Visualizing Pausanias's *Description of Greece* with contemporary GIS

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Abstract

This progress article focuses on an overview of the potential and challenges of using contemporary Geographic Information System (GIS) applications for the visual rendering and analysis of textual spatial data. The case study is an ancient traveling narrative, Pausanias's *Description of Greece* (*Periegesis Hellados*) which was written in the second century CE. First, we describe the process of converting the volumes to spatial data using a customized version of the open-source digital semantic annotation platform Recogito. Then the focus shifts to the implementation of

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collected and organized spatial data to a number of GIS applications: namely Google Maps, DARIAH Geo-Browser, Gephi, Palladio and ArcGIS. Through empirical experimentation with spatial data and their implementation in different platforms, our paper charts the ways in which contemporary GIS applications may be implemented to cast new light on ancient understandings of identity, space, and place.

1 Introduction: A Digital *Periegesis*?

In the past decades, Geographic Information Systems (GISs) has been used extensively in archaeology (Conolly and Lake, 2006; Landeschi, 2019; Trepal *et al.*, 2020; Rajani, 2021) and other humanities disciplines (Dunn, 2019). By locating historical data on a map, space becomes place, imbued with additional meaning. The capacity to identify, aggregate, organize, and to map spatial data in documents is particularly valuable when researching historical modes of spatial thinking beyond the Cartesian, or bird's eye, view that has dominated post-Enlightenment cartography. While ancient maps are rare and incomprehensible to the contemporary scholar, valuable spatial information can be extracted and mapped from various kinds of historical narratives.

Against this backdrop, this article examines the affordances and challenges of analysing an ancient narrative using contemporary GISs. Our case study is second century CE Pausanias's *Periegesis Hellados* (*Description of Greece*). This ten-volume tour from Attica to Phocis, follows a circuit around the Peloponnese. Pausanias's spatial description of the towns, buildings, and monuments through which the reader moves, has been widely used as a guide for interpreting those sites and their archaeology (Dyson, 1988, 2006, pp. 79, 251–54; Shanks, 1996, pp. 49–52. Cf. Habicht, 1985, pp. 70–77). In what follows, we discuss the progress of our project: the Digital Periegesis, essentially converting the text to a GIS, using a customized version of the digital platform Recogito. Through empirical and experimental implementation of spatial data in different GIS platforms, our paper charts the ways in which contemporary GIS may help elucidate ancient understandings of identity, space, and place.

2 Working Method: From Semantic Annotations to Geovisualizations and Analytics

Recogito (https://recogito.pelagios.org) is an open-source web-platform tool essentially a semantic annotation tool for texts and other documents. Developed within the Pelagios project, with its legacy carried out by the Pleagios Network; Recogito enables the researcher to annotate three kinds of entities—places, peoples, and events—in texts and images. Recogito provides a personal workspace for users to import or upload different text and image formats and to collect and organize source materials—texts, images, and tabular data—and to collaborate (Simon *et al.*, 2019; Barker *et al.*, 2020). Texts and images are essentially mined for spatial information manually, as if they were spatial archives of sorts. While no tool will be able to solve fundamental epistemological and ontological issues concerning concepts of pre-modern narratives of space, Recogito enables researchers to collaboratively incorporate semantic modelling into analysis of spatial information.

The method of annotation within the Digital Periegesis project is two-fold: (1) locate the place(s) in your online document, mark up the words, and create an annotation; (2) align annotations to a digital authority file that provides the means to identify and disambiguate between different places (for a detailed analysis see Simon *et al.*, 2019; Foka *et al.*, 2020a,b). Using gazetteers, structured global authorities for place information, Recogito enables the disambiguation and alignment with a range of Uniform Resource Identifiers that help disambiguate places. The Digital Periegesis' team has a private instance of Recogito which operates with a range of customized gazetteers connected directly to the archaeological and

art historical record. At the moment the most granular topographic, archaeological and heritage data can be found in the Topostext gazetteer that is available via the website (https://topostext.org/TT-downloads). For art historical artefacts and heritage monuments we use Judith Binders Art History Gazetteer and the German Archaeological Institute's (https://www.dainst.org/en/) Pausanias's specific gazetteer for archaeological record on the ground (e.g. districts, temples, statues, etc.). If no appropriate match can be found, the team utilizes a yellow flag option in the gazetteer interface and the comments' box for further details that are then returned to the gazetteer developers.

