



Aiteam

NATIONAL & KAPODISTRIAN
UNIVERSITY OF ATHENS

Recent advances in question answering for geospatial knowledge graphs

Manolis Koubarakis

Dept. of Informatics and Telecommunications
National and Kapodistrian University of Athens

GeoLD workshop @ ESWC May 26, 2024

Talk Outline

- Geospatial knowledge graphs
- Older question answering engines
- Recent question answering engines
 - The engine of Hamzei et al. (2022)
 - GeoQA2
 - EarthQA
 - GeoQAMap
 - GeoKBQA
- Benchmark datasets for evaluating question answering engines
 - GeoQuestions201
 - GeoQuestions1089
 - The dataset of Yang et al. (2024)
- Open problems

Geospatial Knowledge Graphs

- **DBpedia** (lat/long coordinates, some cardinal directions, some topological relations implicitly)

About: Athens

An Entity of Type: [Capital_city](#), from Named Graph: [http://dbpedia.org](#), within Data Space: [dbpedia.org](#)

Athens (/'æθənз/ ATH-inz; Greek: Αθήνα, romanized: Athína [a'θina]; Ancient Greek: Ἀθῆναι, Aþēnai (pl) [aθ̄ēnai]) is both the capital and largest city of Greece. With a population close to four million, it is also the seventh largest city in the European Union. Athens dominates and is the capital of the Attica region and is one of the world's oldest cities, with its recorded history spanning over 3,400 years and its earliest human presence beginning somewhere between the 11th and 7th millennia BC.

Property **Value**

dbo_PopulatedPlace/areaMetro	• 2928.717
dbo_PopulatedPlace/areaTotal	• 38.964

www.w3.org/2003/01/geo/wgs84_pos#long



8,621,058 geoentities

About: Athens

geo:geometry • POINT(23.728055953979 37.98416519165)

geo:lat • 37.984165 (xsd:float)

geo:long • 23.728056 (xsd:float)

skos:exactMatch • [http://globalwordnet.org/ili/183036](#)

prov:wasDerivedFrom • [wikipedia-en:Athens?oldid=1124837889&ns=0](#)

foaf:depiction • [wiki-commons:Special:FilePath/10,000-meter final during the 2004 Olympics.jpg](#)
• [wiki-commons:Special:FilePath/20070523-4124-NERATZ/OTISA.jpg](#)
• [wiki-commons:Special:FilePath/2009-02-19_Yachthafen_Glyfada_03.JPG](#)
• [wiki-commons:Special:FilePath/20090801_athina04.jpg](#)
• [wiki-commons:Special:FilePath/2012-02-29_12-06-25_Greece_Athina_Soپا.jpg](#)
• [wiki-commons:Special:FilePath/20140407_athenes44.jpg](#)

Geospatial Knowledge Graphs

8,621,058 geoentities

- **Wikidata** (same as DBpedia but also geoshapes). Geoshapes encode complex geometries e.g., multipolygons.

Greece - Wikidata

wikidata.org/wiki/Q41

coordinates of westernmost point

39°41'30.5"N, 20°0'30.2"E

0 references

geoshape

Data:Greece.map

0 references

Data:Greece.map - Wikimedia

commons.wikimedia.org/wiki/Data:Greece.map

WIKIMEDIA COMMONS

Main page Welcome Community portal Village pump Help center Language select English

Participate Upload file Recent changes Latest files Random file Contact us Tools What links here Related changes Special pages Permanent link Page information

Data Discussion View Edit History Search Wikimedia Commons

Data:Greece.map

From Wikimedia Commons, the free media repository

Greece

Geospatial Knowledge Graphs

- **YAGO2** (geoentities from Wikipedia and GeoNames, lat/long coordinates only, some topological relations implicitly)

The screenshot displays the YAGO Project interface across two browser tabs. The left tab shows the entity `yago:Greece`, which is identified as a country in Southeast Europe. It includes a photo of the Acropolis and links to Graph Visualization, Wikidata, and the Official Website. The right tab shows a detailed list of properties for `yago:Greece`:

