

Mapping Art: 3D geo-visualization and virtual worlds in cultural heritage



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ARTICLE INFO

Article history

Received 2023-09-18

Revised 2023-10-04

Accepted 2023-10-07

Keywords

Virtual Worlds

3D Geo-visualisation

GIS

3D Modelling

Mapping Art

ABSTRACT

The purpose of this paper is to highlight the use of digital mapping and GIS in combination with 3D geo-visualization in depicting landscapes and cultural heritage sites. As computers evolve in their processing capabilities (graphics card, processor, memory speed), so does the graphical output representing our world that can be done in less time. Short processing times and available highly sophisticated software create conditions to test existing models of our 3D world or best create alternative renderings of monuments and landscapes. A study area has been chosen to present such a methodology. Ancient Pylos was selected as the study area due to the abundance of bibliographic references available, facilitating the creation of a cartographic representation of the region based on archaeological discoveries and historical sources. The advantages of employing 3D geo-visualizations in archaeology are numerous and are examined within this article. Visual imaging aids archaeologists in elucidating intricate or deficient details pertaining to a monument, simultaneously streamlining archaeological data for easier comprehension by the general public. The use of 3D geo-visualization to represent data and other non-photorealistic details is expected to dominate in the near future.



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1. Introduction

The representation of landscapes, monuments, or objects of archaeological and historical interest with the assistance of computers and 3D graphics programs is not a novel concept. The term specific to this emerging field was first proposed by Paul Reilly in 1990 and designated as "virtual" archaeology [1]. What has evolved since then is the enhanced capacity of computers to generate realistic models in significantly less time than previously required. This paper analyzes the latest trends in 3D geo-visualization through a specific example, examining the advantages of employing such methodologies in archaeology. The entire process is divided into two parts. The first part presents the broader study area, showcasing archaeological finds and historical evidence conventionally. Maps generated on a GIS platform analyze the collected data and are suitable for research purposes by scholars. In the second part, the decision was made to visualize the same study area in a digital environment through 3D geo-visualization. This section highlights the main aspects in which 3D geo-visualization excels over conventional mapping through GIS in terms of visualizing the environment and its data [2]–[4]. The study area is situated in the southwest Peloponnese in Greece (Fig. 1). The peninsula of Coryphasium is a short distance (8 km) from the modern town of Pylos (Fig. 2). Pylos, also known as Navarino, is a town in the prefecture of Messenia, Peloponnese region (Fig. 1). In Greek mythology, Pylos is the home of the son of Poseidon; Neleus and his son Nestor are also mentioned

in Homer. Beneath the ruins of the old castle (Palaiokastros), and in the wider area, lies the Ancient city of Pylos from the Classical and Hellenistic eras [5]–[8].

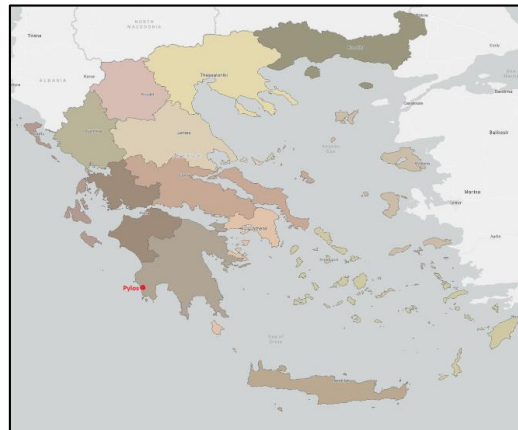


Fig. 1. The location of the study area in Greece (Pylos marked by a red circle).

