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THE GISTARC WEBGIS FOR THE ACCESSIBILITY AND SHARING OF ARCHAEOLOGICAL DATA IN CAMPANIA

1. Introduction

The webGIS GISTArc was created to visualize, manage, and analyse the geoarchaeological data from the research carried out in some areas of the northern Campania, related to the project 'Archaeological Map of Campania', directed by Stefania Quilici Gigli (Quilici Gigli 2016). Over the years, sectors in the districts of Caserta, Benevento, and Avellino have been investigated, considering archaeological data from the Prehistory to the Late Antiquity. The focus is the middle Volturno Valley, the Caudina area, and the *Ager Campanus*, but the activities have also extended to smaller areas in the district of Avellino. It was chosen to conduct extensive surveys of the areas under investigation rather than a sampling survey (Renda 2020, with other bibliographical references). The field survey has led to a significant increase in knowledge on examined areas (Quilici Gigli 2017; Renda 2020).

The majority of the archaeological maps produced have been published in the series 'Carta archeologica e ricerche in Campania', Suppl. XV of the *Atlante Tematico di Topografia Antica*, directed by Lorenzo Quilici and Stefania Quilici Gigli, ensuring the dissemination of research. Studies and surveys in this area have had operating implications. Maps of the archaeological potential were produced, thanks to the collaboration between the University, Soprintendenza and local Government, with the aim of a common strategy for land-use planning (Quilici Gigli *et al.* 2014; Quilici Gigli 2016; Renda 2016, 2022). In this regard, the initial choice to conduct extensive surveys in the investigated territories has proved to be successful, because this type of field research is the most suitable for territorial planning.

The activities of preventive archaeology, especially the research conducted in the *Ager Telesinus*, made us reflect on a 'more dynamic' dissemination that allows for the retrieval of the most significant information of the recorded archaeological sites, related to their spatial data, and the possibility for external users to query them according to their needs. In this regard, the development of a webGIS seemed the most suitable solution, considering the volume and complexity of the available data and the need for high-speed data transmission. The years of experience in the field of GIS and geodatabases (Renda 2019 with bibliographical references), and the creation of ontologies for the structuring of archaeological data (Renda 2014) have served to organize a new logical and conceptual model, used as a documentary base for the webGIS.

G.R.

2. Normalisation and management of archaeological layers

In connection with the development of the webGIS, a normalization activity was conducted on the data created in the GIS environment and used in previous projects. The systematization of the contents was followed by the phase of importing all the alphanumeric data into a geodatabase functional for the webGIS. During the transmigration of data onto the webGIS and to precisely locate the archaeological evidence, it was decided to assign a polygonal geometry to the basic data relating to the archaeological sites, for which the actual dimensions had already been identified through surveying and georeferencing. Another preparatory phase was about the choice of entries within the description sheet of the archaeological assets. It has been created a 'single sheet', that would compact and organize data in a streamlined model. This sheet collects data to the knowledge of the archeological heritages and contexts into single sections. These sections have free fields and fields with drop-down menus with multiple choices, designed in relation to the latest indications provided by the Ministry of Culture for preventive archaeology.

Particular attention was paid to the chronology section. We referred to the model of the formal ontology CIDOC-CRM (Niccolucci 2015). The chronological phases included range from prehistory to the late Middle Ages, with particular focus on periods and territorial compartments within which the archaeological maps drawn up are located. For a more immediate and effective understanding of the archaeological data, a symbology was prepared that differentiated the various sites identified by type.

S.M.