While Recogito keeps track of version history and edit provenance it also supports a range of export formats. The options presented in our private instance relate to downloading annotations in CSV, as a data table for importing into spreadsheet software or a GIS. There is further the possibility to download annotations and document metadata as RDF, encoded using Open Annotation and Dublin Core, in JSON-LD RDF/Turtle RDF/XML formats. For places, the user is able to download confirmed geo-located places in the document as a GeoJSON FeatureCollection. Geo-located places can finally be downloaded as a KML file, for viewing in GIS applications such as Google Earth, for example. Recogito is being extended continuously to offer a growing number of integrating options with external sources and developing standards, such as IIIF or TEI, the latter of which is also good for social network visualization (Pelagios Network, 2021). For Digital Periegesis, we use Recogito's CSV exports for relations, where the origin and destination nodes are listed under 'from_quote' and 'to_quote' columns, respectively, and the edges under 'relation' column. In the special instance of working with the graph visualization software, Gephi, two separate CSV files can be exported from Recogito, one being for the nodes and the other for the edges. Moreover, Recogito itself offers a simple map view feature that enables the users to display all geo-annotations that are linked to one of its patron gazetteers. There are three basemaps based on contemporary aerial imagery and places as well as ancient places. The map view enables a 'jump to text' feature from place point to references in Pausanias's text. Visualization is minimal in Recogito: relational annotations and time animation are not visualized at all.

Google's My Maps provides its users with a service, where spreadsheets and KML files can be imported to create feature layers. At the time of writing this manuscript, the service had limited the maximum number of layers to ten and features to 2,000 per layer. As we work with ten volumes and less than 2,000 annotations per volume are available with coordinates by default Recogito exports, we were able to create a demo under Google's limitations. Prior to importing each volume's annotations as individual layers to a Google My Map project, UTF-8 character encoding was ensured in Excel to display the Greek names properly. Then the imports were realized with 'LAT' (Latitude) and 'LNG' (Longitude) attributes as the placeholders and original quote transcriptions as the labels. The final demo, available on http://tiny.cc/periegesis, categorized all place annotations under volume number and a search box interface feature.

The DARIAH Geo-Browser enables a dynamic visualization of spatial and temporal data, by uploading or linking multiple KML files or spreadsheets to draw correlation implications based on visual comparisons of temporal animations of place-based objects. On https://geobrowser.de.dariah.eu/?csv1=https://geobrowser.de.dariah.eu/storage/803386, we demonstrate how a Recogito export of all ten volumes can be animated on the DARIAH interface, based on annotations and their timestamps. The Dariah Geo-Browser enables uploading basemaps.

Visualizing Recogito data from a social network or relational perspective can be achieved by Gephi and Palladio. Gephi is not primarily a GIS application but is one of the leading open-source software in working with graphs and networks. Its highly sophisticated skills to manipulate node and edge features help us overcome what Recogito, Google My Maps, and DARIAH miss—a visualization of relational annotations. Direct Recogito exports tailored for Gephi provide us with spreadsheets containing labelled junction and link information with unique IDs, which are enough to visualize abstract graphs on different layouts and analyse their statistics and metrics such as betweenness centrality, closeness, diameter, clustering coefficient, modularity, shortest paths, etc. In order to make use of Gephi's limited spatial visualization capabilities, the

GeoLayout plugin can help link annotation nodes to their geographical coordinates, helping cluster nodes with identical labels but unique IDs into one symbol graduated by frequency. At this stage, it is important to join the nodes table with coordinate information from the simple CSV export of annotations, based on the common unique IDs, as Recogito's CSV export of nodes will not contain the LAT–LNG attributes by default. Last but not least, Map of Countries is useful as the only plugin basemap option in Gephi, merely a reproduction of national borders by means of nodes and edges as vertices and segments (see gis.periegesis.org StoryMap for a screenshot of our visualization attempt where the GeoLayout plugin clusters co-located nodes with identical labels and the Map of Countries plugin forms the basemap).

