MOvEIT: a Proof of Concept of a Road Graph for Late Antique Egypt

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Abstract: In the context of the fruitful collaboration between PAThs, an ERC-funded project, and LAD, the Laboratory for Digital Archaeology at Sapienza University of Rome, an experimental attempt to link between them places being described by the Archaeological Atlas of Coptic Literature developed into a road graph for Late Antique Egypt.

Desktop GIS software has been used to build and update the graph by following different sources and methodologies, and the resulting data have been published online as open access (https://paths-erc.eu/moveit/). A single-page application was built and is available to provide a graphical user interface to access the data and use the graph to calculate directions from one place to another. The project is opened and shared with the broad community of scholars for further development.

Keywords: digital archaeology, communication graph, late antique Egypt, landscape archaeology, Web technologies.

FOSS software used and licence: QGIS (GNU General Public License)
Open dataset and licence: https://github.com/paths-erc/moveit (AGPL-3.0 license)

Introduction

This paper is about MOvEIT, a first and still rough attempt aimed at interconnecting the archaeological sites being cataloged and described in the Archaeological Atlas of Coptic Literature by PAThs, a project directed by Paola Buzi and based at the Sapienza University in Rome (Buzi 2017; Bogdani 2019; https://paths.uniroma1.it; https://atlas.paths-erc.eu). This proof of concept has been conceived and developed in the context of LAD: Laboratorio di Archeologia Digitale alla Sapienza (Laboratory for digital Archaeology at Sapienza University of Rome), directed by Julian Bogdani (https://lad.saras.uniroma1.it). The project was strongly inspired, in its initial phases, by the highly stimulating ORBIS: the Stanford Geospatial Network Model of the Roman World (Scheidel 2015; 2014; https://orbis.stanford.edu/). Progressively, as explained in the next paragraphs, it developed in a quite different direction.

MOvEIT is both (1) an open access data set about a road graph connecting Egyptian places dated to Late Antique and Medieval period and (2) a Single Page Web Application (SPA) offering a graphical user interface to easily build least-cost paths between archaeological sites. Although these two products are tightly connected, the road graph being used as the base for all geospatial analysis by the SPA (Single Page Application), they can be used (and are distributed) separately by serving different scopes. The road graph is a continuouslyimproving model to enable spatial comprehension of Egyptian landscape and geography. It is also a centralised multi-temporal database integrating connection data from various sources. The Web application, on the other hand, is a very intuitive way to explore the model by simply retrieving directions, as a sort of Google Maps for late antique Egypt. It is evidently mostly focused on public engagement with archaeological and geospatial data, even if through further customisation it can turn into an easy-to-use spatial analysis tool for people not very familiar with GIS software.

Finally, the name MOvEIT is a play on words between English and Coptic, ⲙⲟⲉⲓⲧ in Coptic meaning “road, path” and even “place”[1] and the addition of the minuscule “v” shapes the English expression “move it”[2]. The strong idea that both expressions push forward is the movement between archaeological places and the underpinning connection network as means to explore the landscape.

The road graph

The road graph of Late Antique and Medieval Egypt is created and maintained in a GIS environment, as a very simple two-layers project. The first layer contains PAThs places, automatically retrieved in real-time from PAThs central database, rendered as a point layer and providing the nodes of the graph. The second theme, a polyline layer, provides connections between these nodes, producing the arcs of the graph. As far as the archaeological sites are concerned, many scientific contributions have already been published explaining the methodology followed to locate and fully describe each place of interest for the Archaeological Atlas of the Coptic Literature (Buzi 2020; Buzi et al. 2018; Colonna 2020). The implementation work is still ongoing and from time-to-time new sites are being added to the Paths atlas, or positions of already available sites are refined. It must be underlined that the Archaeological Atlas of Coptic Literature has entered a very stable phase of implementation and the bulk of the current work consists in providing descriptions of the already listed sites and/or geographical coordinates (i.e., positioning) of toponyms still lacking a proper geographical contextualization. In any case, changes in site location should trigger edits on the arcs of the graph, and therefore it should be considered as continually evolving.