Property	Value
<code>schema:geo</code>	"Point(23 38.5)"^^ <code>geo:wktLiteral</code>
<code>schema:highestPoint</code>	<code>yago:Mount_Olympus</code>
<code>schema:humanDevelopmentIndex</code>	"0.887"^^ <code>xsd:decimal</code>
<code>schema:image</code>	"http://commons.wikimedia.org/wiki/Special:FilePath/The%20Acropolis%20and%20Mount%20Hymettus%20from%20Philopappos%20Hill%20on%20July%2018%2C%202019.jpg" ^^ <code>xsd:anyURI</code>
<code>schema:leader</code>	<code>yago:Kyriakos_Mitsotakis</code> <code>yago:Katerina_Sakellaropoulou</code>
<code>schema:location</code>	<code>yago:Balkans</code>

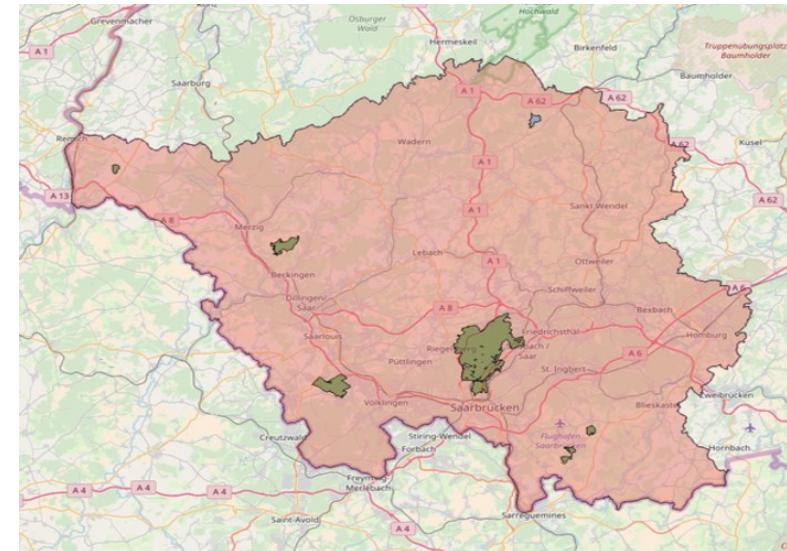
10 million geoentities

Hoffart et al. *YAGO2: A spatially and temporally enhanced knowledge base from Wikipedia*. Artif. Intell. 194: 28-61 (2013)

Geospatial Knowledge Graphs

- **YAGO2geo** (adds to YAGO2 more complex geometries from administrative geodata of Greece/UK/Ireland/USA, GADM and some OpenStreetMap features)

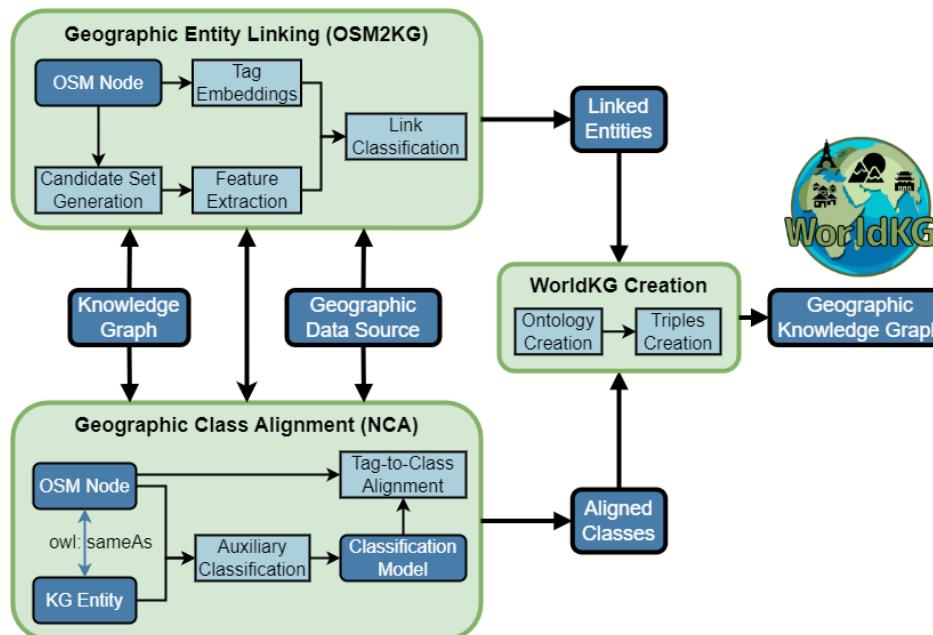
Polygons and multipolygons: 640,000
Linestrings: 137,000



Karalis et al. *Extending the YAGO2 Knowledge Graph with Precise Geospatial Knowledge*. ISWC 2019.