While the Digital Periegesis team is still annotating relations with as much coherence as possible, thinking of the possibility of Gephi visualizations seems a worthy enterprise. The particularly relational data-rich section is Pausanias' description of the monuments in the sanctuary of Zeus at Olympia. As the place of origin of the Olympic Games, the topographic description of the area provides thick relational spatial information; audiences and athletes from the entire Hellenic Mediterranean world are memorialized with artefacts and monuments. The relative placement of portrait statues and other dedications within the Altis, the sacred enclosure is a testimony to dynamic and relational semantic relations of heritage and memory connected to political power and patronage across centuries. Tagging such relations is thus vital to the understanding of his description, since it allows us to derive important semantic data from systematic analysis of who is depicted under what circumstance. There Gephi could be an interesting tool to support a large and complex rigorous information organization that calls for computational support.

Palladio, a web tool developed by the Center for Spatial and Textual Analysis at Stanford University (http://hdlab.stanford.edu/palladio), aims for abstract visualizations of social and temporal data. Beyond being a visualization platform, Palladio is further understood as data exploration tool, suitable for timestamped big data (Irwin, 2018) that can be filtered via timespans and timelines. When map based, a historical background can be ensured, e.g. by manual linking to the DARE tileset (Åhlfeldt, 2019). Palladio-assisted maps are useful in exploring relations in terms of their directions and frequencies but enhancing appropriate symbologies and adding edge labels is not possible. Another drawback is that Palladio does not store projects as aforementioned applications, yet it can be downloaded as a JSON file for later use (see gis.periegesis.org for a screenshot of our visualization attempt).

Finally, Palladio with its focus on temporal data is, to paraphrase Levi-Strauss, 'good to think with'. Temporal data in Pausanias are fuzzy. For example, Pausanias's narrative moves rapidly back and forth in time, from the Golden Age of Greek myth to the wars of Hellenistic monarchs, to his own period. Capturing these varied chronological elements as one moves through the narrative is challenging. Even more difficult is rendering Pausanias's time descriptions as year dates. Again, there is a need to be sensitive and alert to the nuances of Pausanias's description: how he talks about time—as, say, in terms of an event like 'the Trojan War', or else through the figure of a mythical/historical person, like 'Ptolemy Soter'—is an important aspect to investigate for the reader and there needs to be an informed annotation in place. Rich libraries of chronological expressions have been compiled, most noteworthy being the structured authority files for time periods of PeriodO (http://www.perio.do), which is a public domain gazetteer of historical, art-historical, and archaeological periods. While linking among datasets that define periods differently may be an interesting exercise, the resource is at the time of writing by no means complete, although it helps scholars and students see where period definitions overlap or diverge.

An additional concern is the concept of temporality across times and cultures and the division of time more generally. Contemporary terms (e.g. Hellenistic or Classical period) and their associated date ranges seldom map neatly to Pausanias's narrative which tends to establish a working chronology by using known events such as battles or Olympiads. Fortunately, Wikidata is rich in such items. A way to tackle this issue in order to use Palladio is to annotate, e.g. the 102nd Olympia mentioned by Pausanias with its Wikidata ID, Q57337793, and extract the year date as a temporal expression, 'tx : 372 BCE'.

To conclude, Palladio, and to some extent the DARIAH Geo-browser assisted our temporal information organization and analysis by forcing us to think of ways to organize time numerically while staying true to the text.

Last but not least, ArcGIS, a commercial platform of numerous software, applications, and services developed by Esri, or, 'the Cadillac of mapping software, including online and desktop mapping tools' (Irwin, 2018) was extensively utilized within the project Digital Periegesis, especially through the use of the desktop application ArcGIS Pro integrated with the cloud-based SaaS ArcGIS Online (AGOL). At this stage, we initially post-processed Recogito's CSV outputs to introduce a 'Paus' column, where each object is identified by spatial presence of Pausanias, coded according to the volume–chapter–section structure of the entire text. A useful workaround has been to define this field in the Date format, where day–month–year is constant but the hour–minute–second refers to volume–chapter–section, respectively. This approach was feasible as Periegesis consists of ten volumes (less than 12 h) and chapters and sections (paragraphs) never exceed a frequency of 60 (minutes/seconds) per volume. Using AGOL's Web Maps and Web AppBuilder, we created a prototype to animate Pausanias moving along his itinerary within Volume 6 (see gis.periegesis.org) and describing what he sees (Paus) and what he knows (Opsis). Through AGOL, a custom display showing date information only in numerical Volume.Chapter.Section style was also created—a task otherwise not possible with the feature and skills of other applications working with temporal data, such as Palladio.