3. The GISTArc project

The GISTArc project involves the creation of a webGIS environment for the management and visualization of geoarchaeological data, i.e. archaeological data to which geospatial properties have been associated, such as position, perimeter or a track, all of which are georeferenced in an appropriate system of geographical reference. The classic functions of creating, reading, updating and deleting new records (CRUD, Create-Read-Update-Delete) are implemented in the GISTArc geodatabase, both for descriptive data and for associated geometries. For this reason, PostgreSQL database management software was used, with the PostGIS extension for geometries and data georeferencing. PostGIS provides a complete library of functions that are particularly useful in the analysis of archaeological and topographical data. The GISTArc user interface is responsive and can be used with any device (desktop, tablet, smartphone) connected to the Internet via a standard browser, automatically adapting to the size of the screen in use. The system was created to be multilingual, initially in Italian and English, with an automatic translation system based on Google Translate, integrated with multilingual user interface parts, managed directly by the application.

3.1 *The objectives of GISTArc*

The main objective of GISTArc is to make the results of archaeological research, accumulated over years of field surveys, until now accessible to a small number of specialists in the sector, in the form of books only, accessible to as many people as possible, in a more general perspective of public archaeology. Moreover, GISTArc has functions for entering and updating data via the Internet connection. This allows the researcher, in addition to consulting the information already present in the database, to insert new information and correct any errors directly in the field, with a great saving of time. Another objective, by no means secondary, is to be able to access the GISTArc geodatabase on the Internet via standard desktop applications, such as Quantum GIS and ArcGIS, in order to use advanced data analysis and representation functions that may not be available online, ensuring the integration with very well-known standard and most commonly used application.

All users can, even without logging-in, freely view thematic maps with all the information present in the database, select the data using interactive masks, and change the basic cartography from a certain number of pre-set maps. Users with credentials can be 'administrators', who can create and manage other users; 'field researchers', who can enter new data in the field and update existing data; and 'editors', who have complete access to the functions of insertion, modification and deletion of all data.

3.2 *System architecture and development tools*

The GISTArc application was implemented on Linux servers with Node.js. GISTArc is a classic PERN application (PostgreSQL + Express + React + Node), and is therefore made up of a backend (all the functions needed to access the geodatabase) and a frontend (Fig. 1) (the graphical user interface, GUI). GIS desktop applications (QGIS, ArcGIS) can connect directly to the online geodatabase. All the software and libraries used for the development of GISTArc is open source, not only to contain development costs, but also to have maximum flexibility in designing and creating the software, which is not always possible with commercial applications (Tab. 1). Also the development environment (code editor and testing) used for this project, Visual Studio Code, is freely available for downloading on Internet. The GISTArc application was created for the Linux platform, and tested with an Ubuntu virtual server created in an AWS (Amazon Web Services) environment, with NGNIX as the web services manager.

Function	Software
Geodatabase	PostgreSQL + PostGIS
Backend and API	Express.js, JavaScript
Frontend	React, JavaScript
Graphical User Interface	React-Bootstrap + Bootstrap
Gestione mappe	React-Leaflet + Leaflet
Other functions	Additional JavaScript libraries
Execution environment	Node.js (JavaScript runtime)

Tab. 1 – List of the main software components and libraries.

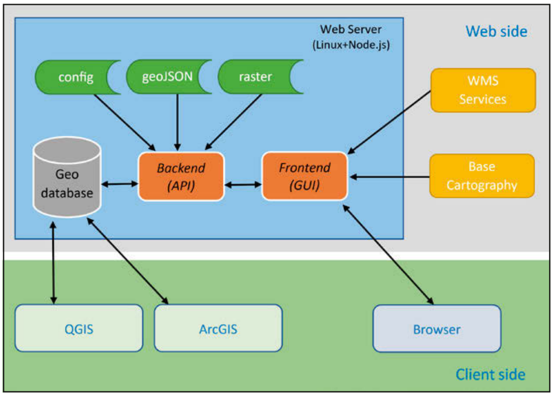

Fig. 1 – Architecture of the GISTArc web application.