Geospatial Knowledge Graphs

- **WorldKG** (makes OpenStreetMap data available as a knowledge graph)



Dsouza, et al. *WorldKG: A World-Scale Geographic Knowledge Graph*. CIKM 2021.

WorldKG Statistics

Quantity	Count
Total triples	<u>828,550,751</u>
Total entities	<u>113,444,975</u>
Top-level classes	<u>33</u>
Sub-classes	<u>1,143</u>
Unique properties	<u>1,820</u>
Links to Wikidata classes	<u>40</u>
Links to DBpedia classes	<u>21</u>

Only points in the SPARQL endpoint currently.

1,224,403

In total, WorldKG covers 113,444,975 geographic entities, clearly more than Wikidata (8,621,058) and DBpedia (8,621,058). 

Geospatial Knowledge Graphs

- **KnowWhereGraph** (integrates thematic and place-centric datasets into a geospatial knowledge graph).
- Pilot scenarios in disaster relief, agricultural land use and food-related supply chains.

Multipolygons: 4,000
Polygons: 2.1 million
Linestrings: 730,000
Points: 3.9 million

Janowicz et al. *Know, Know Where, Knowwheragraph: A Densely Connected, Cross-Domain Knowledge Graph and Geo-Enrichment Service Stack for Applications in Environmental Intelligence*. AI Mag. 43(1): 30-39 (2022)

Thematic Datasets					Place-Centric Datasets		
Dataset Name/Theme	Source Agency	Key Attributes	Spatial Coverage	Temporal Coverage	Place-Centric Dataset	Defining Authority	Spatial Coverage
Soil Properties	USDA	soil type, farmland class	Targeted regions in US	Current	S2 Cells	Google	Lvl 9 (Global), Lvl 13 (US),
Wildfires	USGS, USDA, USFS, NICF	wildfire type, burn severity, num. acres burned, contained date	US	1984-current	Global Administrative Regions	University of Berkeley, Museum of Vertebrate Zoology and the International Rice Research Institute	Global
Earthquakes	USGS	magnitude, length, width, geometry	Global (mag. over 4.5)	2011-01-01 to 2022-01-18			
Climate Hazards	NOAA	injuries, deaths, property damages	US	1950–2022	US Federal Judicial District	DoJ, ESRI	US
Expert - Covid-19 Mobility	Direct Relief	name, affiliation, expertise	Global	2021			
Expert - General	KWG, UC System, DR, Semantic Scholar	name, affiliation, expertise with spatiotemporal scopes	Global	unlimited	National Weather Zones	NOAA	US
Cropland Types	USDA	crop types (raster data)	US	2008-2021	FIPS Codes	NRCS	US
Air Qual. Obs.	U.S. EPA	AQI value, CO concentration	US	1980–2022	Designated Market Area	Nielen	US
Smoke Plumes	NOAA	daily smoke plumes extent	US	2010-2022	ZIP	ZCTA	US
Climate Observations	NOAA	temperature, precipitation, PDSI, PHSI	US	1950 - 2022	Climate Division	NOAA	US
Disaster Declaration	FEMA	designated area, program, amount approved, program designated date	US	1953 - 2022	Census Metropolitan Area	US Census	US
Smoke Plume Extents	NOAA	Smoke extent	US	2017 - 2022	Drought Zone	NDMC, USDA, NOAA	US
BlueSky Forecasts	Bluesky	PM10, PM5	US	2022-03-07	Geographic Name Information System	USGS	US
Transportation (highway network)	DOT	road type, road length, road sign	US	2014			
Public Health Observations	CDC, US Census, University of Wisconsin Population Health Institute	below poverty level, diabetes, obesity, mental health provider rate, annual mammogram, vaccinated, injury death	US	2017, 2021			
Public Health Infrastructure	HIFLD	pharmacies, hospitals, dialysis centers, public health departments	US	2017 - 2022			
Social Vulnerability	CDC/ATSDR	social vulnerability index	US	2018			
Hurricane Tracks	NOAA	max wind speed, min pressure	US	1851-2020			

