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Real Time Fire Monitoring Using Semantic Web and Linked Data Technologies*

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1 Introduction

Fire monitoring and management in Mediterranean countries such as Greece is of paramount importance. Almost every summer massive forest fires break out, causing severe destruction and even human life losses. European initiatives in the area of Earth Observation (EO), such as the Global Monitoring for Environment and Security programme (GMES)[4], have supported the development of relevant operational infrastructures that can be deployed to assist with these emergencies. In the context of the European project TELEIOS[5] and the Greek research project SWeFS, we have developed a fire monitoring service that goes beyond operational systems currently deployed in the GMES context in terms of easiness of implementation, effectiveness and efficiency. The technical advantages of this fire monitoring service, which is now operational at the National Observatory of Athens (NOA), come from its development by using exclusively state-of-the-art Scientific Database, Semantic Web and Linked Data technologies. In this demonstration we focus only on the Semantic Web and Linked Data functionality of the service, and demonstrate the relevant advantages and the contributions to the state of the art. The functionality related to Scientific Database Management is discussed in [2, 1].

There are currently two implementations of this fire monitoring service available: one in the context of project TELEIOS (reported in [2, 1]) and one in the context of the recent Greek project SWeFS which we present in this demo[6]. The only important difference of the two implementations is the Web interface which has been developed by NOA from scratch in SWeFS.

The fire monitoring service implements a processing chain where raw satellite images are analyzed and hotspots (pixels of the image corresponding to geographic regions possibly on fire) are detected. The products of this analysis are encoded in RDF, so they can be combined with auxiliary linked geospatial data (e.g., GeoNames, OpenStreetMap). By comparing detected hotspots with auxiliary data their accuracy can be determined. For example, hotspots lying in the sea are retrieved and marked as invalid. Additionally, we can combine diverse information sources and generate added-value thematic maps

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[4] http://www.emergencyresponse.eu/
[5] http://www.earthobservatory.eu/
[6] http://papos.space.noa.gr/fend_static/

which are very useful to civil protection agencies and firefighting teams during emergency situations.

In the rest of this demo paper we first describe in short the contributions of project TELEIOS. Then, we present the developed fire monitoring service and its advances compared to relevant deployed services. Finally, we describe how we plan to present this service through a live demonstration.

2 TELEIOS Contributions

TELEIOS is a recent European project that addresses the need for scalable access to PBs of EO data and the effective discovery of knowledge hidden in them. TELEIOS started on September 2010 and it will last for 3 years. In the first 18 months of the project, we have made significant progress in the development of state-of-the-art techniques in Scientific Databases, Semantic Web and Image Mining and have applied them to the management of EO data.

We have developed SciQL [8], a new SQL-based query language for scientific applications with arrays as first-class citizens. This allows us to store EO data (e.g., satellite images) in the database, and express low level image processing (e.g., georeferencing) and image content analysis (e.g., pixel classification) in a user-friendly high-level declarative language that provides efficient array manipulation primitives. SciQL is implemented on top of the state of the art column-store DBMS MonetDB[7], which offers capabilities for scalable querying.

We have also developed the model stRDF, an extension of the W3C standard RDF for representing time-varying geospatial data [3, 6]. The accompanying query language, stSPARQL, is an extension of the query language SPARQL 1.1 and it has been implemented in the semantic geospatial DBMS Strabon[8], which offers scalability to billions of stRDF triples [6]. In applications, such as the fire monitoring service presented here, stRDF is used to represent satellite image metadata (e.g., time of acquisition), knowledge extracted from satellite images (e.g., spatial extent of hotspots), and auxiliary geospatial data encoded as linked data (e.g., GeoNames). So, rich user queries that cannot be expressed with database technologies of EO data centers can be expressed in stSPARQL. This is illustrated in this demonstration, but also in [5] where some of the knowledge discovery techniques pioneered by TELEIOS are also discussed.