3.3 *The GISTArc application*

In the basic screen of GISTArc (Fig. 2), since it is a GIS application, we wanted to emphasize the display of the map, which occupies the entire work area. In the upper part, outside the work area, there is a menu that contains general commands, including the button to log in using credentials and the one to change the working language. On the left side, superimposed on the work area, there is a retractable 'toolbar' which includes the main functions of GISTArc (Fig. 2) for: selecting layers, selecting places, viewing the list of places present in the current window, and filtering of places based on the selection of specific attributes. From the Layers panel of the toolbar, it is possible to select: the basic layers, available on the Internet, such as Open Street Map, in the different versions, the ESRI satellite map, the various versions of the Stamen maps, etc. In the same way, it is possible to connect and view WMS (Web Map Service) maps, such as the maps of the Italian Military Geographic Institute, at 1:25,000 and 1:100,000 scale, made available free of charge on

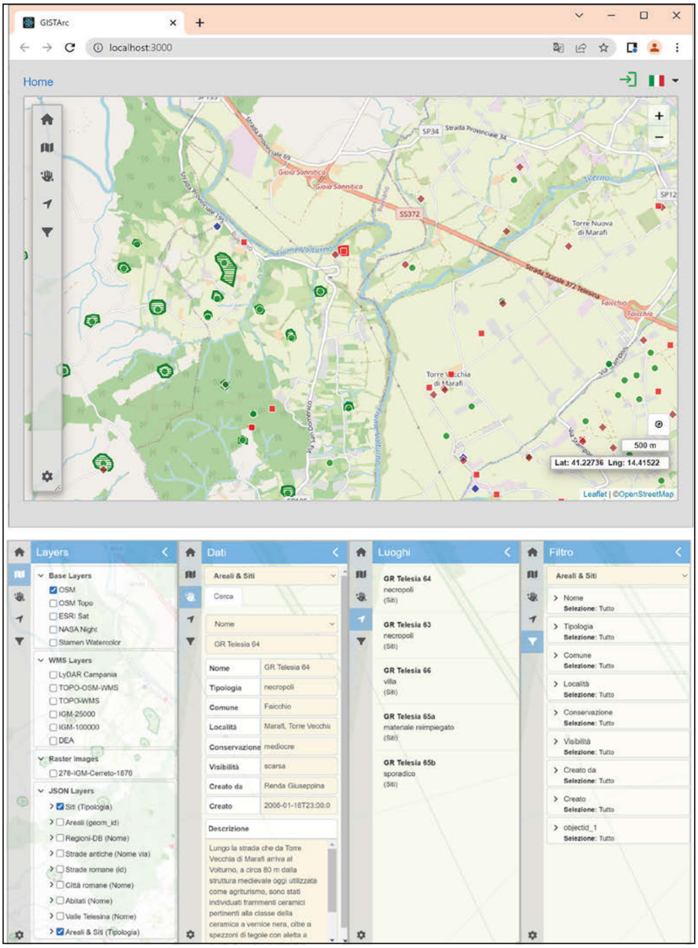

Fig. 2 – GISTArc basic screen (above) and toolbar panels.

the website of the Ministry of the Environment. In addition, it is also possible to view, as a basis, appropriately georeferenced historical maps (raster).

The data contained in the geodatabase are used to create and display vector layers, which are associated with different geometries: points to identify places, cities, archaeological evidence; polygons for the areas of interest associated with individual sites; and lines for ancient road routes. These layers, whose data are contained in the geodatabase, can be dynamically modified by authorized users, with the classic creation, reading, updating and deletion operations. Other 'static' layers (vector layers), such as those of the

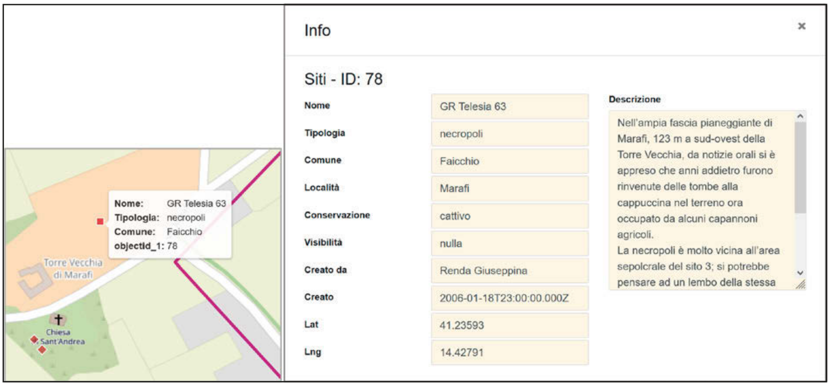

Fig. 3 – Information windows, synthetic (left) and extended (right).