In order to showcase the plethora of geoprocessing tools provided by ArcGIS, an emerging hotspots analysis (EHSA) was performed. Figure 1 shows preliminary results of the EHSA based on a space–time cube (Fig. 2) of geolocated annotations per volume of Periegesis. The annotation points are aggregated in a fishnet grid following their volumes, as each volume is indeed a temporal indicator of Pausanias' clockwise itinerary. The results, based on a 100 km fixed neighbourhood distance, yield five different spatiotemporal patterns such as new, consecutive, persistent, diminishing, and sporadic hotspots. Accordingly, statistically significant persistent hotspots imply that Pausanias almost constantly refers to places in these zones, covering Central Greece, Peloponnese, southern parts of Thessaly and Epirus and the Ionian Islands and Western Cyclades, in at least nine of the ten volumes (90% of the time-step intervals). This zone is surrounded by sporadic hotspots in its north and east, indicating that Pausanias is erratically describing these places as he moves along his journey. Worth mentioning is also a cluster of new hotspots in Macedonia, where statistical significance occurs with the count of the annotations in the final time-step (Volume 10). These results are subject to change under different parameters, but more importantly, with increased inputs from Recogito exports, as more annotations are added and located. The final polygon layer can easily be uploaded to the AGOL web map and its applications. Moreover, the users can be provided with cloud-based services to carry out their own online analyses using the various geoprocessing tools.

2.1 What Lies Ahead for the Digital Periegesis Project?

Despite the initial inertia towards its adoption (Jessop, 2008: Bodenhamer, 2010), utilization of GIS among Digital Humanities scholars is rapidly emerging (Geddes and Gregory, 2014; Crompton, Lane and Siemens, 2016; Dunn, 2019; McHaffie *et al.*, 2019; Schuster and Dunn, 2020). While GIS helps collect, store, curate, and visualize vector or raster-based patterns and relationships, on interactive and even 3D user-facing platforms, what probably makes it even more unique is its analytical power (Barker *et al.*, 2016; Murrieta-Flores *et al.*, 2017), briefly demonstrated in this research note by performing a computation-intensive EHSA. As Gieseking (2018, p. 643) argues, 'GIS software is complex and requires a great deal of training and support' and 'DH GIS scholars are sometimes unable to make use of the richness of the software.' Having tested several applications in terms of their capabilities based on Recogito exports throughout our progress, we believe we can shed light on the said complexities and their contribution to humanities. Our preliminary findings (see Table 1 and the StoryMap on our hub site gis.periegesis.org) on the use of each platform, namely Google My Maps, DARIAH Geo-Browser, Gephi, Palladio, and ArcGIS,

