3D Digital Tools for the Development and Promotion of Religious Heritage Tourism

Dimitris ANASTASIOU, Elpida BAXEVANIDI, Vassilios ANDRITSANOS, Michail GIANNIOU, Vassilios PAGOUNIS and Maria TSAKIRI, Greece

Key words: Geoinformation/GI, Laser scanning, cultural heritage, 3D models, digital tools

SUMMARY

Religious heritage forms a unique and essential pillar of Europe's cultural identity. There are almost half million religious buildings along with their associated contents in Europe and is important to take measures to preserve these for the future generations. Furthermore, religious heritage constitutes a great leverage in the growing interest for religious tourism worldwide which is beneficial for international tourism and economic growth. This paper aims to highlight the fact that promoting the conservation of religious heritage can provide a positive impact on social innovation, smart, sustainable and inclusive growth, competitiveness and job creation. Specifically, a case study is described where a number of churches of varying periods located in the island of Syros, Greece, are documented with high accuracy techniques and precise 3D rendered models are derived for input in an online repository. A developed platfrom ”GeoSyros Portal” with access to a repository that provides information of educational and histroric content on religious structures destined for a wider audience is described. Finally, a discussion is given on efforts that enhance the visitors' experience as well as promote religious tourism in general.

3D Digital Tools for the Development and Promotion of Religious Heritage Tourism

Dimitris ANASTASIOU, Elpida BAXEVANIDI, Vassilios ANDRITSANOS, Michail GIANNIOU, Vassilios PAGOUNIS and Maria TSAKIRI, Greece

1. INTRODUCTION

Cultural activities in the era of digital-communication globalization are the means of protecting, preserving and promoting the cultural heritage as well as promoting modern cultural creation. These are all events related to the production of cultural goods, materials and intangibles for the general public. Cultural activities designed in the light of the principles of general (public) interest contribute to the development of cultural processes and are an important factor in the development of cultural policy and economic, social and spiritual well-being in the (region). The design and production of successful and sustainable cultural activities need to be supported by innovation and innovative management and development models. Culture nowadays, grows dynamically in two different, complementary and parallel landscapes, the real and the digital landscape of culture, thereby contributing to the development of culture - both real and in the digital landscape - shaping the right conditions for the development of local, regional and global cultural policy networks (Gantzias, 2010; Timothy, 2003).

Religious culture heritage forms a unique and essential pillar of Europe's cultural identity. There are almost half million religious buildings along with their associated contents in Europe that have inspired numerous people over the centuries. It is interesting to note that approximately 20%of the properties inscribed on the World Heritage List have some sort of religious or spiritual connection. In fact, ICOMOS has adopted the term "Religious Heritage" which defines "any form of property with religious or spiritual associations: churches, monasteries, shrines, sanctuaries, mosques, synagogues, temples, sacred landscapes, sacred groves, and other landscape features, etc."Therefore, understanding the continuing nature of religious and sacred heritage, having the capacity to protect its authenticity and integrity, including its particular spiritual significance, and sharing the knowledge of the common history, are some of the measures to preserve religious and sacred places for the future generations. In recent years UNESCO, the leader in the development and promotion for the protection of cultural and natural heritage in all its forms, carried out a number of research studies and analyses of religious heritage and sacred sites (e.g. ICCROM 2003 Forum on the conservation of Living Religious Heritage, 2005 ICOMOS General Assembly resolution, 2011 ICOMOS General Assembly Resolution, UNESCO MAB/IUCN Guidelines for the Conservation and Management of Sacred Natural Sites).

Furthermore, religious heritage constitutes a great leverage in the growing interest for religious tourism worldwide which is beneficial for international tourism and economic growth. In fact, religious travel is the oldest type of travel (Vukonić, 1996). From the 90s, increasing numbers of religiously motivated travellers, in conjunction with the general growthof cultural heritage tourism, have made this industry as an economic resource and capital (e.g. Ashworth, 1991; Graham, 2000, Christou, 2005). Recently, also, research on cultural tourism has sought to find a balance between tourism development and cultural heritage conservation (e.g. Cerquetti, 2015).

