Martech 2021.
Marine Technology Workshop
16,18th June. Vigo, Spain

# Photogrammetry in Marine Science

Simone Sammartino[1,2], Pablo Otero Roth[1], Andres Góngora González[3], Jesús García Lafuente[2]

[1] *Ocean Engineering Institute, University of Málaga. ETSI Telecomunicación. Campus de Teatinos s/n. 29071. Málaga, Spain*
[2] *Physical Oceanography Group, University of Málaga. ETSI Telecomunicación. Campus de Teatinos s/n. 29071. Málaga, Spain*
[3] *Machine perception and Intelligent Robotics (MAPIR), and Biomedical Research Institute of Malaga (IBIMA) University of Malaga, Campus de Teatinos s/n. 29071. Málaga, Spain*

***Abstract* – Photogrammetry is one of the oldest but constantly evolving branch of computer vision. The main concept behind it is based on obtaining three-dimensional coordinates of a real word object from a series of pictures of it, collected from different locations. The outcome is a three-dimensional model of the object, on which any kind of virtual manipulation and quantitative measuring can be carried out. Several examples of both aerial (based on aerial photographs) and close-range (based on standard close-distance pictures) photogrammetry applications to different fields of marine science, are described, promoting the use of this technique as an undeniable aid for oceanographers, marine geologists and biologists.**

***Keywords* –** *Photogrammetry, Image processing, 3D models.*

## I. PHOTOGRAMMETRY

Photogrammetry is the science of obtaining quantitative information about surface and volume of an object, from a series of pictures of it. The basic concept is the known pinhole camera model [1], which describes the mathematical relationship between the three-dimensional coordinates of a point in the exterior (real world) space and its projection on the bi-dimensional plane of the camera sensor in the interior space. This model is sophisticated by accounting lens geometry and distortion (camera calibration) that affect the accuracy of the previous transformation. For a given camera location, a line of sight (ray) to the target point is drawn and, if the same point is seen from other camera locations, the intersection of these multiple rays determines the three-dimensional position of the point (triangulation, [2]). This technique is iterated through a generally large number of pixels recorded in multiple neighbor images, with a recursive approach aimed at minimizing errors, and a three-dimensional point cloud is obtained. Eventually, the object shape can be reconstructed by interpolating the point clouds on a triangular mesh, usually by means of a Poisson Surface Reconstruction algorithm [3], to obtain a complete texturized 3D model.

## II. AERIAL AND CLOSE-RANGE PHOTOGRAMMETRY

Two different approaches of the photogrammetric technique are widely employed in environmental science. The aerial photogrammetry is based on the pool of aerial images collected along predefined tracks with a high degree of overlap among neighbor images. The outcomes are typically 3D terrain models employed in topography, civil engineering and coastal/land management. On the other hand, close-range photogrammetry relies on images collected by standard cameras, with typically inclined orientation, surrounding the object. Archaeology, medicine, mechanic engineering and morphometry are only few of the fields where this technique is successfully applied. The main difference with the previous method is the lack of information on the camera location and orientation, which is provided by the aircraft in the aerial counterpart. This implies the lack of a real-word scale, which however can be inferred by adding scaled references in the scene.

## III. APPLICATIONS TO MARINE SCIENCE

Different examples of applications of both aerial and close-range photogrammetry are presented in this work, all sharing the common field of marine science and technology. Drone-based aerial photogrammetry is proposed as a technique to improve the quality of the sites mapping in coastal management. Marine coastal evolution after storm events, morphology inspection of riverine margins and even the combined use of shallow bathymetric survey and high resolution photogrammetric coastal mapping are presented (Fig.1). On the other hand, a successful example of application of close-range photogrammetry to the digitalization of the Marine fauna collection of the Spanish Institute of Oceanography, is also described. A bunch of unique specimen of abyssal fishes, included a rare dicephalus blue shark (*Prionace glauca*), have

been digitalized providing a unique way of handling, measuring and analyzing the samples with no further need of physical contact with them (Fig.1).

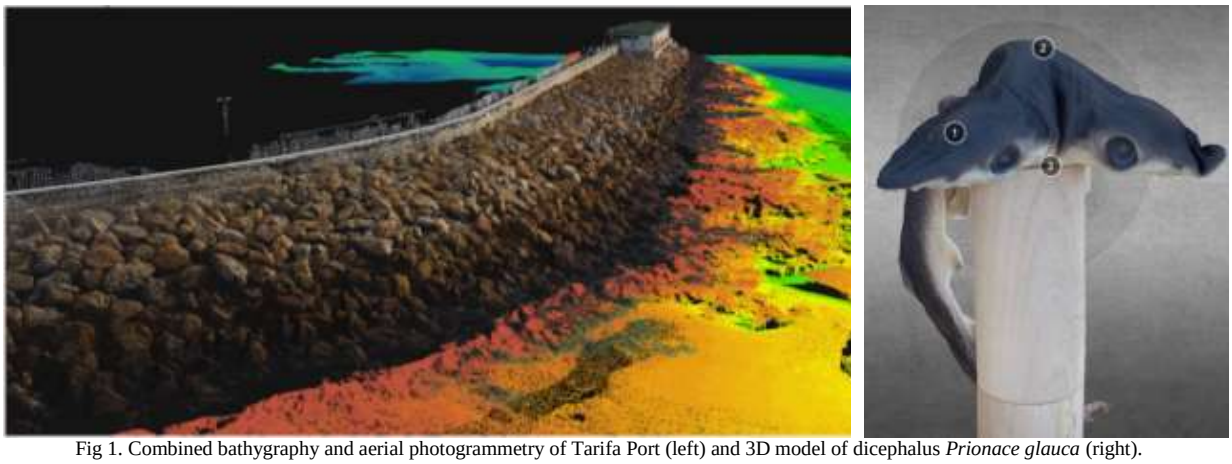

Fig 1. Combined bathygraphy and aerial photogrammetry of Tarifa Port (left) and 3D model of dicephalus *Prionace glauca* (right).

## IV. PHOTOGRAMMETRIC SPHERE

One of the main bottleneck factors in close-range photogrammetry is the uniformity of lighting and pictures scale. The quality of the 3D output model strictly depends on the coherence of paired targets (neighbor pictures pixels), which in turn is directly correlated to the strength and position of the light source and the distance of the camera to the subject. Keeping them constant during the survey may result very hard and the successful completion of the model may be compromised. In order to solve these issues, the photogrammetric sphere is proposed. It consists on a spherical lattice structure, hosting an array of digital cameras and multiple lighting LED rings, capable of simultaneously shooting several pictures of the object located in the center, so guaranteeing coherent lighting and precise photographs dimensions.

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