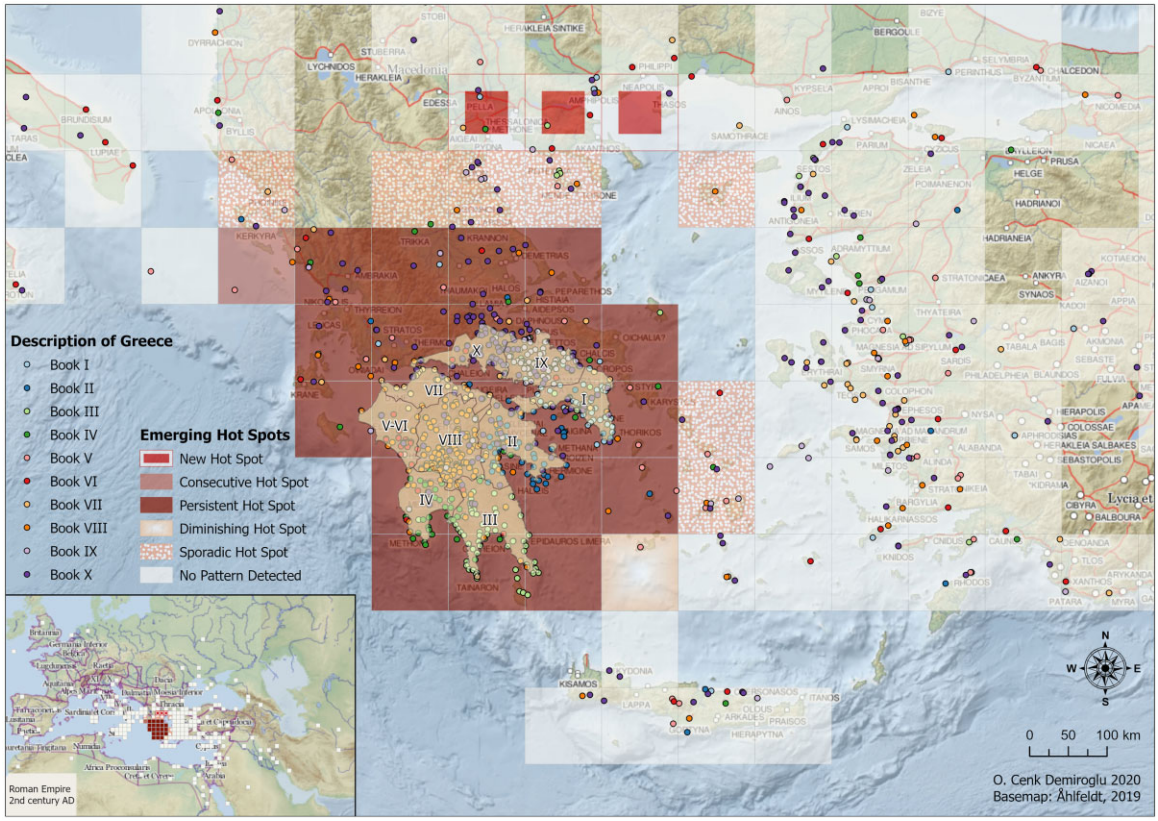

Fig. 1 An EHSA of annotations from Volumes 1 to 10 of *Periegesis*. Each point refers to individual annotations per volume. Emerging hotspot patterns are identified according to statistically significant spatial clusters and temporal trends of annotations (see Esri, 2020a).

reveal some of the comparative features and skills. While ArcGIS offers the most comprehensive platform for data analysis, the opportunity to draw attention to and understand better the underlying topological connections in the narrative—the links that Pausanias makes between places, objects, and peoples—were best served by network visualization tools such Gephi and Palladio. Our future work involves overcoming this issue by exporting Gephi's graphs through the SHPExporter plugin (SHP being the abbreviation for ArcGIS's native file format—shapefile) as well as testing the recently released ArcGIS Pro Intelligence software that promises to provide the user with interactive visualizations and advanced analyses of relations (Esri, 2021). Our future agenda with ArcGIS Pro also includes execution of the EHSA at a much finer temporal resolution, beyond the ten volume regions, by referring to the timesteps informed by the Paus column in the post-processed Recogito spreadsheets. For instance, in the case of Volume 6, we have determined fifty Paus events that may help us yield more refined spatiotemporal patterns. Moreover, we look forward to disclose other hidden patterns with other spatial statistics tools, and not least with R usage in ArcGIS (r.esri.com).

More on our future agenda is to utilize Esri's ArcGIS for Developers in order to further customize and refine our prototype according to different user typologies, including a 3D version and enhanced symbologies, by moving to the backend of Web AppBuilder's what-you-see-is-what-you-get limits. Moreover, using AppStudio, we also plan for creating a native mobile app that will allow for visualizing Periegesis in Augmented Reality (AR), as AR can be

