Worldwide AI 🌐

Greece

■ *We survey the AI research carried out in Greece recently. We concentrate on the case of linked geospatial data, an area with significant practical importance, very interesting research results, and implemented systems developed by a Greek research team.*

AI in Greece: The Case of Research on Linked Geospatial Data

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Artificial intelligence has been an active research field in Greece for over 40 years, and there are more than 30 AI groups throughout the country covering almost all subareas of AI. A milestone for AI research in Greece came in 1988, when the Hellenic Artificial Intelligence Society (EETN) was founded as a nonprofit scientific organization devoted to organizing and promoting AI research in Greece and abroad. EETN is an affiliated society of the European Association for Artificial Intelligence (EurAI, formerly known as ECCAI). One of the many roles of EETN is the organization of conferences, workshops, summer schools, and other events, such as the Hellenic Conference on Artificial Intelligence (SETN). SETN is

the most prominent forum at which Greek and international AI scientists present original and high-quality research on emerging AI topics. The first SETN was organized in 1996 at the University of Piraeus. Since 2002, the conference has been held biennially. The SETN 2016 conference was co-organized by EETN and the Aristotle University of Thessaloniki. Held in May of 2016, the conference featured presentations of high-quality AI research work (the acceptance ratio for full papers was below 33 percent). SETN 2016 also attracted international attention, with more than 120 participants from Greece and abroad joining the event. SETN 2018[1] will take place July 9–15 at the University of Patras. Aside from conferences, EETN also organizes a summer school — the Hellenic Artificial Intelligence Summer School (HAISS), which, like SETN, is held on a biennial basis.

Current Lines of AI Research in Greece

At the time of this writing, AI research is being conducted by 31 research groups affiliated with 15 Greek universities and research institutes. Many of the groups consist of large number of researchers, postgraduate students, and PhD students working on a wide variety of topics,[2] including machine learning and data mining, uncertainty in AI, natural language processing, computer vision, robotics, multiagent and agent-based systems, constraint satisfaction, planning and scheduling, and knowledge representation and reasoning. In this article, we will focus on the latter, and more specifically on linked geospatial data — an exciting domain with many applications, and one pioneered by the team of Manolis Koubarakis. But let us begin first with a quick history lesson.

Some History (1968 to Today)

Knowledge representation (KR) is an area of research in which Greece has had a strong presence for many years. This work has been greatly influenced by the work of John Mylopoulos at the University of Toronto during the 1970s and 1980s. Mylopoulos (who is also an honorary EETN member) supervised a number of students who ended up in Greek universities and spread his influence to younger students entering the AI field. Mylopoulos was especially influential in the work done at the Institute of Computer Science, Foundation of Research and Technology – Hellas (ICS-FORTH), based in Heraklion, Crete. Since 1985, Mylopoulos and the researchers at ICS-FORTH have collaborated on a number of ESPRIT projects that have a strong KR component. A core contribution of this research has been the development of the KR language Telos and its application to engineering and cultural informatics.

The arrival of the semantic web in 2001, with the visionary *Scientific American* paper written by Tim-

Berners Lee (2016 Turing Award winner), Jim Hendler, and Ora Lassila, found the Institute of Computer Science with a team well grounded in KR. That team went on to become one of the most influential teams in the European semantic web area, especially through the development of RQL, an early query language for the resource description framework (RDF). RQL has been greatly influenced by Telos, which had one of the closest representational frameworks to RDF.[3]

Manolis Koubarakis was one of the young researchers who worked, under the supervision of John Mylopoulos, on Telos. A few years after earning an MSc in computer science at the University of Toronto in 1988, Koubarakis returned to Greece and completed his PhD in constraint databases — a research area pioneered in 1990 by another Greek, the late Paris Kanellakis, a professor at Brown University. Koubarakis then went on to a career in the United Kingdom (Imperial College and University of Manchester) and in Greece, first at the Technical University of Crete and later at the National and Kapodistrian University of Athens, where he is now based. He was elected a fellow of the European Association for Artificial Intelligence (EurAI) in 2015. His Knowledge Representation, Reasoning and Analytics (KRR&A) group[4] in Athens has done lots of pioneering work on linked geospatial data, and the group constitutes a point of reference for this line of research internationally. As such, the remainder of this article will focus on surveying that work.