The high level vision of TELEIOS is presented in [4] while more information about its activities can be found on the Web site of the project.

3 The NOA Fire Monitoring Application

NOA operates an MSG/SEVIRI satellite acquisition station, and has developed a real-time fire hotspot detection service for effectively monitoring a fire-front. We present this service graphically in Figure 1 and explain below in some detail the improvements that we have achieved by using TELEIOS technologies.

On a regular basis (5 or 15 minutes) satellite images arrive at the acquisition station and are stored as arrays in MonetDB. The arrays are processed with a series of SciQL

[7] http://www.monetdb.org/

[8] http://www.strabon.di.uoa.gr/

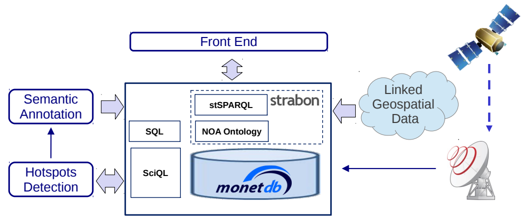

Fig. 1. The NOA fire monitoring service

queries (for cropping, georeferencing, and hotspot detection) and shapefiles describing the detected hotspots are generated for each acquisition. Because of the low spatial resolution of the SEVIRI instrument, possible errors in image georeferencing, and potential weaknesses of the algorithms in [7], the derived products have limited accuracy for specific scenarios. We increase their accuracy by combining them with linked geospatial data.

The main problem with the product accuracy is the existence of false alarms in the fire detection technique. For example, hotspots shown to be occurring in the sea or in locations with inconsistent land use (e.g., urban areas) should be considered false alarms instead of forest fire emergency situations. To query generated data using stSPARQL and combine it with linked data, we derive stRDF triples from the generated shapefiles. The derived triples mainly hold information about the coordinates of detected fire location, the date and time, and the confidence level of the detection for each hotspot. We execute stSPARQL updates which compare the hotspots with two RDF datasets and mark as false positives the hotspots that lie in the sea or in locations with inconsistent land use. The datasets that we use are: (*i*) a dataset describing the coastline of Greece, and (*ii*) a dataset describing the Greek environmental landscape. These two datasets have been published as linked data in the context of TELEIOS and are available, together with other linked data of interest to Greece, on the portal Greek Linked Open Data[9].

Another problem is spatial and temporal inconsistencies in hotspots generated by the processing chain due to using a single image acquisition and not using information from previous acquisitions. A simple heuristic we use is retrieving hotspots that were detected at least once during a specific time period (e.g., half hour) but they were not detected in the last acquisition. In this case we add a virtual hotspot for the last acquisition with a confidence level equals to the average confidence level of the real detections during the last half hour.

Finally, the need to generate added-value thematic maps is addressed. The Linked Open Data Cloud supplies an abundance of datasets, in addition to internal EO data, that cover a large variety of geospatial entities, ranging from fine-grained geometric objects like fire stations, to coarser ones like countries. So, instead of manually combining heterogeneous data, a user can pose an stSPARQL query for each layer that she wants to depict in a map and overlay the retrieved data using the ability of Strabon to expose data in KML or GeoJSON. Although this service has been designed for Greece, it can be applied to any geographic area due to the generality of the used technologies(e.g., RDF, linked data, KML).