administrative, municipal, provincial, regional borders, which do not require updates but are created one-off and then simply loaded as needed, are not stored in the database, but on disk of the server, so as not to unnecessarily overload the database management system. All vector layers, both from database and from disk, are managed within GISTArc as GeoJSON structures, i.e. JSON (JavaScript Object Notation) data with the addition of geospatial information, because they are more easily managed by JavaScript, which is the base language with which the application was created.

Elements of a layer can also be selected from the Data panel of the toolbar. In the example in Fig. 3, the 'GR Telesia 64' site was selected from the 'Areas & Sites' layer. The selected site is placed in the center of the screen, highlighted with a yellow circle and the map is automatically rescaled with a predefined zoom level, in order to display the site and its surroundings in adequate detail. If the current user is authenticated as 'editor' ('field', owner of the data), the panel becomes a full-fledged data editing and entry form, and all the data can be modified and updated, and new places can be added too. Fig. 4 shows the toolbar of the Search tab, located under the name of the selected element, with buttons for: editing non-spatial data; modifying the geometry; canceling unsaved changes; saving changes; and deleting the item. The geometry associated with the object is also displayed under the toolbar in GeoJSON format. This can be modified directly on the map with the 'Edit geometry' button.

In addition to these basic functions for viewing, editing, and entering data, functions have been implemented through the Places and Filter panels that make selecting and accessing data very simple. The Places panel is used to list all the 'places', i.e. the elements associated with specific layers, present in the portion of the currently displayed map.

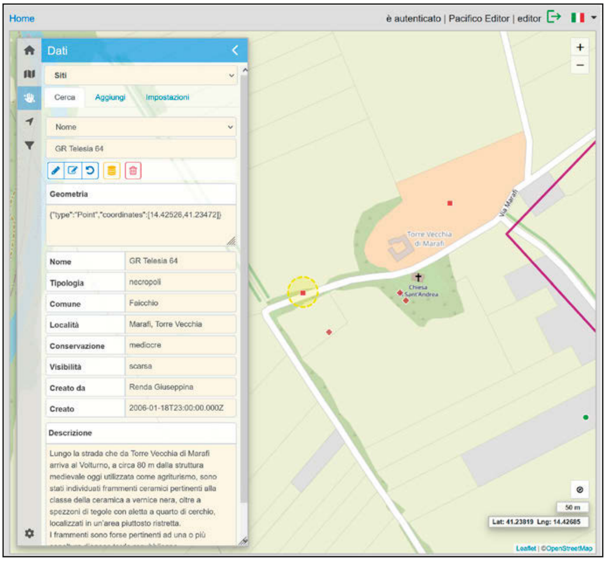

Fig. 4 – Data modification panel, by an authenticated 'editor' type user.

3.4 *The configuration of GISTArc*

The GISTArc application is built starting from a common and general code core, which we have called 'mapplet' that can be used to create, in principle, any webGIS application. This is a general code containing basic functions for connecting to external base maps and WMS, loading maps from geodatabases, managing CRUD functions, managing application users and many other accessory functions. An application built with this core code can manage any layer and any set of data, i.e. those defined in configuration files external to the code and loaded when the application is run. These are text files in JSON format, which 'describe' the data that give 'content' to the application itself, according to a predefined syntax.