Linked Geospatial Data Work by the KRR&A Group (2010 – Present)

A great deal of geospatial data has recently become available at no charge in Europe and the US, and there is a strong push for more open geospatial data. This data includes data from volunteer mapping efforts such as OpenStreetMap, gazetteers such as GeoNames, national geographical data made available in government data portals,[5] and earth observation (EO) data from both the US satellite program Landsat and the Copernicus program of the European Commission.

Linked data is a research area that studies how one can make RDF data available on the web and interconnect it with other data with the aim of increasing its value. In the last few years, linked geospatial data has received a lot of attention as researchers and practitioners have started tapping the wealth of geospatial information available online. As a result, the linked open-data cloud has been rapidly populated with geospatial data.

The KRR&A group was the first international group to introduce the linked data paradigm to the EO domain, and the first such group to develop prototype applications based on transforming earth observation data into RDF and combining them with other kinds of open linked data. Examples of such
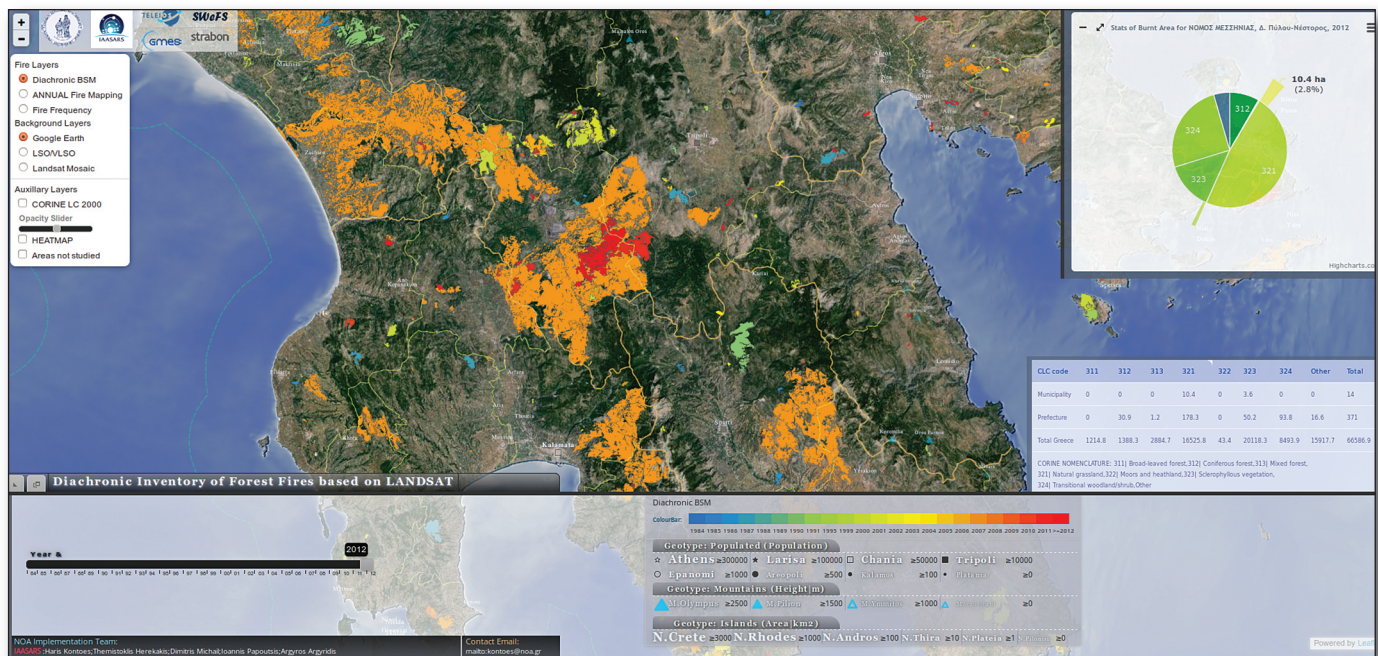
Figure 1. The FireHub Service.

applications include wildfire monitoring and burnt-scar mapping, building semantic catalogues for EO archives, precision farming, change detection using satellite images, real-time maritime situation awareness, and various environmental services. Probably the best example of an application developed by the group is the wildfire monitoring application (figure 1). The application has been available on the web since 2012, and it was the basis for the operational FireHub service deployed at the National Observatory of Athens.[6] FireHub won the Best Service Challenge in the 2014 Copernicus Masters competition.