Different criteria have been followed to create the arcs connecting archaeological sites and defining the communication network (fig. 1). While the precise position of a site can be in most cases clearly defined thanks to a long tradition of archaeological and literary studies, the same cannot be said for the communication network. Two primary sources have been used to build the graph: the Barrington Atlas of the Greek and Roman World (Talbert and Bagnall 2000) and the hydrographic network of Egypt. The Barrington Atlas was used in its already digital, GIS-ready, format developed and openly distributed by the Ancient World Mapping Center[3] (fig. 1, red lines).

[1] TLA lemma no. C2072 (ⲙⲟⲉⲓⲧ), in: Coptic Dictionary Online, ed. by the Koptische/Coptic Electronic Language and Literature International Alliance (KELLIA), https://coptic-dictionary.org/entry.cgi?tla=C2072 (accessed 2022-05-24).
[2] Credits for the name of the projects go to Domizia D’Erasmo.
[3] All data sets are distributed as open data with Open Database License 1.0 in the Shapefile format (http://awmc.unc.edu/awmc/map_data/, accessed 2022.05-24). For our purpose, the ba_roads data set was downloaded and processed.

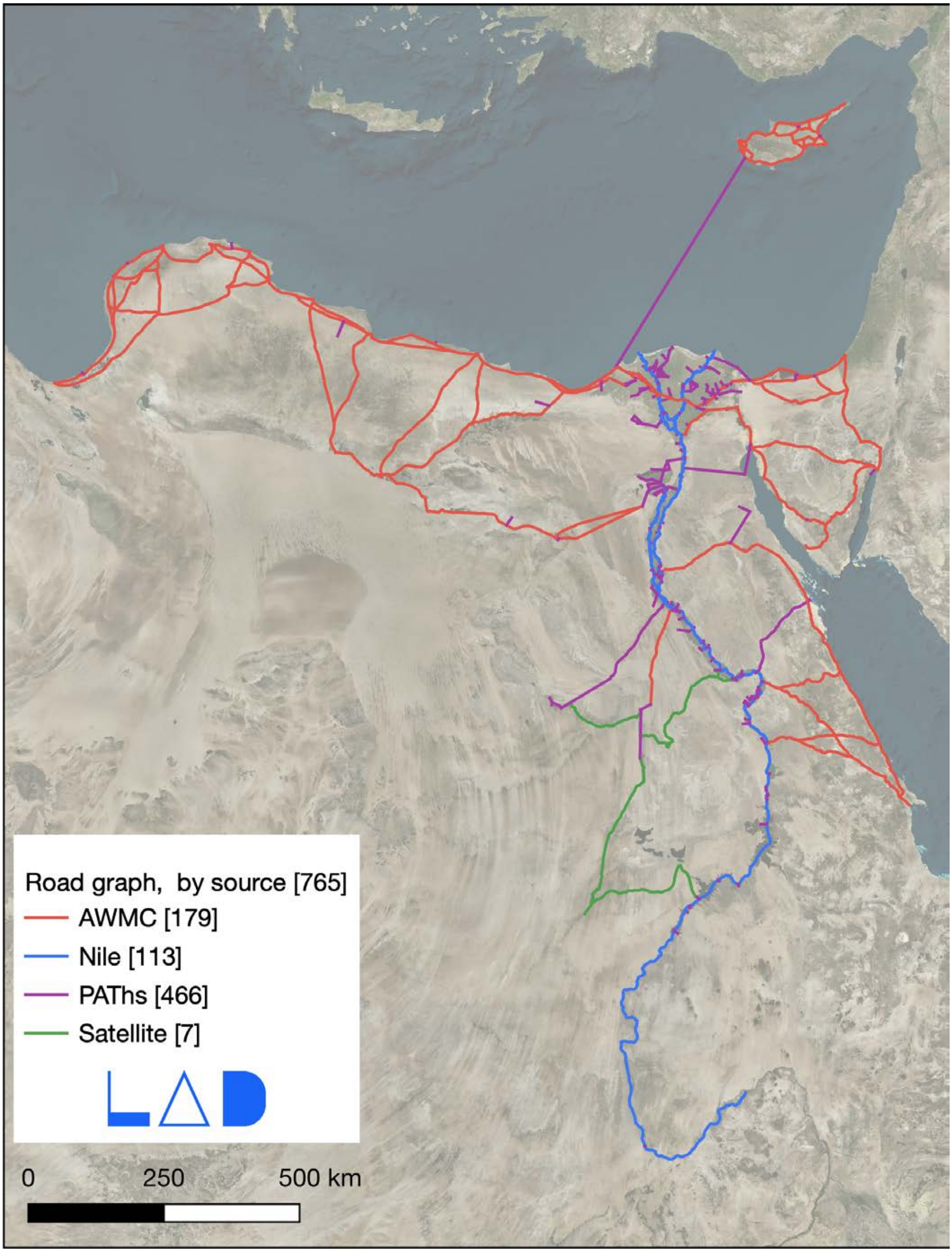

Figure 1. General view of the Egyptian road graph; in different colours are represented the different sources of information for each feature.

A second important source of information is the course of the Nile itself and its main navigable branches: the Nile, the Rossetta and Damietta branches of the Delta and the Bahr Yussef, connecting the Nile with the Fayyum (fig. 1, blue lines). It is well known that the Egyptian hydrological network has