Older Geospatial Question Answering Engines

- Hybrid geo-spatial query methods on the semantic web with a spatially-enhanced index of DBpedia
 - Younis et al., 2012
- Template-based question answering over linked geospatial data (the engine **GeoQA**)
 - Punjani et al., 2018 and 2020
- Neural factoid geospatial question answering
 - Li et al., 2021

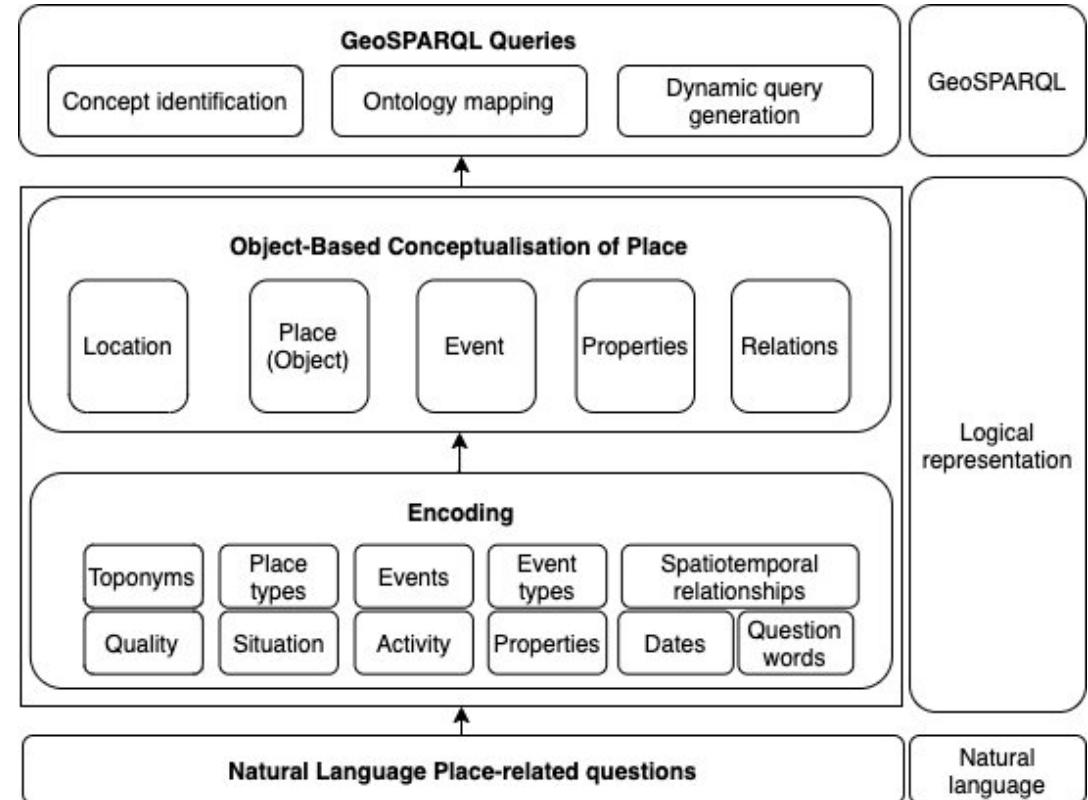


More Recent Geospatial Question Answering Engines

- The engine of Hamzei et al. (2022)
- GeoQA2
- EarthQA
- GeoQAMap
- GeoKBQA

The engine of Hamzei et al. (2022)