The work of the KRR&A group that concentrated on the whole lifecycle of linked open EO data and its combination with linked geospatial data is shown in figure 2.

The technical challenges of various phases of this lifecycle have been addressed by the development of open source tools that represent today's state of the art in the area of linked geospatial data. Perhaps the most well-known is Strabon,[7] a spatiotemporal RDF store. Strabon extends the well-known RDF store Sesame and uses PostgreSQL as the backend spatially and temporally enabled DBMS. One of the query languages supported by Strabon is the Open Geospatial Consortium standard GeoSPARQL, an extension of the well-known RDF query language SPARQL with vocabulary for querying geospatial data. As shown by the experiments by Garbis, Kyzirakos, and Koubarakis (2013), Strabon is currently the most functional and performant geospatial and temporal RDF store available. Application developers who use Strabon also use GeoTriples,[8] a tool that enables

them to transform data from many popular geospatial data formats into RDF.

It is often the case that geospatial data is stored in geospatial relational databases (for example, PostGIS or SpatialLite) that are not available as linked data. When these databases are frequently updated or are very large, domain experts are discouraged from transforming the data into RDF and storing it in a triple store such as Strabon. To solve this problem, the KRR&A group developed Ontop-spatial,[9] the first geospatial ontology-based data access system. This is a very interesting contribution, especially in the light of many published papers on spatial-description logics and geospatial databases. Ontop-spatial allows domain users to leave their data in geospatial databases and enables on-the-fly GeoSPARQL-to-SQL translation using ontologies and mappings. The experimental evaluation of Ontop-spatial (Bereta and Koubarakis 2016) has shown that this approach is not only simpler for the users (because it does not require materialization of data), but also more efficient in terms of query response time when compared with state-of-the-art geospatial RDF stores such as Strabon or even commercial systems.

Another of the KRR&A group's contributions to the state of the art in visualizing geospatial and temporal linked data is development of the tool called Sextant.[10] Sextant (figure 3) is a WebGIS for linked data. It can be used to produce maps by combining geospatial data from GeoSPARQL endpoints and well-known GIS file formats.