The GISTArc configuration JSON file (default.json), in compact form, is shown in Fig. 5, compared to the Layers menu of GISTArc. The configuration file contains the definitions associated with the layers that are loaded into the application at startup. Each layer has specific metadata, according to the type of layer. As an example, for a layer connected to an external resource (map or WMS), in addition to the basic attributes common to all types of layers, there are the 'url', 'maxZoom' and 'attribution' metadata, necessary for loading from the Internet. A 'jsonLayers' defines a typical GIS layer, and have a more complex set of metadata, because it is necessary to define the characteristics

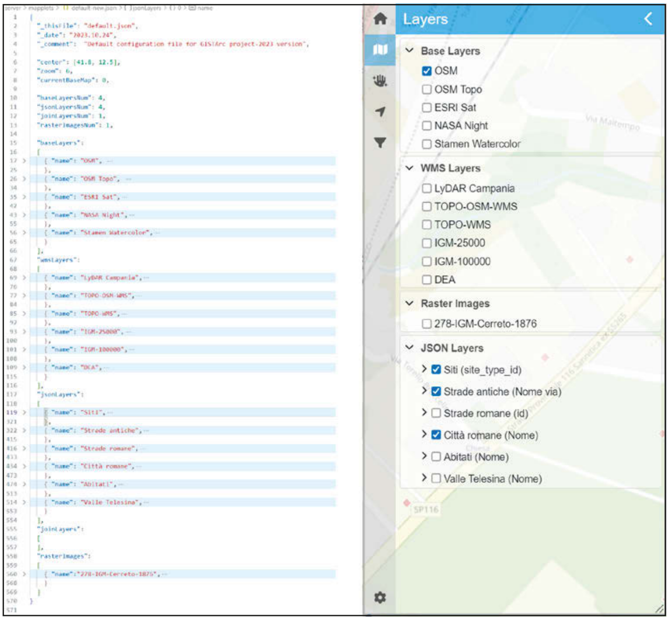

Fig. 5 – The configuration file and the layers panel.

relating to the display of the symbols or icons associated with the geometries and the management of the attributes, as shown in the definition of the 'Sites' layer which follows. Moreover, they contain a description of the geodatabase fields used, as shown in Fig. 6.