Pausanias, in his description of Greece, clearly delineates the location of Ancient Pylos at Cape Coryphasium and the island of Sphacteria that extends in front of its harbor [9]. According to Marinatos's research, the primary part of the settlement has been identified in the northern part of Coryphasium Cape, beneath the 'Cave of Nestor.' Marinatos notes the presence of remains such as walls, foundations of small houses, numerous shells dating from the Hellenistic and Classical eras, and other minor artifacts [10]. He also makes reference to its Homeric history, stating, "In Pylos, there is a temple of Athena Coryphasia and an old house that belonged to Nestor, in which there is a representation of Nestor himself; there is also a tomb for him in the city, while another tomb at a short distance from Pylos is said to be of his son Thrasymlides. The so-called Tomb of Thrasymlides is identified as the Tholos tomb at the north end of Voidokoilia Bay, which is in direct visual contact with Coryphasium [10], [11]. Within the city, there is also a cave said to have served as a stable for the cows of Nestor and before that, of Nileas [10], [12], [13]. The large cave, located in an inaccessible position above the middle of the north slope of the Coryphasium peninsula, is known as the 'Cave of Nestor.' Findings from the interior are reported from throughout prehistory and the classical period [11], [13], [14]. Pritchett hypothesizes that this area may have been the site of the temple of Athena Coryphasia and the house of Nestor, as mentioned by Pausanias [14].

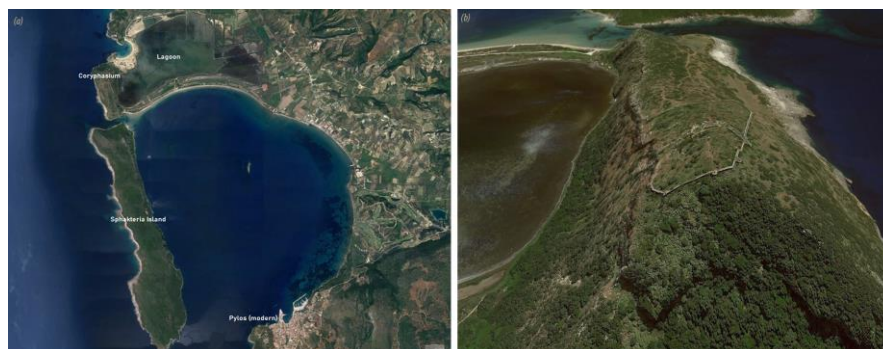


Fig. 2. (a) Aerial view of the wider area of Navarino Bay and (b) Palaiokastros in the peninsula of Coryphasium (Source: Google Earth Images).

In fact, the so-called tomb of Thrasymlides was identified at the end of the 19th century by the English historian G.B. Grundy, but the first systematic excavation took place in the 1960s, conducted by Greek archaeologist Spyros Marinatos [15], [16]. Marinatos believed it to be the burial monument of Thrasymlides, the son of the mythical king Nestor, as mentioned by Pausanias in his travels [14]. Although the tomb was only partially excavated, the remaining offerings provide insight into its wealth, including stone arrows, two necklaces made of amethyst and sardium, four gold plates, two small Mycenaean vases, and various other small objects [10]. All these artifacts can be mapped using GIS and other mapping methodologies to represent life, social interactions, or trade in ancient cities [17]. Data sets containing unique objects, such as coins or pottery, can be utilized to create different

layers that can be combined to provide a more realistic depiction of life in Pylos or other significant cities [18]. These layers can also be employed independently or in conjunction with 3D graphics in museums or other settings for educational or entertainment purposes [19]. The methodology begins with recording the most significant antiquities in the area, drawn from various literary sources [20]–[23], and their spatial representation on maps using GIS and digital mapping, constituting the initial step [24]. These maps will be used to illustrate the distinctions between conventional digital mapping and the final product of the 3D geo-visualization technique. They also demonstrate how these maps are processed to create 3D virtual worlds, offering diverse cultural applications and serving educational purposes [25], [26]. Numerous platforms already exist that can host a 3D realistic terrain, like the one presented here. Through the development of virtual worlds, students and other interested parties can browse, interact, and learn about the cultural, historical, or archaeological elements of a place in an engaging manner [27]. Conventional methods involve constructing various maps, such as Digital Elevation Models, through the processing of satellite imagery or aerial photography (Fig. 3) to represent details of a specific area of interest.