Understanding the continuing nature of religious and sacred heritage, having the capacity to protect its authenticity and integrity, including its particular spiritual significance, and sharing the knowledge of the common history, are some of the measures to preserve religious and sacred places for the future generations. Today many places of worship in Europe are suffering from neglect and abandonment due to financial distress and lack of specialist knowledge about the conservation of buildings and the treasures they hold. The challenges facing religious heritage are complex, the aims of its multiple stakeholders are widely diverse and there is a general lack of credible information upon which to build a forward-looking policy for the sector. This paper aims to highlight the fact that promoting the conservation of religious heritage assets and their inclusion in sustainable religious tourism activities can provide a positive impact on social innovation, smart, sustainable and inclusive growth, competitiveness and job creation. In light of the above, the paper describes the implementation of geodetic techniques to collect geospatial data that deliver a number of products regarding the geometric documentation of religious heritage buildings. Specifically, a number of churches of varying periods located in the island of Syros, Greece, are documented and precise 3D models are derived from a combination of surveying, GNSS and laser scanning techniques. The 3D models are rendered using photographic images and the imaging models are then included in a database. The developed online platform named "GeoSyros Portal" provides the 3D models of churches with historic/religious background information destined for a wide audience. It is easy to use and designed to an international standard. Such tools can help the managers of religious heritage to promote their use in the community and religious tourism in general. The paper comprises four sections. In section 2 a brief description of the area and the religious places of worship that are included in the developed platform is given. Sections 3 and 4 detail the development of the platform and the production of the digital models to be included in the platform and section 5 summarises the presented work.

2. AREA OF INTEREST

The developed platfrom presented in this paper focus on the religious monuments on three islands of Cyclades in Greece. The islands of Syros, Tinos, Mykonos, were devastated several times during the Middle Ages by raiders from different origins. In the Byzantine years, the islands was conquered by the Venetians and remained under Venetian rule until 1522. During the Latin period, the majority of the local communities in some islands like Syros were

Roman Catholics, but maintained the Greek language. During the reign of almost three and a half centuries of the Duchy of the Archipelago, Syros had a singular feudal regime. By 16th century, the Ottoman fleet became dominant in the Aegean and the Duchy fell apart. At the beginning of the 16th century the corsair Barbarossa took possession of the islands, which would be known as "Sire" during Ottoman rule. However, negotiations of the local authorities with the Ottomans gave the Cyclades substantial privileges, such as the reduction of taxes and religious freedom. At the same time, following an agreement of France and the Holy See with the Ottoman authorities, the Catholics of the islands came under the protection of France and Rome and so Syros sometimes was called "the Pope's island". In 1827 the islands became part of the newly founded First Hellenic Republic and later (1834) the Greek Kingdom. The islands returned to peace and tranquillity and prospered. Especially, Syros became known as a cross-road in the Aegean and as an international commercial centre linking Western Europe and the Mediterranean Sea to the East. The construction of the first buildings began in 1822, and in 1824 the first Orthodox Church Metamorphosis was constructed.

Due to the dynamic environment of all three islands through the coexistence of the Orthodox with the Catholic element, a number of religious monuments of incomparable architectural and historical significance, with icons, paintings of immeasurable value, and libraries that hold important manuscripts and books exist on the islands that are of great religious and historical value. Some of them are functional monasteries, early Christian or Byzantine churches and chapels scattered in the towns and villages and attract thousands of visitors all year round. Thus, the islands provides significant foundations for the development of this thematic tourism.

The developed “GeoSyros Portal” currently includes data for 47 churches in three islands of Cyclades (Syros, Tinos and Mykonos) and is updated frequently to include more. The following sections describe in a general way the creation of the database and the management system that supports the geoportal.

3. DATA COLLECTION

For the construction of the 3D models of the religious buildings and churches that are included in the platform, a series of technical procedures for data collection need to take place. Initially, the field work implements geodetic and surveying techniques to set up the geodetic infrastructure for the georeference of the digital models and all the products in the platform. The laser scanning of the monuments then follows that will produce the necessary point cloud data and the resulted digital models.

