

## Digitizing of the ancient bronze sculpture of Apoxyomenos



Apoxyomenos, an ancient bronze statue of an athlete, was found in 1999 in the sea close to Lošinj, a Croatian island. The sculpture is full of very fine and realistic details. In January 2002 the company TOPOMATIKA conducted full 3D-digitizing and measurements of the statue...

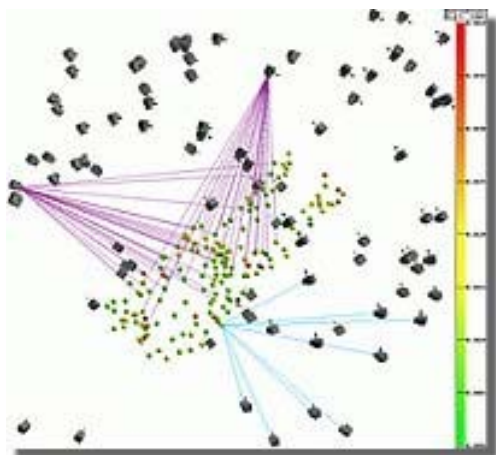
Apoxyomenos, an ancient bronze statue of an athlete scraping off oil and dust from his body after a competition, was found in 1999 in the sea close to Lošinj, a Croatian island (Fig. 1). Investigations suggest that it might be an original Greek statue dated back to the 4th century BC, or a Roman copy of this statue. Since only a few original Greek bronze statues remained, Apoxyomenos is an extraordinary example of the world cultural heritage, therefore restoration and determination of its origin is of great importance. Despite structural damages, erosion and fused sediments caused by centuries of underwater stay, specialists in the Croatian Conservation Institute in Zagreb already succeeded in bringing the shine of the statue to light.



**Fig. 1** Statue of Apoxyomenos lying 40m beneath the surface of the Adriatic Sea

In January 2002, the company "Topomatika" d.o.o., from Zagreb conducted full 3D-digitizing and measurements of the statue in the Croatian Conservatory Institute. The sculpture of Apoxyomenos is full of very fine and realistic details which cannot be captured by measuring its length, width, height, diameter, angle, etc. The beauty of the shape and the richness of details can be recorded by photo documentation and sketches but the result is only a two-dimensional outline of the sculpture, failing to give enough information about its shape and measures. Only digitization provides for an accurate recording of the sculpture's shape by gathering accurate and dense measuring points on its surface. This task was successfully carried out using the ATOS and TRITOP systems from GOM ([www.gom.com](http://www.gom.com)).

The statue of Apoxyomenos was digitized in individual measurements using the ATOS II system, with a typical measuring area of 350 x 280 millimeters. During each of these measurements, multiple fringe patterns were projected on the object and the resulting images of the object area were recorded by two high resolution cameras. The data gathering for one area typically takes 10 seconds and typically leads to one million data points, defining the shape of the measured area very accurately. Then, the individual measurements were registered in a global coordinate system based on reference points (markers), applied on the fixtures and a few on flat areas on the object. The exact position in space (3D coordinates) of these reference points was determined before scanning using the photogrammetric system TRITOP (Fig. 2).



**Fig. 2** Fotogrametrijski sustav TRITOP - položaji kamere u trenutku snimanja i referentne točke.



**Fig. 3** Trodimenzionalna digitalizacija Apoksiomena pomoću sustava ATOS II firme GOM mbH.

Since the complete restoration of the statue of Apoxyomenos is still in process, scanning had to be made in the actual position of the sculpture. First, the front side was scanned (Fig 3), then the sculpture was turned upside-down in its holder for scanning the backside. As the head of the statue is separated from the body, it was scanned separately (Fig. 4). The results of all three scanning sessions were combined in a global coordinate system using common reference points, giving the complete shape of the sculpture.



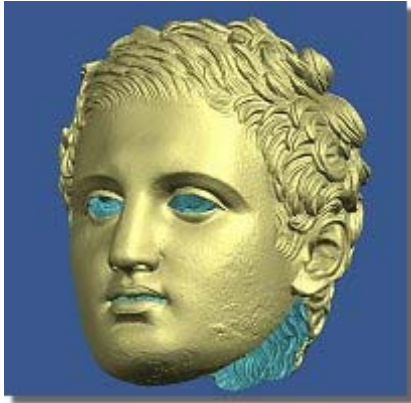
**Fig. 4** Digitizing of the Apoxyomenos head with ATOS II - the projected fringe pattern and the reference markers are visible