undergone important changes in the course of history and radical ones in the last one hundred years. For this reason, and at least for the main water courses, a frequent use of historical cartographical sources has facilitated the survey. Some of these notable documents, such as the Napoleonic map of Egypt (Jacotin and Jomard 1828; Jacotin 1824) have been made objects of deep analysis at LAD (Bogdani et al. 2022; D'Erasmo 2020). It must be clear enough, nevertheless, that when historical maps are considered, the state of the art of the road graph is only a little scratch on the surface of the potential data set. A huge quantity of information encoded in these maps is still waiting to be recovered (see paragraph Future implementation).

These two important sources of communication do provide an important backbone but are far from being exhaustive and are not able to connect all places mapped by PATHs. The next implementation step involved connecting the remaining sites to the graph by straight and direct arcs (fig. 1, violet lines). This is a highly abstract and not realistic implementation of the communication graph from the archaeological point of view. Nevertheless, it is plausible, considering the geomorphology of the country, where the Nile acts as an arterial road and direct connections to it are facilitated by the generally flat surface of the country (fig. 2). Interconnections through the sites are also created using straight lines, trying to privilege direct communications. Much more complex is the situation of the area of the Delta where

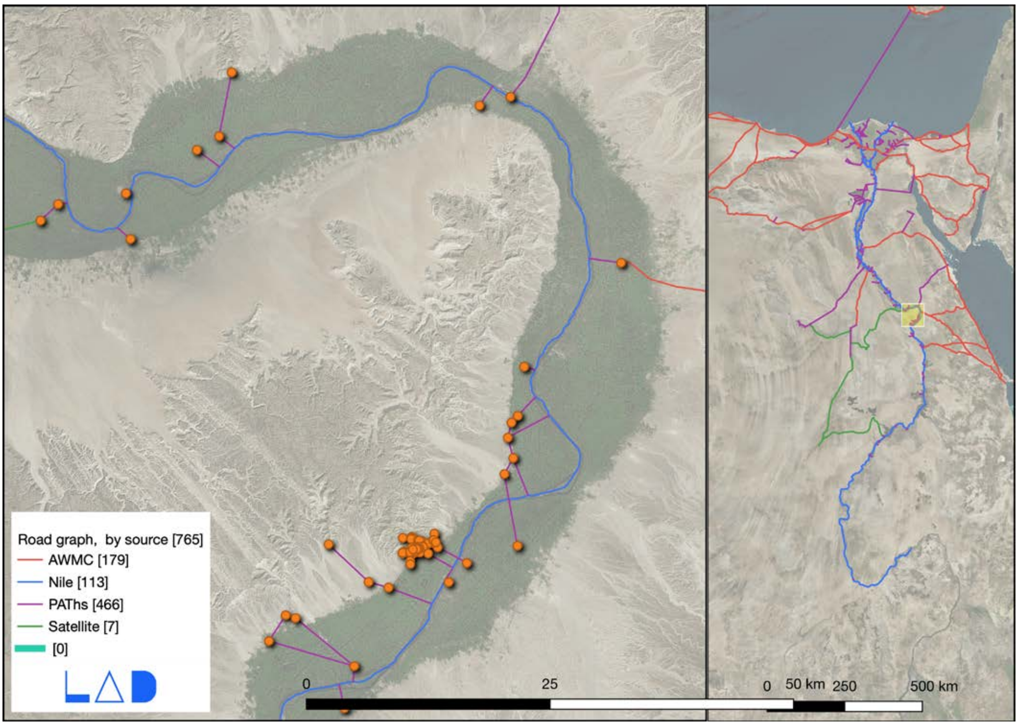

Figure 2. Detail of the meander of the Nile between modern Qena and Luxor.