2. Method

Data encompass archaeological, remote sensing, various spatial data, and historical data. For instance, archaeological data consist of objects documented during archaeological excavations, such as tombs, walls, housing units (partial or complete), pottery, coins, statues, utensils, and tools that provide insights into everyday activities and trade. Remote sensing data incorporate satellite images used for generating a Digital Elevation Model (DEM) and its derivatives, including the Digital Terrain Model (DTM) (refer to Fig. 3 and Table 1). Historical data may encompass newspapers, notes, diaries of local or transit populations, and printed materials. The methods employed to create spatial datasets for the aforementioned data types depend on the unique characteristics of each dataset and are summarized below. The subsequent section provides a more detailed description of the utilization of references in newspapers.

Table 1. Data and Methods

Data type	Examples	Methods	Purpose
Archaeological	Walls, tombs, houses, tools, coins, jewelry, pottery, utensils	Specialty GIS software such as QGIS, ArcGIS,	Create spatial data
Remote Sensing	Satellite, drone, lidar	Specialty software using remote sensing data (e.g. ENVI, TerrSET/IDRISI, ERDAS/Imagine)	Create DEM (Fig. 3)
Various Historical	Newspapers, notes diaries	Various non-spatial and spatial methods to record these and assign geographical coordinates when possible	Create data layer for analysis or spatial data for spatial analysis

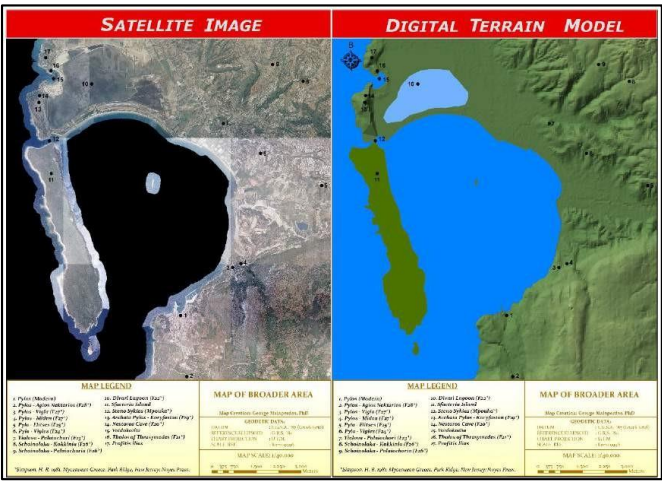


Fig. 3. Mapping through conventional methods (Left) Study area as captured by a satellite sensor and (right) a DTM of the same area using GIS software.

A less conventional approach involves utilizing references from historical newspapers. Specifically, by examining information extracted from the diaries and notes of early foreign travelers, valuable insights are gained into Ancient Pylos, the capital of the mythical wise King Nestor. The purpose of the presented methodology is to document historical occurrences and assess the area's significance. The underlying idea of this methodology is that the reporting of certain information in national vs. local newspapers could further emphasize the area's importance. With the above considerations, an Excel spreadsheet was created featuring five columns, namely the date, the source of the newspaper, the full title of the article, a brief description, and, finally, the full reference text (Fig. 4).

