. From individual underwater images to a single composite image.

2 Pablo F Alcantarilla, Jesús Nuevo, and Adrien Bartoli. Fast explicit diffusion for accelerated features in nonlinear scale spaces. Trans. Pattern Anal. Machine Intell, 34(7):1281–1298, 2011.

## 9. UW- MOS: 3D Reconstruction task

Reconstructs a 3D scene observed in a set of overlapping images as a textured surface triangle mesh using OpenMVG and OpenMVS libraries.

The current version of the service only requires the user to upload a set of images. As in the 2D mosaicing case, the scene observed by the images should have some overlap. However, the amount of overlap for 3D reconstruction should be larger: the more redundant the data is the better. As a rule of thumb, consider that a part of the scene may be reconstructed only if it is seen, at least, in three different images.

The result is a textured surface triangle mesh, downloadable in formats amenable to web/desktop 3D viewers:

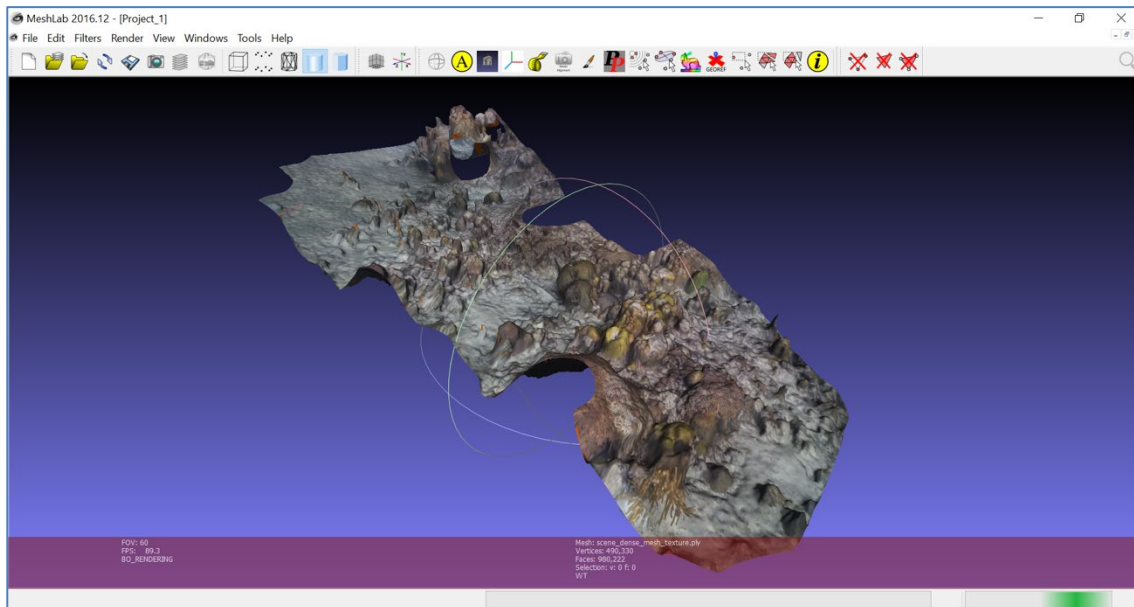


Figure 10. Results of the 3D reconstruction task, visualized in the Meshlab desktop 3D viewer.

## 10. Useful links:

Neanias UW-MOS Service: <https://uw-mos.neanias.eu>

Neanias UW-MOS Documentation: <https://docs.neanias.eu/projects/u2-service/en/latest/>

Neanias UW-MOS API Documentation: <https://uw-mos.neanias.eu/api/docs/>

EOSC Marketplace: <https://marketplace.eosc-portal.eu/services/uw-mos>

NEANIAS Catalogue: <https://catalogue.neanias.eu/service/coronis.uw-mos>