3.1 Geodetic infrastructure

Initially, for the geodetic control of the project, a geodetic network comprising 65 reference points around each church were established on three islands of Cyclades (22 on Syros, 34 on Tinos and 9 on Mykonos). These points are used to support the field measurements and the georeferencing of all data and form a geodetic infrastructure that will facilitate additional works in the future, like complementary surveys using more sensors, deformation monitoring etc. (Fig. 1). The coordinates of the points were determined using GNSS carrier phase observations. The measurements were conducted using two dual frequency GPS-GLONASS geodetic receivers (Javad Triumph-1, 3mm±0.5ppm in horizontal and 5mm±0.5ppm in vertical).

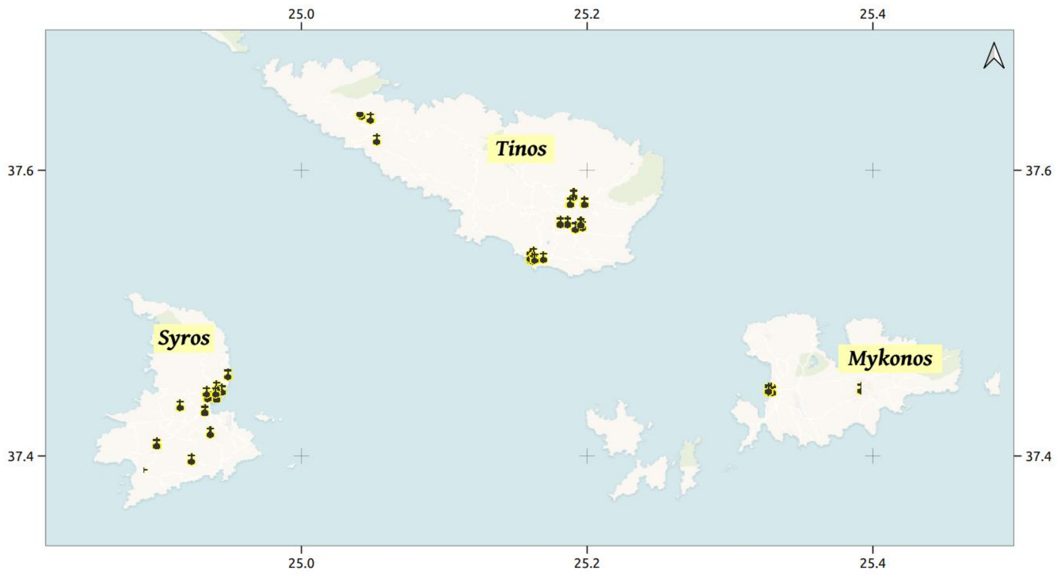

Figure 1: The locations of the 65 control points established on the Islands of Syros (west), Tinos (north) and Mykonos (east).

The main challenge faced during the GNSS measurements was the limited satellite visibility at points in the cities and villages caused by the unique built environment of the Cyclades Islands (narrow alleys surrounded by buildings). The combined use of GPS and GLONASS was mandatory to obtain a reliable fixed solution with acceptable precision. To further anticipate for the difficult urban observation environment the adopted occupation time was considerably longer than the typical occupation duration of rapid rapid-static measurements, which is 8 min. More precisely, the observation time varied from 22 min (locations with open sky view) up to 70 min (built-up areas). The integer carrier phase ambiguities were resolved for all baselines leading to a mean positional precision of 0.012 m (horizontal) 0.021m (vertical). Nevertheless, considering that Galileo (GAL) and BEIDOU (BDS) are approaching their full deployment having already many operational satellites, it was investigated in this work the benefits of the potential use of 3 or 4 GNSS. The recent advances in the estimation of orbit and clock products for GAL and BDS allowed the implementation of these systems in RTK-networks (Montenbruck at., 2017). Figure 2 shows the number of visible satellites at one of the most demanding locations for different GNSS combinations (church of Agios Ioannis in the city of Mykonos). As can be seen, the additional use of GLONASS, Galileo and BEIDOU significantly improves the situation: The maximum number of visible satellites increases from 4 (GPS only) to 6 in the case of GPS-GLN, to 10 in the case of GPS-GLN-GAL and up to 15 when using GPS-GLN-GAL-BDS. This example demonstrates the advantage of upgrading GNSS infrastructure (RTK-networks and rovers) to full constellation (Zahn, 2019).