Year	Source	Title	Brief Description	Original Text
1895	To Λατο, αρ. φύλ. 1691, 05.08.1895: 2	Η ΑΓΟΡΑ ΤΗΣ ΠΥΛΟΥ Αρχαιολογικά έρευνας. - Συνέντευξη με Άγγλον αρχαιολόγον	Η αγορά των Πυλίων (βά του γκυστροφείου Νταλινών). Στην ίδια θέση προ ετών πρό ετών. « εύρεθη άγαλμα εκ πυρίνου λίθου παρά χωρικού, άνασκάπτοντος την άμπελόν του»	ΠΥΛΟΣ, 2 Αύγουστου Χάρων των άναγνωστών του «Λατο» έλαβον σημειον δημοσιογραφικόν συνέντευξιν μετά του παρρησιόμοιτος καθηγητού της αρχαιολογίας του Πανεπιστημίου της Οξφόρδης, Γράνθ, Μολοντί ητο κατάκοπος εκ της εργασίας, ην από πέντε ημερών διεύγειν ο διακεκομμένος σούφρ, εύμενέστατα μίς υπέλεθη. Μετά της συνήθεις δεξιώσεως ήρωτησαν τον κ. Γράνθ τον σκοπόν της άφίξεώς του, μίς είπε δ' ότι ήθελαν άναυδά όπως μελέτηση το έδαφος και ει δυνατόν όρίση τον τόπον ένθα ή πόλις του Νέστορος, πατεύει δέ ότι η εργασία του θέλει είσθαι (sic) έπαιτυχής, διότι νομίζω ότι ώρισε προς το βορειοδυτικόν μέρος του γκυστροφείου (Νταλινών) την αγοράν των Πυλίων. Τότε συνέβη άπαιτησόμενος εις τον κ. Γράνθ και προς προγενεστέρας άνασκαφάς, διότι κατ' αύτην τό μέρος πρό ετών εύρέθη άγαλμα εκ πυρίνου λίθου παρά χωρικού, άνασκάπτοντος την άμπελόν του- έκτός τούτου εκεί που εύρίσκουν και σημερον οι χωρικοί θακρυβόχους λαγήνους. Τότε ο κ. Γράνθ μίς εύχαρίστησε διά της πληροφορίας και μίς παρεκάλει να τον
1896	To Λατο, αρ. φύλ. 2022, 06.07.1896: 3	ΝΕΑ ΤΗΣ ΠΥΛΟΥ	Ανακάλυψη αρχαιοτήτων (κεραμική εντός σπηλαιο Νέστορος)	ΠΥΛΟΣ, 4 Ιουλίου Από χθές άφίχθη ο έταίρος της εν Αθήναις γαλλικής σχολής κ. Ρολάν μετά του ακολουθούντος αύτον κ. Αίρη, πρηνή ντυματεμένου Αθηνών, επισκέφθη δέ την Σφακτηρίαν και όλα τα εν αύτῃ αρχαία ως και τό Νεαυρίλιον και τό εις τούς πρόποδας αύτου ύπάρχον σπήλαιον του περηνουστάτου βασιλέως της ερβώλιακος Πύλου, εν τῷ οποίῳ άνεκάλυψε κέραρον, επί του οποίου ύπάρχουν γεγραμμένοι λέξεις, ως εκ τούτου δέ σύμμερον παρακαλού έρωτήσαν

Fig. 4. Partial view of the catalog created in Excel with data collected from newspapers (content in Greek)

3. Results and Discussion

According to archival material from newspapers, the great Schliemann visited Pylos - after making the great discoveries of Troy and Mycenae - in search of the mythical Kingdom of Nestor. This occurred in 1888, just two years before his death. Perhaps if he had started sooner, Ancient Pylos would have been excavated by now. Nonetheless, his detailed notes contained important information, including observations of the Cyclopean walls on the Isle of Sphacteria. Another crucial piece of information gathered from newspapers indicates that Pylos was frequently visited by high-profile personalities of the time, such as the Russian ambassador in 1872 and the Prince of Hesse in 1899, who explored the ancient ruins of Pylos. Printed materials report numerous foreign nationals traveling through the area, revealing a strong attraction to the region. This interest was so intense that, for the first time in 1901, a guard was appointed when antiquities theft was at its peak (Fig. 5).