We notice that the 'datatype' metadata is present, to which in the previous example the value 'db' is assigned, precisely to specify that all the information associated to the layer is stored in a database. Another possible value is 'file'; in this case the data relating to the layer is stored in a file on the server disk. The .env file contains server and database connection information, as in the example below:

```
NODE_ENV=devel
JWT_SECRET=12123o1iwqJHMNMkjswnLJLKaqieu32193218u9\398)(&)
(79876KJKjhMnuhnHIg&3&%/7)
PORT=5000
PGUSER=postgres
PGHOST=localhost
PGPASSWORD=pcpcpc
PGPORT=5432
USERSDB=jwtusers
PGMAPPLETSDB=gisdb
```

```json
{ "name": "Siti",
  "datatype": "db",


  "fname": "sites",
  "prefix": "site",
  "checked": true,

  "type": "points",
  "geometryType": "Point",
  "srid": "32633",
  "latlng": false,

  "publicField": "site_pub_val",

  "idField": "site_num_val",
  "crDateField": "site_crdate_val",
  "crByField": "site_crby_userid",
  "moDateField": "site_modate_val",
  "moByField": "site_moby_userid",

  "descrField": "site_descr_val",
  "markerField": "site_type_id",

  "--searchField": "site_num_val",
  "--searchText": "site_com_id",
  "--labelField": "site_num_val",

  "_comment-required_fields": "can't be empty",
  "_comment-auto_fields": "'auto' fields values are created/updated automatically by the program",

  "fields": [
    {"label": "Geometria",         "required": true,  "mode": "auto",   "name": "geom"},

    {"label": "Numero",            "required": true,  "mode": "auto",   "name": "site_num_val"},
    {"label": "Creazione",         "required": true,  "mode": "auto",   "name": "site_crdate_val"},
    {"label": "Modifica",          "required": false, "mode": "auto",   "name": "site_modate_val"},
    {"label": "Creato da",         "required": true,  "mode": "auto",   "name": "site_crby_userid", "ids":[], "vals":[]},
    {"label": "Modificato da",     "required": false, "mode": "auto",   "name": "site_moby_userid", "ids":[], "vals":[]},

    {"label": "Pubblico",          "required": true,  "mode": "manual", "name": "site_pub_val"},

    {"label": "Nome",              "required": true,  "mode": "manual", "name": "site_name_val"},
    {"label": "Descrizione",       "required": false, "mode": "manual", "name": "site_descr_val"},
    {"label": "Località",          "required": false, "mode": "manual", "name": "site_loc_val"},

    {"label": "Comune",            "required": true,  "mode": "manual", "name": "site_com_id",      "ids":[], "vals":[]},
    {"label": "Tipologia",         "required": true,  "mode": "manual", "name": "site_type_id",     "ids":[], "vals":[]},
    {"label": "Visibilità",        "required": false, "mode": "manual", "name": "site_vis_id",      "ids":[], "vals":[]},
    {"label": "Conservazione",     "required": false, "mode": "manual", "name": "site_con_id",      "ids":[], "vals":[]},

    {"label": "Elementi",          "required": false, "mode": "manual", "name": "site_archels_ids", "ids":[], "vals":[]},
    {"label": "Ceramiche-metalli", "required": false, "mode": "manual", "name": "site_cermets_ids", "ids":[], "vals":[]},
    {"label": "Tecniche",          "required": false, "mode": "manual", "name": "site_edtechs_ids", "ids":[], "vals":[]},
    {"label": "Individuazione",    "required": false, "mode": "manual", "name": "site_idmods_ids",  "ids":[], "vals":[]},
    {"label": "Epoche",            "required": false, "mode": "manual", "name": "site_histeps_ids", "ids":[], "vals":[]},
    {"label": "Funerarie",         "required": false, "mode": "manual", "name": "site_funs_ids",    "ids":[], "vals":[]},

    {"label": "Media",             "required": false, "mode": "manual", "name": "site_meds_ids"},
    {"label": "Riferimenti",       "required": false, "mode": "manual", "name": "site_refs_ids"}

  ],

  "infoFields": [ ···
  ],
  "keyFields": [ ···
  ],
  "keyGroups": [ ···
  ],
```


Fig. 6 – GeoJSON layer with database fields description.

Thanks to these configuration files it is possible to 'reconfigure' the entire application, both in terms of the layers made available to the user and for the migration of the application itself from one platform to another, having parameterized all the information relating to the server and online database manager.

P.C.

4. The database architecture

The database design involved initial requirements analysis work which relied on in-depth knowledge of the domain of interest by the research group. With a view to reusing the software, an application was used whose data structure was simplified and above all, for the definition of some vocabularies, the ontology for the cataloging and communication of the archaeological assets of the MARA platform. The design phase continued with the definition of the tables and the relationships between them. The data structure is based on a main Sites table, with a series of accessory tables that contain lists of predefined values, and additional tables relating to bibliography and media (photos, drawings, images in general) (Fig. 7). The information present in the database is also the result of the integration of external open databases. In particular, geographical data (shapefiles for municipalities and localities) from the territorial base system published by ISTAT were used. Furthermore, the structure was implemented with some codified vocabularies as required by the guidelines on preventive archeology of the Ministry of Cultural Heritage.