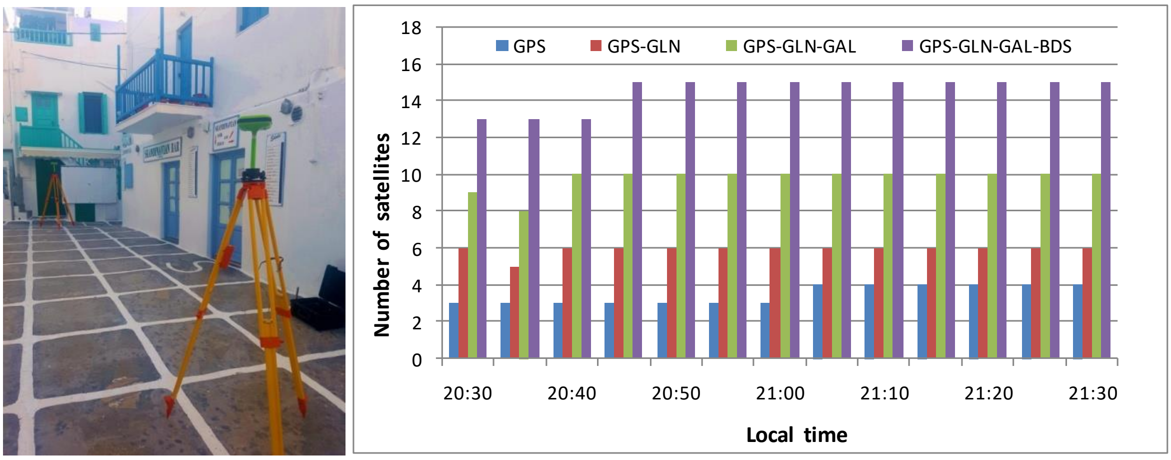

Figure 2: A representative example of unfavorable observation environment (left) and the corresponding number of visible satellites for different GNSS combinations (right).

3.2 3D Data

The 3D data collection involved the use of terrestrial laser scanning for the geometric documentation of the external and internal parts of the churches (Fig 3). The scanning was performed using the Leica Geosystems BLK360 image laser scanner (https://leica-geosystems.com).All scans were performed with a 4 mm step and the distance between the object and the scanner was always less than 10m. The percentage of the scan overlap ranged from 30% to 40%.

Figure 3: Snapshot of the scanning process (left) and example of a point cloud output (right).

The collected point clouds were processed in proprietary software (Leica Geosystems Cyclone). The alignment of individual scans was performed using tie points in an independent reference system. Regarding the accuracy of the merged point cloud, the mean square error (RMS) ranged from 1 to 1.3cm. From the merged point cloud, a number of products were created including the meshed model and the ortho-photo models with texture (e.g. RGB, gray scale etc) as seen in Fig. 4 and 5.When all 3D models were created, they were imported in the platform with suitable software offering interactive measuring tools. In this work, the proprietary Leica Geosystems TruView Enterprise software was used where the online user can browse inside and outside the churches, choose to browse through different layers (such as RGB, IR, HDR, Intensity Grayscale and Intensity Hue Layer) and take distance, angle and temperature readings.

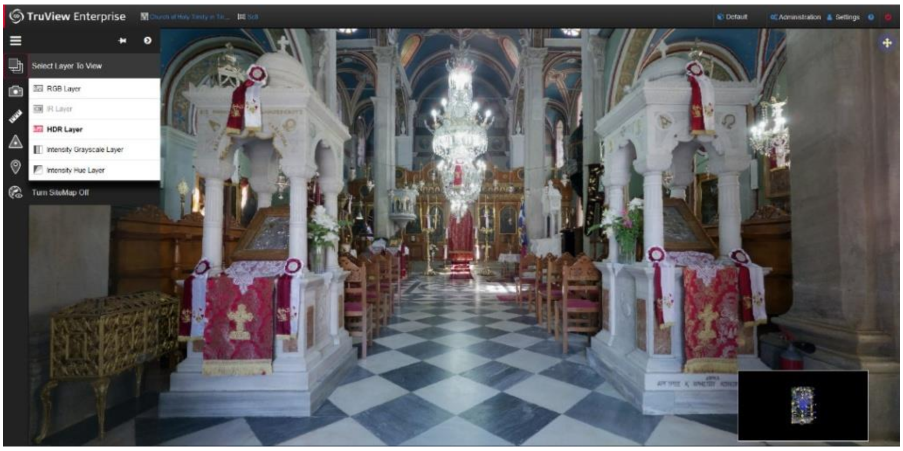

Figure 4: Inside of the church of Holy Trinity of Tinos with the HDR Layer selected.