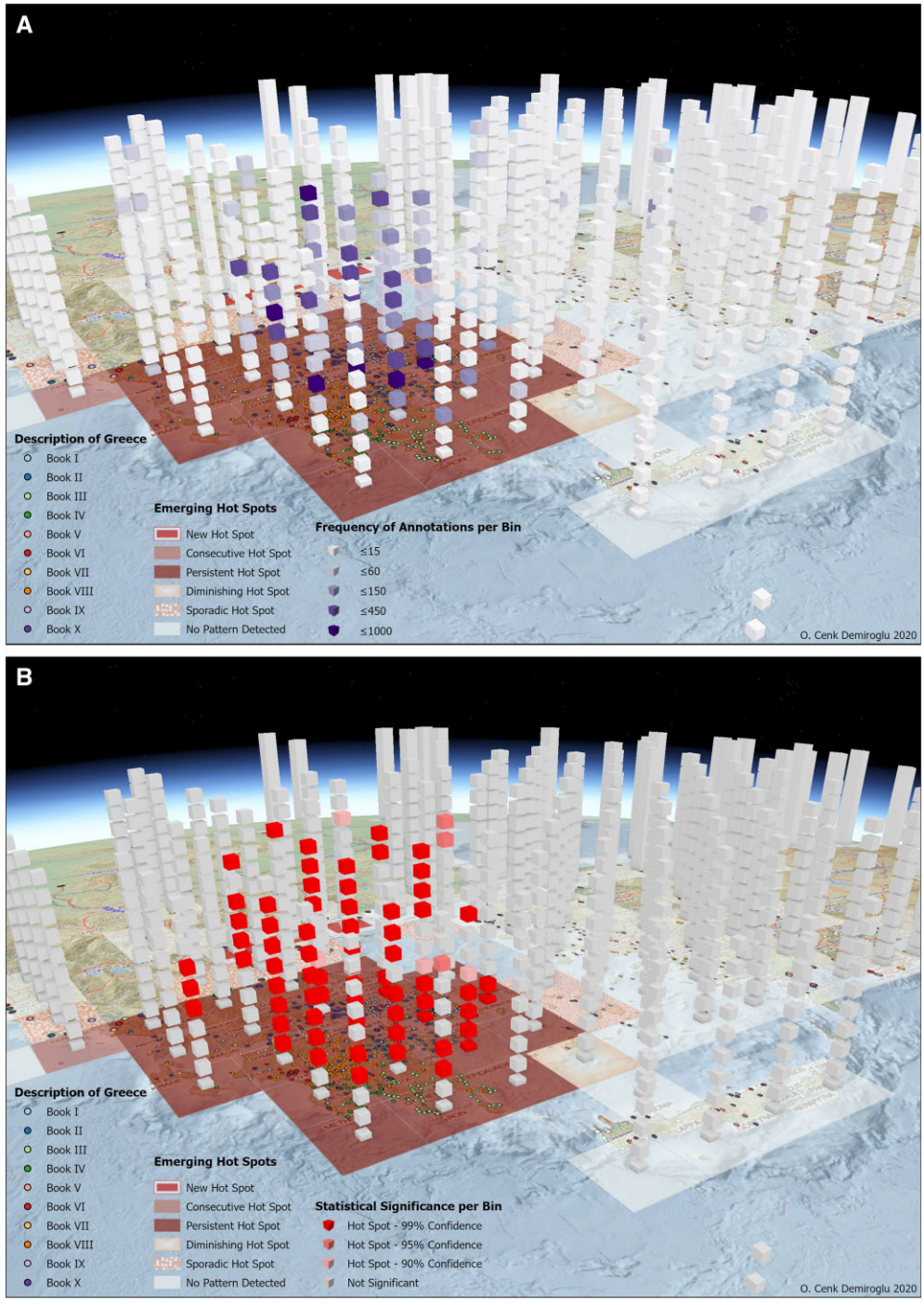

Fig. 2 The space-time cube with a 100 km grid and the 10 volumes of *Periegesis* as the time intervals. Bins on Scene A symbolize the raw number of annotations per grid volume, while Scene B shows statistical significance of the hotspots (see Esri, 2020b).

Table 1. Features and skills of GIS platforms compatible with Recogito annotations

Platform	Time	Relations	Basemap	Web	3D	Analysis
Google Maps	No	No	Limited	Yes	No	No
DARIAH Geo-Browser	Yes	No	Yes	Yes	No	Limited
Gephi	Yes	Yes	Limited	No	No	Limited
Palladio	Yes	Yes	Yes	Yes	No	No
ArcGIS	Yes	To be tested	Yes	Yes	Yes	Yes?

a critical link among historical and modern travel geographies and humanities while some challenges remain (Kounavis *et al.*, 2012; Barrado-Timón and Hidalgo-Giralt, 2019). The quest will also continue by testing other applications such as Nodegoat, StoryMap JS, Neatline, and QGIS—not least to draw comparisons among free and open-source versus commercial software. Most importantly, we look forward to what lies ahead as technology and epistemologies intersect to create new ways to read and to render old texts.

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