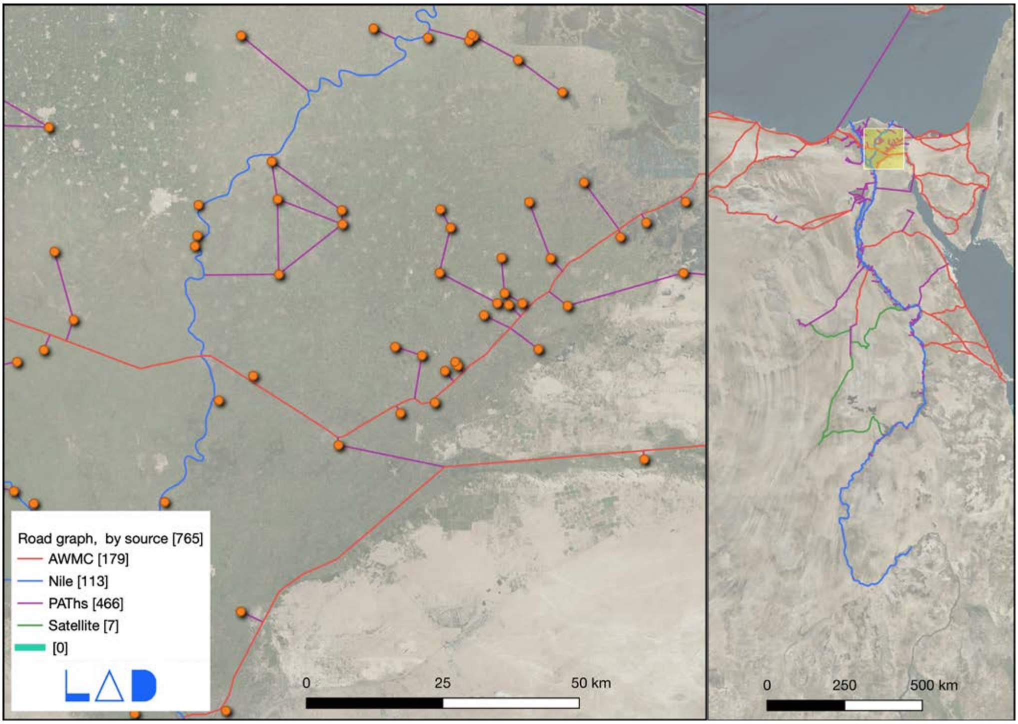

Figure 3. Detail of the Delta area around modern Zagazig.

connections are much more schematic and highly uncertain (fig. 3). The base assumption, as much as arbitrary, is that sites were connected to each other if no natural barrier forbade the direct passage. Straight lines have been manually adapted in a few cases to avoid natural barriers, such as hills, or ridges that are difficult to cross.

Finally, a few desert tracks, mostly located in the Western desert, have been digitised based on traditional paths still visible on the satellite imagery of commercial providers such as Google Maps or Bing Maps (fig. 1, green lines; fig. 4). These tracks, as is well known, are strongly conditioned by the difficult morphology of the terrain and their trace should be considered as highly conservative (Paprocki 2019: 190–275).

It is clear from the above paragraph that the different data sets integrated into this road graph are highly uneven, considering the resolution, adherence to archaeological methodology and general reliability of the information. Moreover, even if a general agreement is put on the soundness of the single tracks, these expect quite different transportation means and times, or simply put, costs. A boat trip of 100 km along the Nile can be a quite different experience compared to an equal linear distance in the rough Western desert of the wetlands of the Delta. These different parameters cannot be mixed accidentally.