Figure 5: Inside of the church of Holy Trinity of Tinos with the Grayscale Layer selected.

4. DEVELOPMENT OF THE "GeoSyrosPortal"

The "GeoSyros Portal" is a geographical information map that was developed to promote the religious heritage of Cyclades Island region and is freely accessible (http://195.130.106.60/GeoSyros/). It was developed using exclusively Free and Open Source Software (FOSS). The applications that were used to develop the portal are given in Table 1 with their respective releases and licenses.

Table 1: Free and Open Source Software used to develop the "GeoSyros portal"

Software Package	Version	License
QGIS (http://qgis.com)	3.6.0	GNU-GPLv2
PostgreSQL (http://www.postgresql.org)	10.5	PostgreSQL
PostGIS (http://postgis.net)	2.4	GNU-GPLv2
Geoserver (http:/geoserver.org)	2.15	GNU-GPLv2
GeoWebCache (http://geowebcache.org)	1.14.2	GNU-LGPL
GET SDI Portal (http://www.getmap.gr)	4.0	GNU-GPLv3

Data stored in the database are available through a server that supports the Web Map Services (WMS) standard for versions 1.1.1 and 1.3.0. The WMS is accessible at http://195.130.106.60/geoserver/imsyros/wms where all available information can be retrieved. The GET SDI Portal v4.0 mapping platform (https://github.com/) was used to disseminate all available data to citizens and scientific community. This mapping platform, developed by Geospatial Enabling Technologies (http://www.getmap.gr), was based on open source projects and is available under the terms of the GNU=GPL v3 license.

The mapping layers were grouped into seven basic teams. The following five groups relate to the basic background:

- Administrative borders for South Aegean Region,
- terrain features,
- environment - protection,
- anthropogenic environment,
- Temples.

The portal is constantly being updated when new data are available to the database. A schematic of the design structure of the web portal is given in Fig. 6.

The database that supports the GeoSyros Portal was developed in a Postgre SQL environment to store, share and easily retrieve the metadata of each temple. The Post GIS extension was used to access the geospatial information of each temple. The database was installed on a central server of the Department of Surveying and Geoinformatics at the University of West Attica.

Cultural content in museum collections, libraries, and other content repositories is usually described using metadata schemas (also called annotation schemas or annotation ontologies). These templates specify a set of obligatory and optional elements, i.e. properties, by which the metadata for content items should be described.The templates in GeoSyros portal consist of two separate schemas: "public" schema which comprises the tables for the map background, and "naoi" schema which contains tables for temples metadata.

Characteristic tables in schema "public" include coastline of the islands, contours with 20m interval as extracted from the data of hurtle Radar Topography Mission - SRTM (Farr, 2007), main and secondary road network of each island. Specifically, the data for coastline, major and minor roads were derived from national maps of 1:50,000 by the Hellenic Military Service (HMS) which were digitized using QGIS environment. Characteristic tables in schema "naoi" include lists of islands, cities and villages, the metadata for each documented church, encoded list of photos and metadata table for each photo stored on the server.

Furthermore, the database uses encoding guidelines which tell how to express the elements in certain serialisation formats and qualifiers, such as encoding schemes, enumerated lists of values, and other processing clues to provide more detailed information about a resource. For example, the "date" element that can further be specified as "date published" or "date last modified".

.