We have summarized the progress that has been made in the last seven years by the KRR&A group in
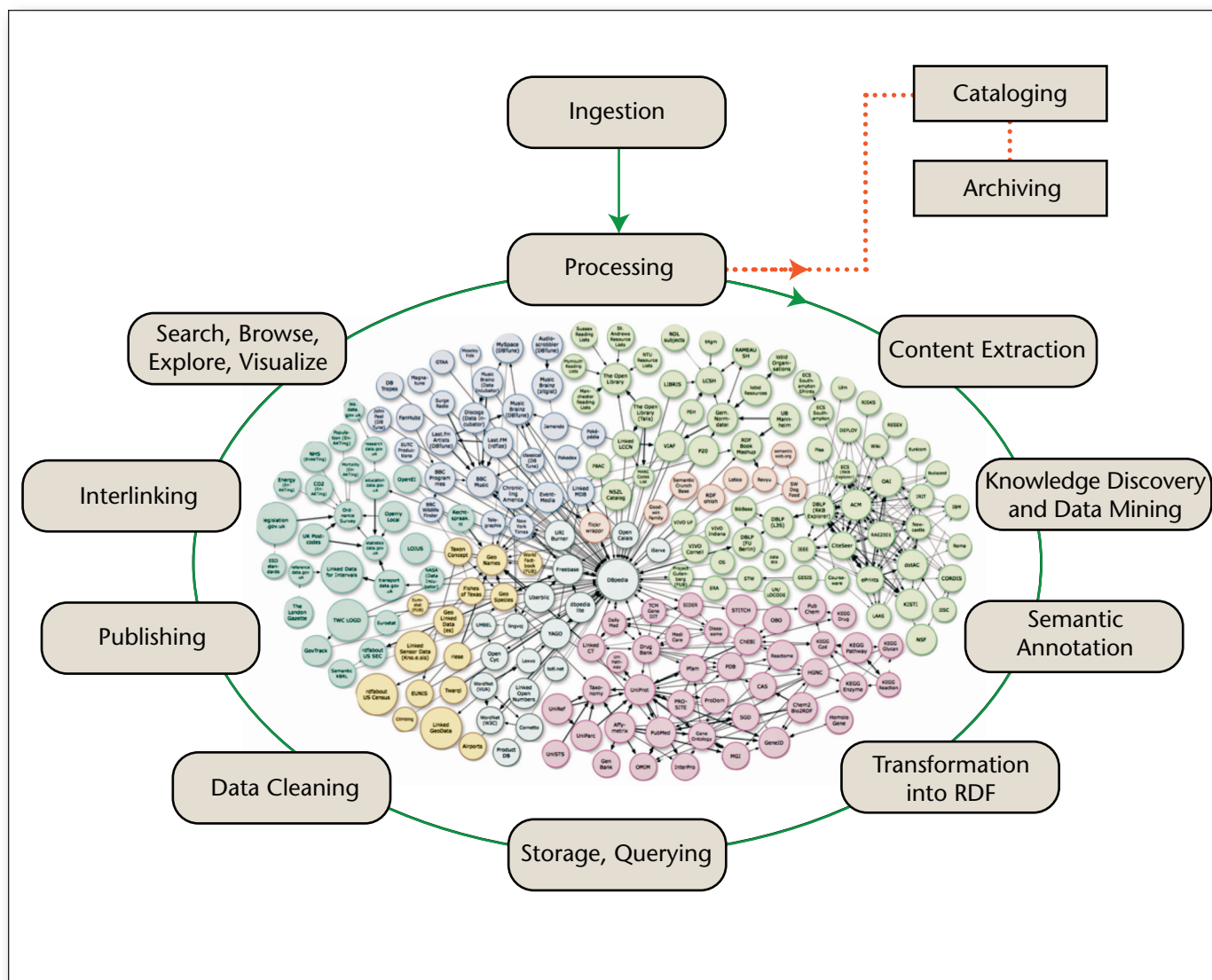
Figure 2: The Lifecycle of Linked Open EO Data.

the area of linked geospatial data. A more detailed presentation can be found in the paper by Koubarakis et al. (2017). That work has been supported generously by the European Commission through six research projects and by the Greek government through the prestigious research excellence grant ΑΡΙΣΤΕΙΑ (excellence) for Manolis Koubarakis. The current work of the group concentrates on (1) making the aforementioned tools scale to big data by utilizing big data technologies such as Apache Spark, and (2) question answering for geospatial and temporal knowledge graphs.