Detailed metadata are provided for each feature of the graph with the aim of clearly stating the source, the resolution and reliability of the information, and to make it possible to assign to each vector a different weight in the calculation of the least cost path (fig. 5). Information

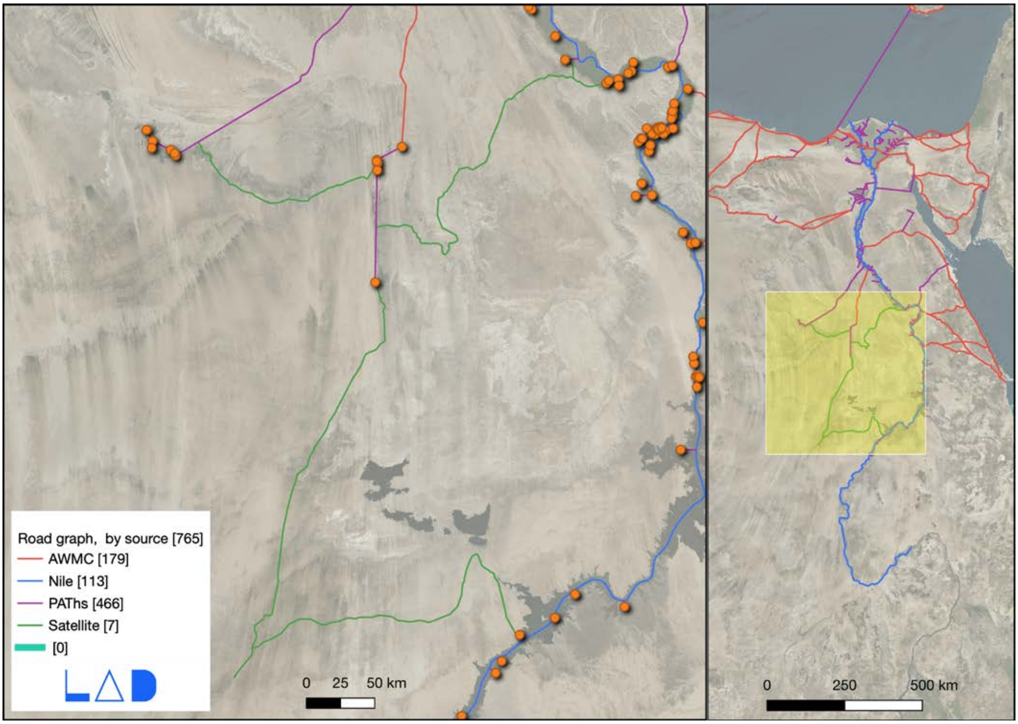

Figure 4. Detail of the tracks in the Western desert.

about the operator who created the feature and the date it was created permits tracking successive edits of the graph. In conclusion, this data set should not be considered as a final point of arrival, but as a pilot project testing methodologies and opening the road towards a collaborative and continuously developed effort, able to collect studies about connections and movements with a multi-temporal paradigm. As such, each single arc of the main graph can be made the object of further studies, discussions, and reviews.

The Web application

A Web application has been made available as a SPA built with HTML and JavaScript, serving as a graphical user interface to the graph-model[4]. This application, basically, calculates least-cost routes from one site to another, manually selected from the map by clicking markers or selected from drop-down menus containing the available PAThs places. The cost is calculated considering only two parameters: the linear overall distance between the two points and the type of path for each travelled segment. In fact, to each path-type a multiplying factor has been associated, as shown in the table.

Path type	Multiplying factor
Rivers	0.8
Channels	0.8
Sea routes	1
Along the coast (land) paths	1
Valley	1
Desert	2

[4] https://paths-erc.eu/moveit/ (accessed 2022-05-25).