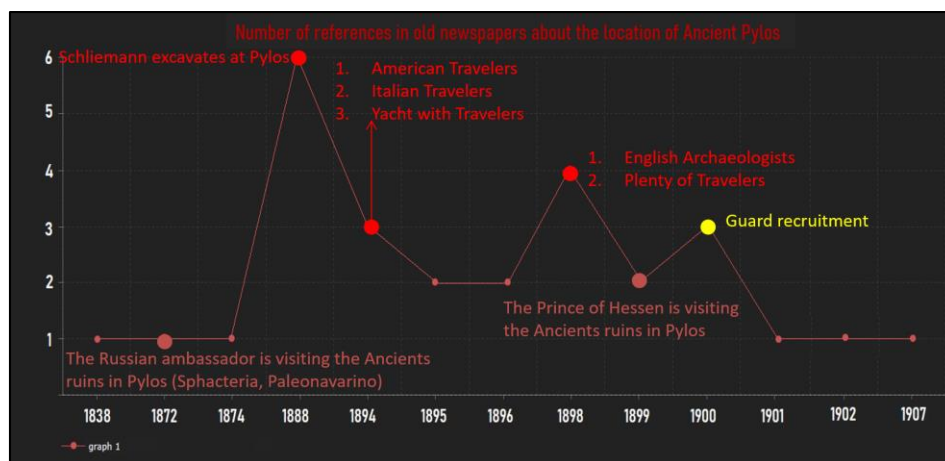


Fig. 5. The graph highlights the most important information about the region as extracted from newspapers. The X-axis shows the year an event was recorded and the Y-axis the number of newspaper publications.

Visitor information and relevant details, collected from newspapers, were utilized to create a density map and perform a more in-depth analysis of Ancient Pylos. Specifically, international visitors' information was employed to illustrate mobility around Palaiokastros (using the Kernel density method) and to identify areas of particular attraction (see Fig. 6). An inset map of the area was also generated with five subdivisions. The purpose of these subdivisions was to facilitate easy differentiation of areas with unique characteristics for future research of the area of interest. For instance, Subsection 1 encompasses the Acropolis and its surrounding area, the largest hill where the Franks built Palaiokastros in 1278. Palaiokastros was constructed atop the ruins of the ancient classical Acropolis of Pylos. Subsection 2 represents the main part of the town (Pylos), while Subsection 3 covers the Southern Suburb, bordering Section 5 to the south and located at the site of the old port. Section 4, to the east of that, designates the cemetery where the lagoon of Divari is interred (refer to Fig. 6).

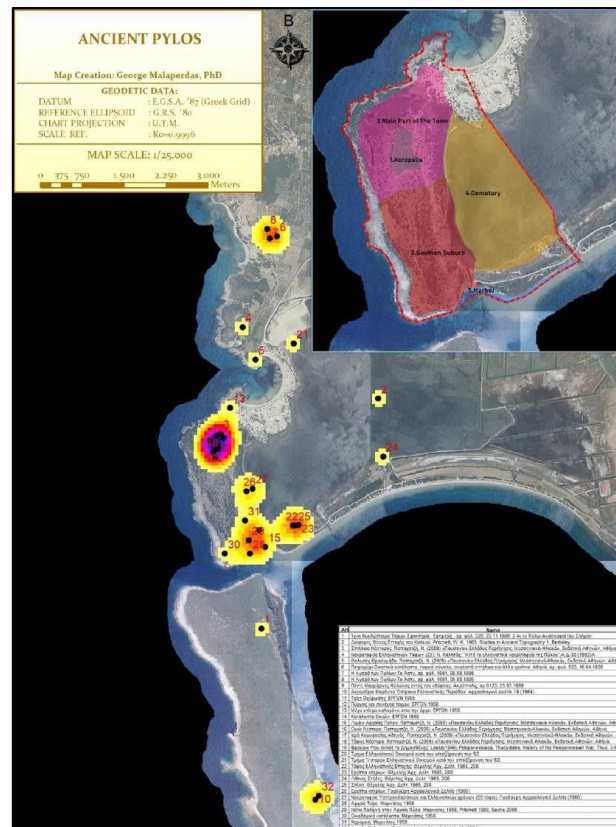


Fig. 6. Density map of collected reports extracted from archives (see text in a table in the lower right) superimposed on the Ancient Pylos topographic map. The Inset map shows the division of the Pylos