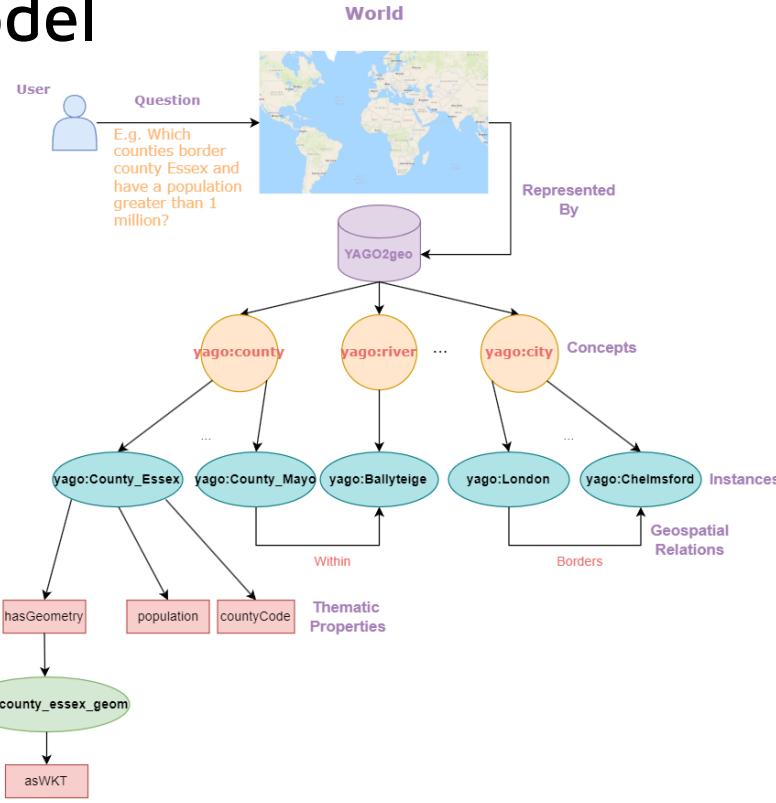
- It has a comprehensive conceptual model
- It targets an extension of the YAGO2geo knowledge graph
- It is template-based



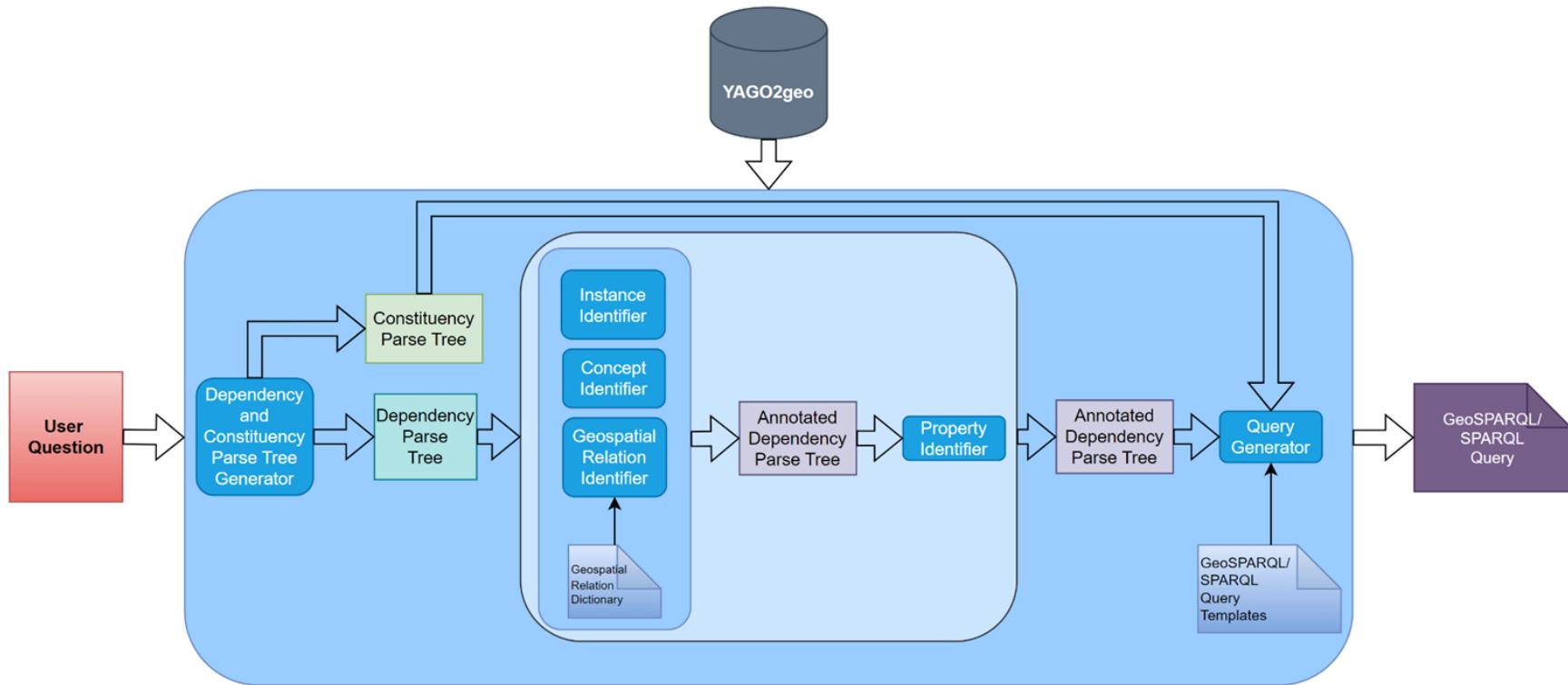
Hamzei, et al. *Translating Place-Related Questions to GeoSPARQL Queries*. The Web Conference 2022.