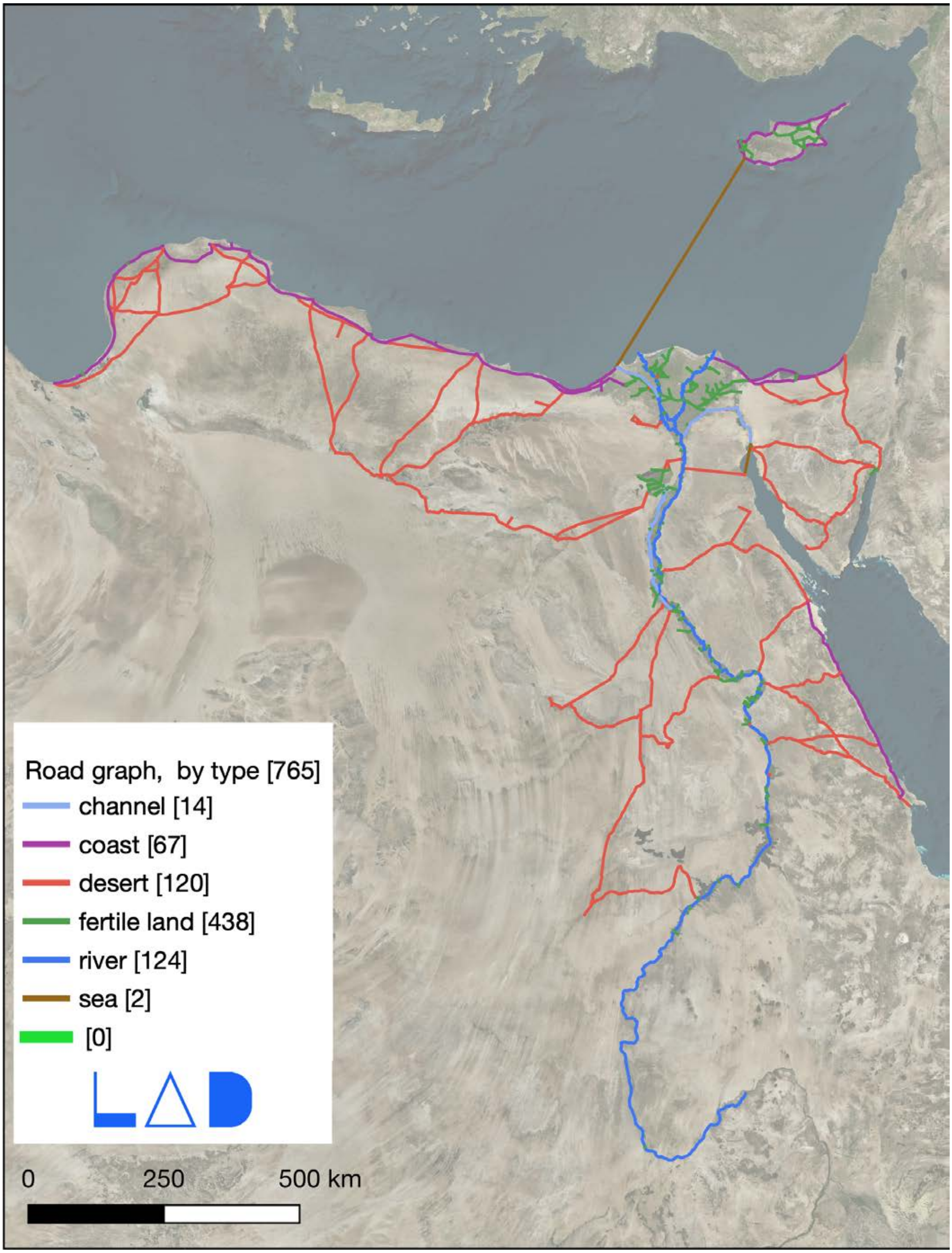

Figure 5. General view of the Egyptian road graph; the different typologies of paths are classified in different colours.

These coefficients listed above should be considered as a faint attempt to assign different weights to diverse track typologies and can (and should) be made the object of further consideration. An example of the different results obtained by taking into account the path type, an optional parameter, is shown in fig. 7.

The routing functionality — i.e., the calculation of the shortest path between two nodes — is handled by the GeoJSON Path Finder[5] an open source, serverless, offline routing JavaScript library for the browser. Since this library doesn't integrate any UI (user interface) tool, this has been built using Leaflet, the well-known and open source web-mapping library[6]. The application embeds the road graph and pulls the list of the PAThs Places from the PAThs web database based on BraDypUS, by using the available read-only REST API (Bogdani 2022)[7]. When a new site is added to the database and the road graph is not promptly updated, an error will be thrown and the path to/from the newly added site will not be calculated. Each time a route is calculated, the URL of the page in the address locator will be updated, easily obtaining shareable URLs containing routes.