3.1 Three Dimension (3D) Modelling

3D modeling is the process of generating graphics and images that appear to have three dimensions [28]. Although the process is quite complex, the underlying idea is straightforward: 3D shapes (with triangles being the simplest polygon) can be combined to create any shape. Each shape comprises points and lines connecting those points, forming the skeleton of a model. Most illustration software includes pre-made simple shapes such as cubes, cones, and spheres, which can be combined to construct more complex objects. Any shape can be represented by a mosaic of polygons to create a 3D surface (e.g., TIN). A triangle is, by definition, a polygon, and DEMs can be created using triangles (TIN). This approach is one way to create a DEM, which is vector-based. The topography of our area of interest will be compared against our DEM, which serves as the "ground truth." The DEM used for creating 3D models functions similarly to any other DEM used in a GIS, and the accuracy of our model is determined based on this, while maintaining the georeference of the area. The accuracy of the three-dimensional model depends not only on the quality of data used to create the DEM but also on the different software and technology (see Fig. 7).

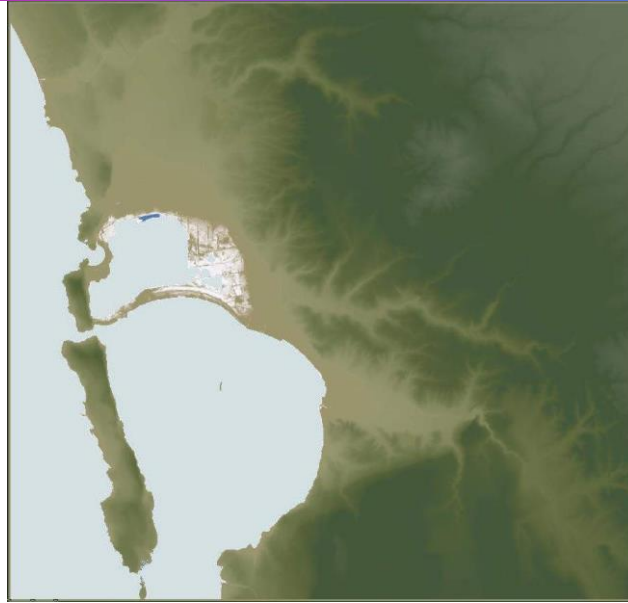


Fig. 7. High-Resolution Digital Elevation Model of the study area (accuracy 1 m).

A new landscape model can be generated from the DEM, representing the area of interest in space in realistic ways [29]. The presentation of relief, whether smoother or rougher, depends on the purpose and application of the final product. Specifically, the use of intense relief is often seen in video games [30], where users find exaggerated relief desirable for easy visibility of mountains or flatter areas; indeed, users are often attracted to this exaggeration (see Fig. 8). As with many applications, need and desirability influence the end product in 3D graphics. There are many similarities in the end products of video games, which involve the simulation of areas with cultural heritage and communication of those in museums and other media [31].

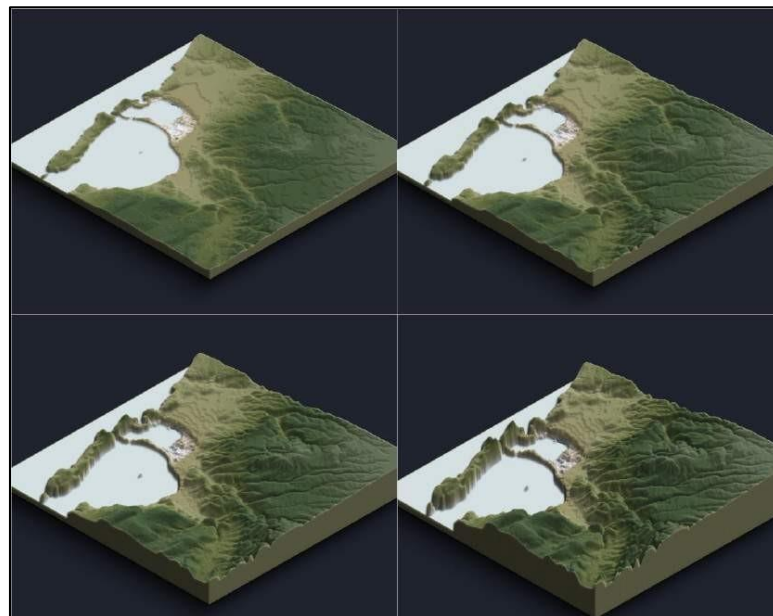


Fig. 8. Generated Elevation Intensity using GIS tools and specialty software. Different relief exaggeration is demonstrated in the 4 images.