4.1 *The database management system*

PostgreSQL was chosen as the open-source database management system. It is software based on the typical client-server model with the ability to combine the potential of object-oriented programming with those of relational DBMS. The

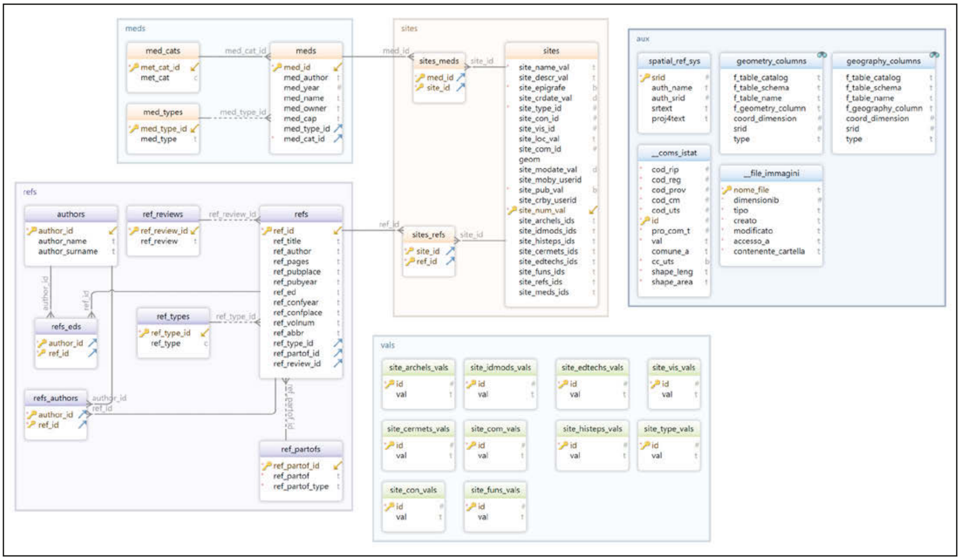

Fig. 7 – Database architecture.

advantages offered by PostgreSQL are many. In fact, it is multi-platform, has high performance and excellent reliability, and guarantees security and extensibility. It also has easy-to-use administration tools; in this work both psql, with a command line interface for entering SQL queries, and pgAdmin, an administration tool with a graphical interface, were used. Of great importance is the availability of the PostGIS module for PostgreSQL which extends the functionality of the DBMS with spatial functions, which allow you to manage georeferenced data and create, update and query geodatabases quickly and efficiently.

C.C.

5. Conclusion

The first purpose of the GISTArc was to make information accessible to those involved in research, preservation, and territorial planning, providing alphanumeric information, vector, and raster layers that maintain spatial accuracy. This last point (the spatial accuracy) became crucial: unfortunately, some of our data was incorporated into a newly licensed webGIS without our direct involvement, leading to incorrect localization of some of our archaeological data. A second purpose was to make the system 'real-time' usable, meaning to provide data entry directly in the field, in order to reduce the times and steps of registration. Furthermore, the possibility of using data pre-entered enhances the understanding of each site identified in the field activities.

The work presented here is still in progress. A future development of GISTArc could be in a semantic sense, especially regarding the use of ontologies associated with archaeological, bibliographical and topographical data. A further step should be to use semantic technologies applied to the geospatial data themselves (Janowicz *et al.* 2010; Zhu 2010).

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ABSTRACT

The GISTArc project envisions the implementation of a webGIS environment for the management and visualization of geoarchaeological data from research included in the Archaeological Map of Northern Campania project, conceived and directed by Stefania Quilici Gigli. The creation of the new system began with the normalization of some completed research data. They were managed in a GIS environment and were subsequently imported into a Web geodatabase, with the preparation of layers containing all the textual, graphical/ photographical and spatial information of the catalogued archaeological evidence, together with the required bibliographical references. The GISTArc project has a threefold aim: make the results of archaeological research conducted in some sectors of northern Campania more usable; allow the researcher to consult, integrate and enter the data from future research, thanks to the connection to the system via the Internet and the possibility of recording data directly during the survey; and finally access via standard desktop applications, such as Quantum GIS and ArcGIS, rather than the internet-based GISTArc geodatabase, in order to use advanced data analysis and representation functions that may not be available online. This paper describes the technical and scientific approach to the creation of our webGIS. It focuses on the system architecture, operative environment, and development tools.