GeoJSON Path Finder is a NodeJS[8] package, which means that NodeJS is required for further development or update, even when the road graph is updated. The Web application, nevertheless, integrates a few scripts to render plain and fast, both developing and building the application.

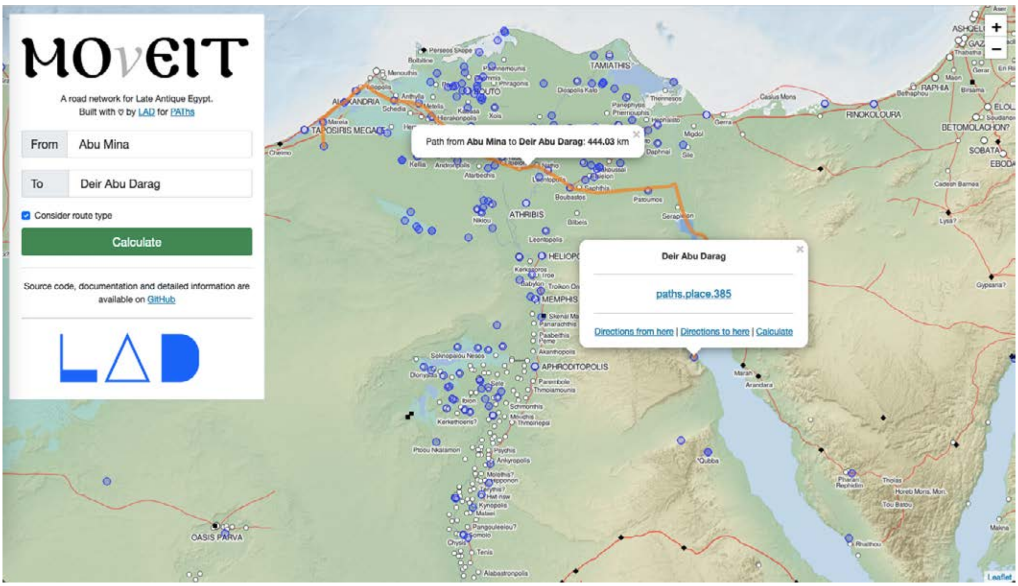

Figure 6. Screen capture of the Web application, available at https://paths-erc.eu/moveit (accessed 2022-05-25).

[5] https://www.liedman.net/geojson-path-finder/ (accessed 2022-05-25), ISC License.
[6] https://leafletjs.com/ (accessed 2022-05-25), BSD-2-Clause License.
[7] https://docs.bdus.cloud (accessed 2022-05-25)
[8] https://nodejs.org/ (accessed 2022-05-25)