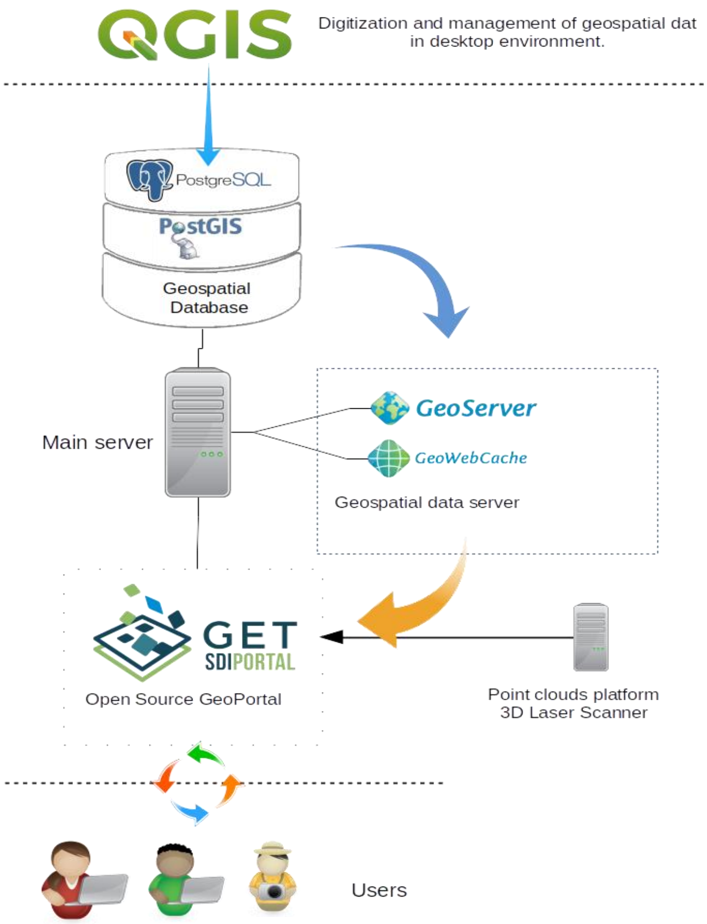

Figure 6: Workflow implementation portal

Figure 7 shows the structure of the "naoi" schema, the correlation of the tables, and the data type for each column. Table 1 gives the fields that are completed for each temple and are stored in the database. The database is designed to be expanded with new fields that may be added in the future for each temple. It is also under constant update as new data is stored in the tables.