[9] `http://www.linkedopendata.gr/`

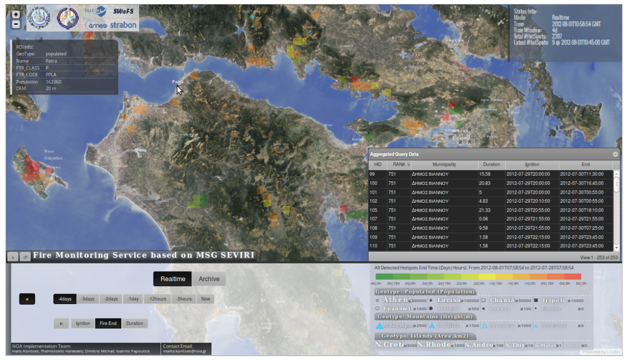

Fig. 2. The NOA fire monitoring application GUI developed in project SWeFS

4 Demonstration

The demonstration consists of three parts. First, the user will start an instance of the processing chain described above and browse its results in the GUI of the application (shown in Figure 2). The user can also use the search functionality or pose stSPARQL queries to retrieve fire products of previously executed instances of the processing chain. Second, the demonstration focuses on the improvement of the accuracy of the fire products. We will demonstrate how stSPARQL update statements and linked geospatial data are used in order to increase the accuracy of derived fire products. Finally, the creation of added-value thematic maps by combining information from different data sources will be demonstrated.

References

1. Kontoes, C., Papoutsis, I., Michail, D., Herekakis, T.: An implementation of the real-time fire monitoring application - Phase I. Deliverable D7.2, TELEIOS project (2012), available from `http://www.earthobservatory.eu/deliverables/FP7-257662-TELEIOS-D7.2.pdf`
2. Koubarakis, M., Kyzirakos, K., Karpathiotakis, M., Nikolaou, C., Vassos, S., Garbis, G., Sioutis, M., Bereta, K., Kontoes, C., Papoutsis, I., Herekakis, T., Michail, D., Manegold, S., Kersten, M., Ivanova, M., Pirk, H., Zhang, Y., Datcu, M., Schwarz, G., Dumitru, O.C., Molina, D.E., Molch, K., Giammatteo, U.D., Sagona, M., Perelli, S., Reitz, T., Klien, E., Gregor, R.: Building Remote Sensing Applications Using Scientific Database and Semantic Web Technologies. In: Proceedings of the 8th Conference on Image Information Mining (2012)
3. Koubarakis, M., Karpathiotakis, M., Kyzirakos, K., Nikolaou, C., Sioutis, M.: Data Models and Query Languages for Linked Geospatial Data. In: Reasoning Web. Semantic Technologies for Advanced Query Answering. LNCS, vol. 7487, pp. 290–328. Springer (2012)
4. Koubarakis, M., Karpathiotakis, M., Kyzirakos, K., Nikolaou, C., Vassos, S., Garbis, G., Sioutis, M., Bereta, K., Manegold, S., Kersten, M.L., Ivanova, M., Pirk, H., Zhang, Y., Kontoes, C., Papoutsis, I., Herekakis, T., Mihail, D., Datcu, M., Schwarz, G., Dumitru, O., Espinoza-Molina, D., Molch, K., Giammatteo, U.D., Sagona, M., Perelli, S., Klien, E., Reitz, T., Gregor, R.: Building virtual earth observatories using ontologies and linked geospatial data. In: RR. pp. 229–233 (2012)
5. Koubarakis, M., Sioutis, M., Kyzirakos, K., Karpathiotakis, M., Nikolaou, C., Vassos, S., Garbis, G., Bereta, K., Dumitru, O.C., Molina, D.E., Molch, K., Schwarz, G., Datcu, M.: Building

Virtual Earth Observatories using Ontologies, Linked Geospatial Data and Knowledge Discovery Algorithms. In: ODBASE (2012)
6. Kyzirakos, K., Karpathiotakis, M., Koubarakis, M.: Strabon: A Semantic Geospatial DBMS. In: Proceedings of the 11th International Semantic Web Conference (2012)
7. Sifakis, N., Iossifidis, C., Kontoes, C., Keramitsoglou, I.: Wildfire Detection and Tracking over Greece Using MSG-SEVIRI Satellite Data. Remote Sensing 3, 524–538 (2011)
8. Zhang, Y., Kersten, M.L., Ivanova, M., Nes, N.: SciQL: bridging the gap between science and relational DBMS. In: IDEAS (2011)