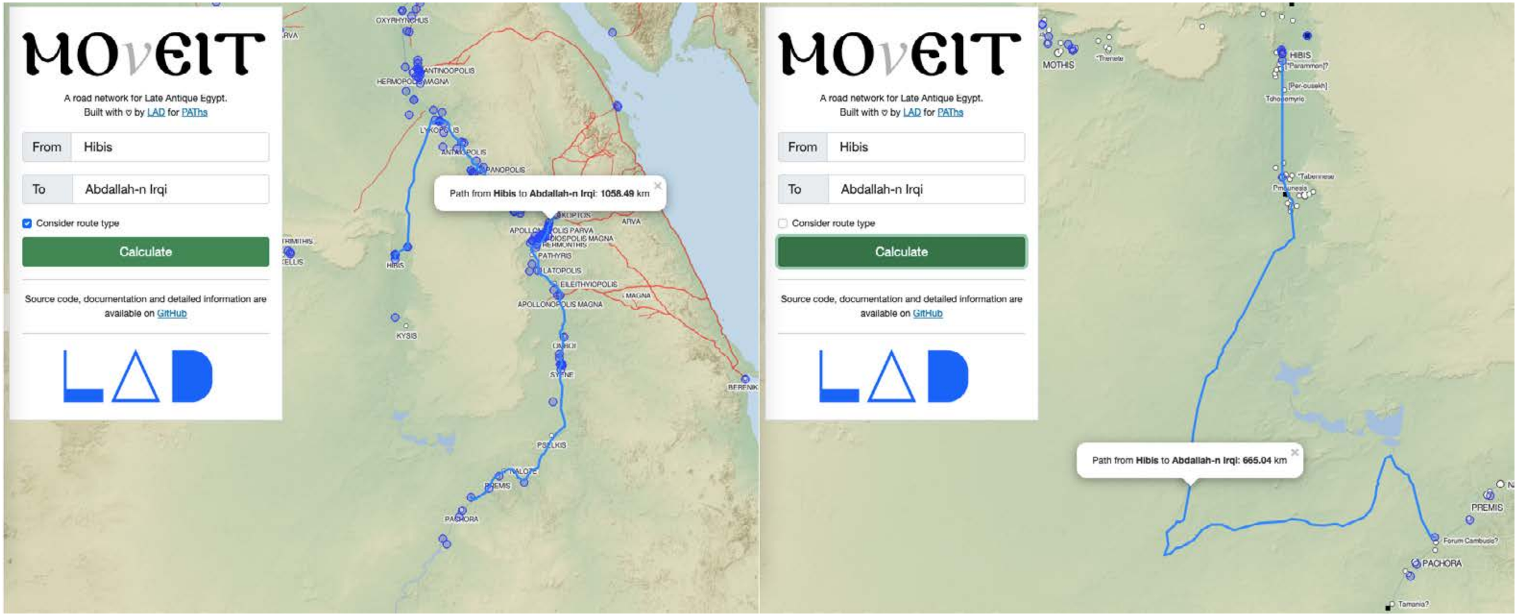

Figure 7. Different results of least-cost path analysis travelling from Hibis (paths.place.185) to Abdallah-n Iqri (paths.place.360) by applying the cost coefficient associated with path type on the left (desert road are much more "expensive" in relation to water/valley paths) and by considering only the linear distance on the right.

Further implementation

As already mentioned, the road graph and the graphical application should be considered as a proof of concept, aimed at defining methodologies and means to future development. None of these products should be considered as a finite research object ready to be deployed but as a starting point for the integration of information about movement from different sources.

Many further developments can be considered by deepening the analysis of the already considered sources, on one hand, and by considering other sources.

An eloquent example of the first case is the rich information of the Napoleonic map of Egypt, at present considered only for the course of the Nile and its main branches. Yet, this precious source can be further examined since it provides much more movement-related information, such as the late 17-century road network, medium and minor natural and artificial canals, dams, bridges, river-crossing, etc. (Bogdani et al. 2022). Also specific studies related to movement analysis through different means and in different periods (for Roman times desert roads, cf. Paprocki 2019; for mediaeval period waterways, cf. Cooper 2014) can be transformed into data and integrated into the road graph. The same is true for specific, large-scale archaeological, topographical, or geographical studies dealing with specific areas or contexts.

It is far beyond the scope of LAD to build and maintain a complete road graph of Late Antique and Medieval Egypt; our modest aim with this project is mostly to investigate how multi-scale, multi-temporal and multi-sourced data can be integrated, without flattering the general complexity.

Access to code and availability, collaboration, Acknowledgements

MOvEIT is created and maintained by LAD as an open source project. The GIS files and the SPA code is made available in Github[9] and deposited for long-term preservation on Zenodo[10]. The entire project has been released with the GNU Affero General Public License Version 3, 19 November 2007, also known as AGPL 3.0, which extends the "share alike" statement also for derived versions running on a remote server. To facilitate collaboration, detailed documentation is maintained online, providing useful resources and guides to enhance the graph, test it, and install and maintain a local copy of the web application[11].

This project is the fruit of a collaborative work in the LAD context, and special thanks go to Paolo Rosati and Domizia D'Erasmo.

[9] https://github.com/paths-erc/moveit (accessed 2022-05-25), AGPL-3.0 License.
[10] DOI: https://dx.doi.org/10.5281/zenodo.6583305.
[11] https://github.com/paths-erc/moveit/blob/master/README.md (accessed 2022-05-25)

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