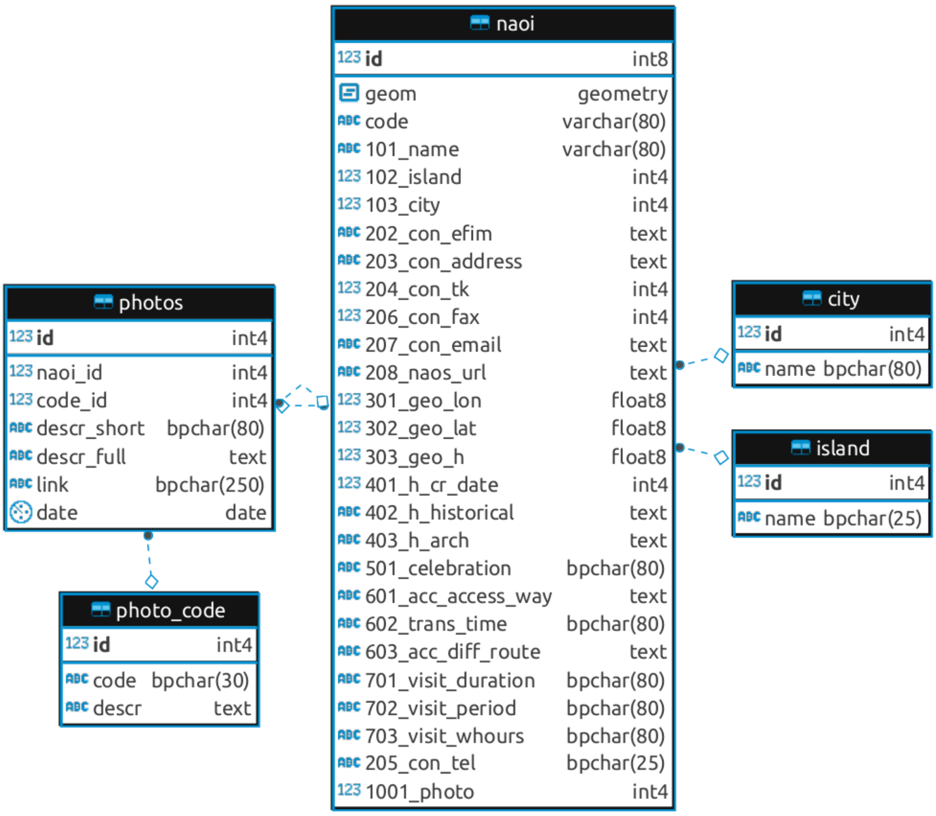

Figure 7: Database structure and relations

In its current form, GeoSyros Portal follows traditional portals where the search is usually based on free text search (e.g., Google), database queries, and/or a stable classification hierarchy (e.g., Yahoo!). However, it aims to use semantic content which makes it possible to provide the end-user with more "intelligent" facilities based on ontological concepts and structures, such as semantic search, semantic autocompletion, and (multi-)faceted semantic search (e.g Junnila et al., 2006). In addition, semantic content facilitates semantic browsing and the semantic associations between search objects can be exposed to the end-user as recommendation links, possibly with explicit explanations. Also other kind of intelligent services can be created based on machine interpretable content, such as knowledge and association discovery, personalization, and semantic visualizations based on e.g. historical and contemporary maps and time lines.

Table 2: Collected and archived information for each documented religious monument

code	db_name	Field description	Type
100		**Site of interest**	
101	**name**	**Name of Temple**	text
102	**island**	Island	text
103	**city**	City /Village	text
200	**con**	**Contact information**	
202	**con_efim**	Vicar	text
203	**con_address**	Address	text
204	**con_tk**	Postcode	int
205	**con_tel**	telephone	int
206	**con_fax**	fax	int
207	**con_email**	email	text
208	**naos_url**	website	text
300	**geo**	**Geodetic localization**	
301	**geo_lon**	Latitude (λ)	float
302	**geo_lat**	Longtitude (φ)	float
303	**geo_h**	elevation (h)	float
400	**h**	**Historical data**	
401	**h_cr_date**	construction date	int
402	**h_historical**	Historical interest	text
403	**h_arch**	Artistic/Architectural interest	text
500		**Temple celebration**	
501	**celebration**	temple celebration	date
600	**acc**	**Access**	
601	**acc_access_way**	Way to access	text
602	**acc_trans_time**	Access time	time
603	**acc_diff_route**	Difficulty of the route	text
700	**visit**	**Visit**	
701	**visit_duration**	Duration of visit	date
702	**visit_period**	Visiting periods	date period
703	**visit_whours**	Opening hours	time period

5. CONCLUDING REMARKS

Cultural heritage provides a rich application domain in which useful collection contents are available, and where relevant organizations are eager to make their content easily and publicly accessible. In this work, a portal named GeoSyros Portal has been developed to provide collection content about the religious monuments and churches of the Cyclades region which belongs to the Holy Metropolis of Syros in Greece.

The advantage of a portal is mainly the global view to heterogeneous, distributed contents which may come from different content providers and are available through one serviceas if it were a single, seamless homogenous repository. In the case of GeoSyros Portal, there was no prior available content and this was created from its inception. The content involves products from high accuracy documentation procedures from a large number of churches bothe externally and internally.

The connection to the contents in the developed portal has been achieved by georeferencing the resources. The georeferenced information has the advantage to enable different precise searches and meta searches. The georeferencing was performed with geodetic techniques and specifically with GNSS measurements in a number of points around each church.

In its current form, GeoSyros portal is not of semantic nature. The portal content has been created in a centralized fashion by using a content management system (CMS). However, it is within the future directions of this work to enhance the portal with semantic properties that will help creating and maintaining links up-to-date automatically based on the metadata and ontologies and allow the portal content to be reused in different applications and cross-portal systems.

ACKNOWLEDEMENTS

The authors are grateful to the Holy Metropolis of Syros for providing permission and help for the data collection.

REFERENCES

Gantzias G (2010).Cultural Policy, Sponsorship and Corporate Social Responsibility.Papsotiriou, ISBN13 9789607182135 (in Greek)

Ashworth G. (1991). Products, places and promotion: destination images in the analysis of the tourism industry. In The Tourism Industry: an International Analysis, ed. M.T. Sinclair & M. Stabler, 121-142. Wallingford: CAB International.