Additionally, digital 3D models are easily viewable from various angles and sides, if necessary, through 3D rotation [32]. In many cases, the creator of the model aims to emphasize the attributes of a monument that are best observed from different viewing angles (see Fig. 9).

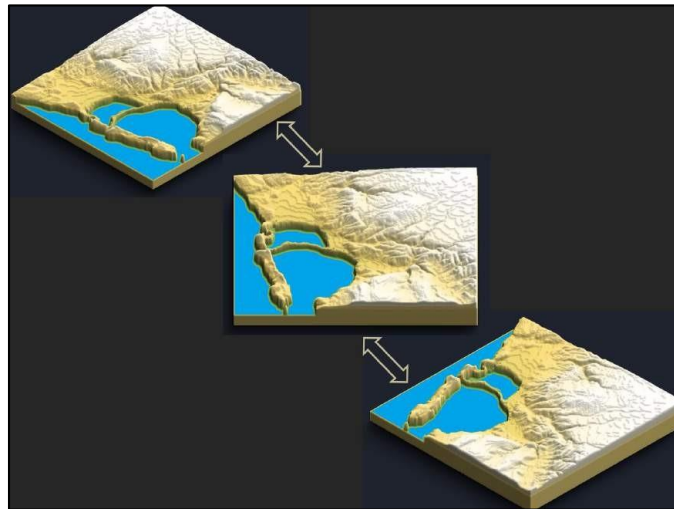


Fig. 9. 3D Model Rotation allows the display of each model from a different viewer perspective.

Another significant application involves the capability to select a relief that simulates the appearance of different climate zones, coupled with the elevation profile. This feature can be valuable in interpreting habitual characteristics of people in ancient or historical settlements and/or understanding changes in human behavior throughout history influenced by climatic changes. In our area of interest, we have chosen various color palettes within Adobe Photoshop software to illustrate different climate zones, providing examples of colors and their meanings (see Fig. 10). Adobe Photoshop offers an extensive array of reliefs to choose from, ranging from classic to specialized ones with bold colors and vintage effects [33]. This abundance of options within the Adobe software facilitates the construction of a variety of 3D models and maps for numerous applications [34] (refer to Fig. 10). For instance, depending on the type of map we intend to render, we can use the most suitable background that aligns with its theme. For a historical map, the background can be a vintage one, while for a more modern map, we can employ a different shading technique based on our preferences [35].

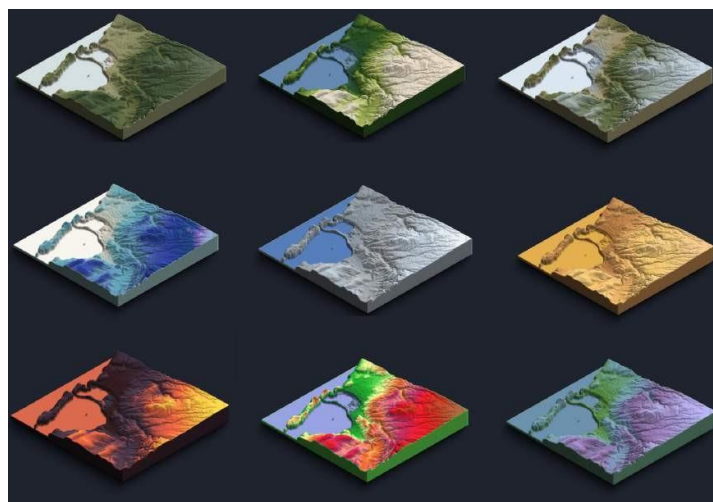


Fig. 10. Different terrain gradation to mimic the look of different climate zones, along with the elevation profile.