The bronze surface of the sculpture was very dark and reflective. For standard engineering work the objects and tools can usually be treated (sprayed or painted) to show a uniform dull surface, ideal for optical scanning. Here a surface treatment was not acceptable. The ATOS II system can be set to gather data with different exposure times in one measurement to capture data on dark and bright areas. For glossy areas, the shape data can be calculated based on the images from one camera only. Using these parameter settings, the statue could be successfully scanned with ATOS II, capturing very accurate and dense data, thus proving its great potential for scanning of shiny and dark surfaces. To digitize the complete statue 114 scans for the body and 57 scans for the head were needed, some of these scans were needed only for small areas, to define the complete shape of detailed parts such as hair or fingers.

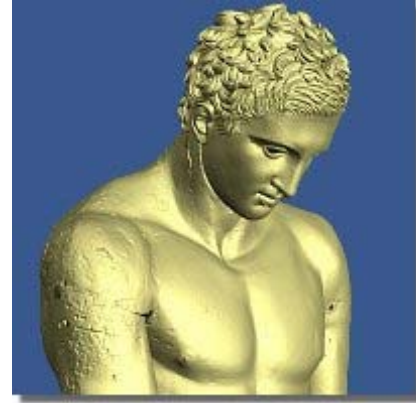
The result of the complete digitization is a file with more than ten million data points connected to a polygonal mesh (STL data) as shown in Fig. 5-7. Due to the high resolution scanner (typically 13 measuring

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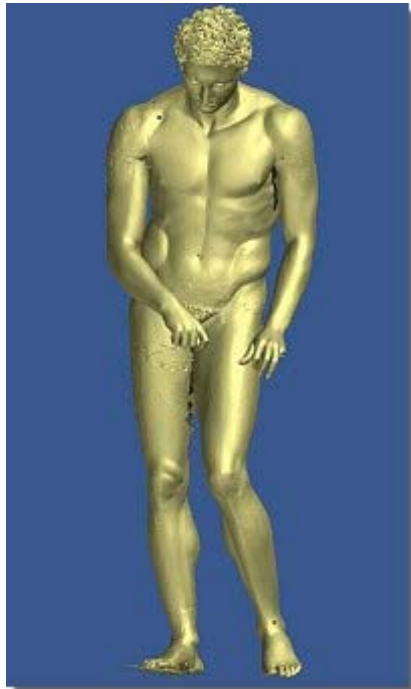
points per square millimeter), all details of the sculpture including damages are visible. Based on the digitized data, parallel sections can be easily computed as shown in Fig. 8.



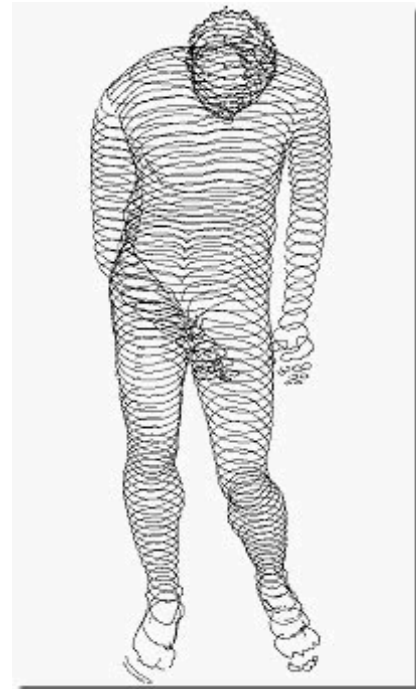
**Fig. 5** Scanned data of the head of Apoxyomenos



**Fig. 6** Detail of the scanned data of Apoxyomenos



**Fig. 7** Scanned data of Apoxyomenos - polygonal mesh



**Fig. 8** Scanned data of Apoxyomenos - parallel sections

Three-dimensional digitizing in this quality is a digital copy of the real part in the actual moment. It enables to document the restoration process, enables shape analyses, computer presentations and monitoring the shape of the statue during time. But also highly accurate copies of the statue or optimal holders for its transportation can be produced based on these data. This highly accurate computer model rich in detail was obtained by non-contact measurement and without any treatment of the bronze surface of Apoxyomenos, so, at no time during the scanning process the sculpture's safety was endangered. The measuring systems ATOS II and TRITOP once again proved as a valuable asset in three-dimensional digitizing of complex and delicate parts.

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**We would like to thank the Croatian Conservation Institute for their trust and the permission to show this report to the public.**