Conclusions

A vibrant AI research community exists in Greece, one that produces original and high-impact work such as that we have discussed. There are, however, many other ongoing AI research success stories in Greece — as evidenced by the AI research institutes with an internationally renowned research track record that operate in the country (for example, Institute of Informatics and Telecommunications at the National Centre for Scientific Research "Demokritos," and the Institute of Language and Speech Processing at the Athena Research and Innovation Center), as well as the number (5 in the last 15 years) of Greek researchers and EETN members who have been appointed EurAI fellows. EETN strives to help maintain this momentum, for example by assisting young AI researchers with scholarships to attend and present their work to AI conferences worldwide. A new institution recently launched by
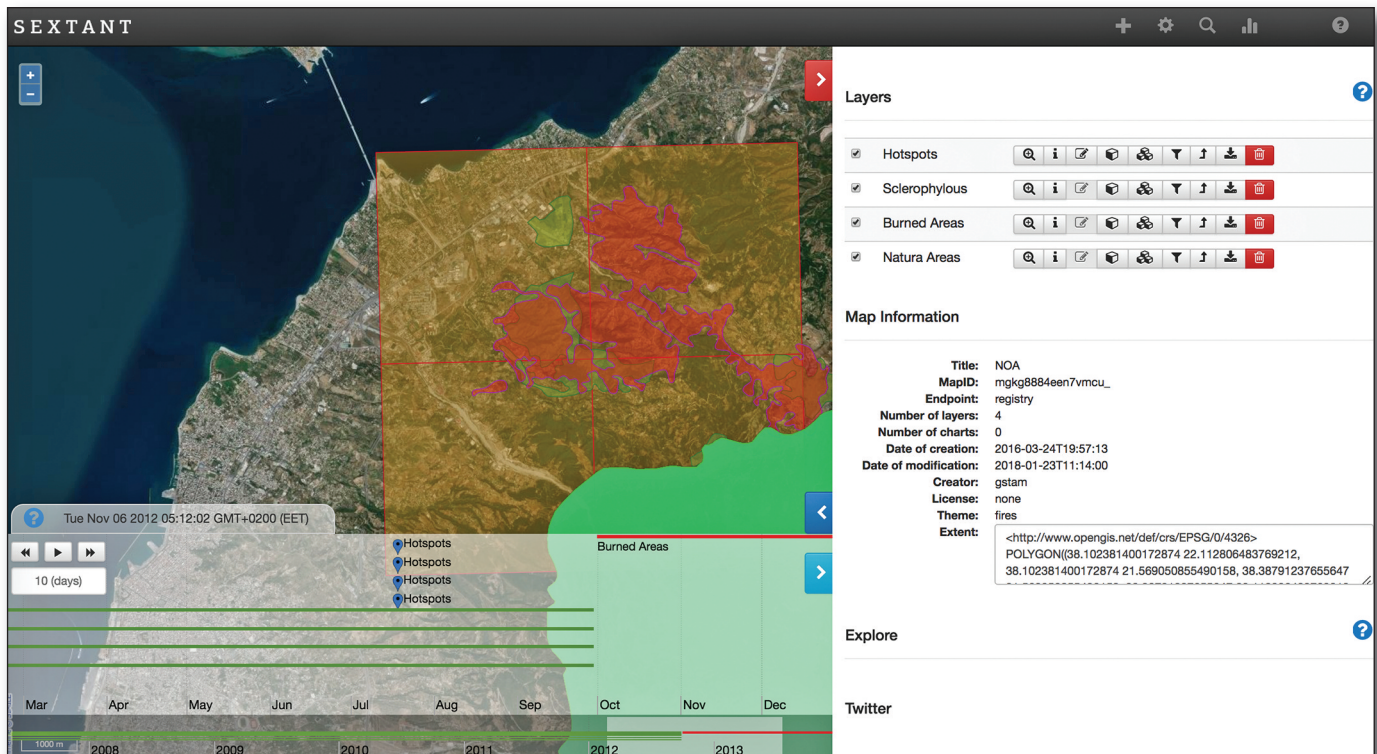
Figure 3. Visualizing a Burned Area Map with Sextant.

EETN is Technothesis, which pairs undergraduate or graduate AI students with EETN members (not necessarily located at the student's host university), who then act as scientific mentors and thesis committee members. Finally, EETN is active in popularizing Greek AI research. By co-organizing AI discussion forums, exhibitions, and competitions, EETN encourages both university and high school students to enter the AI field.

Notes

1. setn2018.upatras.gr.

2. Some research articles on topics that have been pursued by Greek AI researchers in recent years can be found at www.eetn.gr/index.php/members/research-areas-groups.

3. For a detailed discussion, readers may want to consult Chaudhri et al. (2009).

4. kr.di.uoa.gr.

5. For example, in data.gov.uk.

6. 195.251.203.238/seviri.

7. strabon.di.uoa.

8. geotriples.di.uoa.gr.

9. ontop-spatial.di.uoa.gr.

10. sextant.di.uoa.gr.

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