3.2 The final 3d Map

Ideally, the final result of 3D geovisualization is a map of an entire region (AOI). In our case study, we present an image that has been georeferenced (properly placed in space), while retaining the topographic features of the area based on the primary DEM data we provided earlier (see Fig. 11).

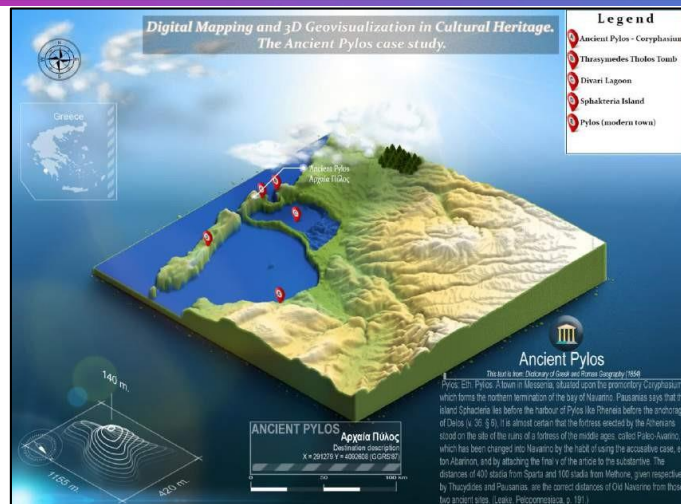


Fig. 11. The final 3D map.

At the same time, our digital product encompasses all the primary and secondary information typically found on a map: (1) the map title, (2) a north arrow, (3) an inset map depicting the study area's location in Greece; (4) a legend; (5) and potentially other graphics on the map, such as trees or clouds in the sky; (6) additional points of interest; (7) a realistic terrain, and optionally; (8) a box with general information related to the created map, (9) a destination description indicating the coordinates of Ancient Pylos and specifying the projection system used; (10) a graphical map scale; and finally, (11) a helpful model displayed in the left corner of the map. This model aids in quickly understanding the dimensions of each feature on the map, the altitude presented both metrically and in relation to the rest of the terrain, and provides directional information. Additionally, (12) users have the flexibility to choose any background they prefer to use (see Fig. 12).



Fig. 12. Final map with explanations added as an additional text element in addition to the standard map constructs (legend, north arrow, etc.).

4. Conclusion

To summarize, understanding the importance of three-dimensional representation in landscapes concurrently with the ongoing development of 3D data and technology is crucial. Geoinformatics professionals often create maps for analytical or decision-making purposes, but the focus on enjoyment or artistic expression can sometimes be overlooked. While GIS tools are powerful for professionals, it is also beneficial to have the opportunity to work on maps in environments that allow for a more leisurely or creative process. The distinct advantages of 3D geo-visualization over two-dimensional space lie in the heightened realism it offers, acknowledging that the world we live in comprises more than two dimensions. Visual imaging aids scientists in clarifying challenging or

fragmentary information about a monument, while also simplifying archaeological information through visualization for the end user (public). The use of GIS tools enables the combination of various layers and types of information (images, vector data, raster data) to create a complex model that better represents our world and the surrounding space. Furthermore, three-dimensional geo-imaging provides a dynamic and interactive environment, considered more flexible. This environment assists users in managing scene elements, altering views, adjusting parameters, processing data, and easily observing the results of these changes. With numerous useful browsing skills and the ability to use multimedia to create a map, a virtual world can be effortlessly generated.

Acknowledgment

The author would like to thank the Department of History, Archaeology and Cultural Resources Management, University of The Peloponnese, Kalamata, Greece, and Urban Environmental Policy and Planning, Tufts University, Medford, Massachusetts, United States, Poland, for the granted support.

Declarations

- Author contribution** : All authors contributed equally to the main contributor to this paper. All authors read and approved the final paper.
- Funding statement** : None of the authors have received any funding or grants from any institution or funding body for the research.
- Conflict of interest** : The authors declare no conflict of interest.
- Additional information** : No additional information is available for this paper.

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