Cerquetti M., Montella M.M. (2015). Museum Networks and Sustainable Tourism Management. The Case Study of Marche Region's Museums (Italy). Enlightening Tourism. A Pathmaking Journal, Vol. 5, No 1 (2015), pp.-100- 125

Christou E., Turp K. (2005). Heritage & Cultural Tourism. Thessaloniki: Alpha Publications.

Farr, T.G., Rosen, P.A., Caro, Edward, Crippen, R., Duren, R., Hensley, S., Kobrick, M., Paller, M., Rodriguez, E., Roth, L., Seal, D., Shaffer, S., Shimada, J., Umland, J., Werner, M., Oskin, M., Burbank, D., Alsdorf, D. (2007). The Shuttle Radar Topography Mission. Reviews of Geophysics. 45(2): RG2004.doi:10.1029/2005RG000183

Graham, B., Ashworth, G. J., Tunbridge, J. E. (2000). A Geography of Heritage: Power, Culture, and Economy. London: Arnold

Jaelani, A., Setyawan, E., Hasyim(2016). Religious Heritage Tourism and Creative Economy. in Cirebon: The Diversity of Religious, Cultures and Culinary,Journal of Social and Administrative Sciences, Vol. 3, Issue 1, March.Timothy, D.J., Boyd, S.W. (2003). Heritage Tourism. UK: Prentice Hall

Junnila, M., Hyvonen, M. E., Salminen, M. (2007). Describing and linking cultural semantic content by using situations and actions. Klaus Robering (Ed.), Information Technology for the Virtual Museum. LIT Verlag

Kauppinen, T., Henriksson, R., Vaatainen, J., Deichstetter, C., Hyvonen, E. (2006). Ontology based modeling and visualization of cultural spatio-temporal knowledge. In Semantic Web at Work—Proceedings of STeP 2006, November

Montenbruck, O., Steigenberger, P., Prange, L., Deng, Z., Zhao, Q., Perosanz, F., Romero, I., Noll, C., Stürze, A., Weber, G. and Schmid, R., (2017). The Multi-GNSS Experiment (MGEX) of the International GNSS Service (IGS)–achievements, prospects and challenges. Advances in space research, 59(7), pp.1671-1697

Vukonić, B. (1996). Tourism and Religion. Oxford: Pergamon

Vukonić, B. (2002). Religion, Tourism and Economics: A Convenient Symbiosis. Tourism RecreationResearch, 27(2), 59-64

Zahn, E. (2019). APOS - Austrian Positioning Service on the Way to Multi GNSS, Vermes-sung& Geoinformation 2/2019, pp. 119-123, https://www.ovg.at/de/vgi/files/pdf/5291

BIOGRAPHICAL NOTES

Dr. Dimitris Anastasiou is temporary academic staff at the Department of Surveying & Geoinformatics Engineering of the University of West Attica. He holds a Ph.D. in Geodesy and a Dipl. Eng in Rural and Surveying Engineering from the National Technical University of Athens, Greece.

Ms Elpida Baxevanidi is a senior student at the Department of Surveying & Geoinformatics Engineering of the University of West Attica.

Dr. VassiliosAndritsanos is Associate Professor at the Department of Surveying & Geoinformatics Engineering of the University of West Attica. He holds a diploma in Rural and Surveying Engineering from the Aristotle University in Thessaloniki, Greece and a PhD from the same University.

Dr. MichailGianniou is Associate Professor at the Department of Surveying & Geoinformatics Engineering of the University of West Attica. He holds a Ph.D. in Satellite Surveying from the Technical University of Darmstadt, Germany and a Dipl. Eng in Rural and Surveying Engineering from the Aristotle University of Thessaloniki, Greece.

Dr. Vassilios Pagounis is currently Professor at the Department of Surveying & Geoinformatics Engineering of the University of West Attica. He obtained his PhD in 2000 from the National Technical University of Athens (NTUA) in Greece.

Dr Maria Tsakiri is Professor at the School of Rural and Surveying Engineering, National Technical University of Athens. She holds a PhD in geodesy from The University of Nottingham, UK.

CONTACTS

Professor Vassilios Pagounis
University of West Attica
AgiouSpyridonos Str.
Aegaleo, Athens
GREECE
Tel. +30-210-5385820
Fax + 30-210-5385886
Email: pagounis@uniwa.gr