GeoQA2 – Conceptual Model

- It is an extension and reengineering of GeoQA.



GeoQA2 – Software Architecture



GeoQA2 - Example

- Which lakes are **in counties** that **border** with **County Mayo**?

- Instances: [yago:County_Mayo](#)
- Concepts: [y2geoo:OSI_County](#), [y2geoo:OSM_lake](#)
- Relations: [geof:sfContains](#), [geof:sfTouches](#)
- Properties: -

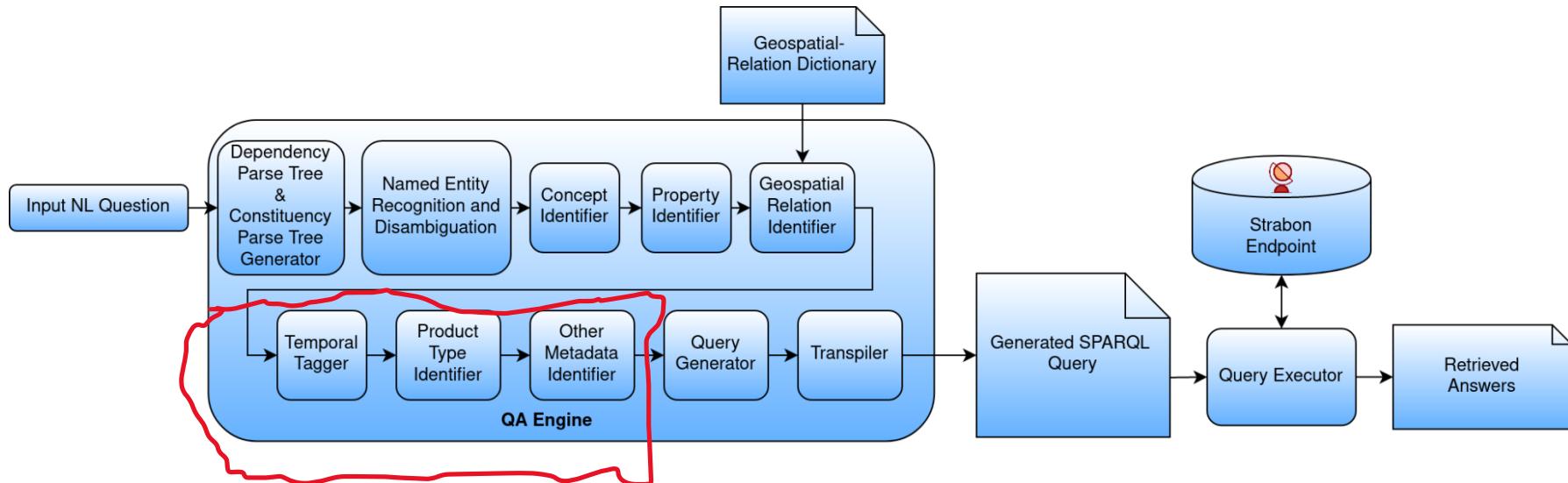


Generated GeoSPARQL Query

```
SELECT DISTINCT ?c17 WHERE {
  ?c17 a <http://kr.di.uoa.gr/yago2geo/ontology/OSI\_County>.
  ?c17 geo:hasGeometry ?cGeometry17.
  ?cGeometry17 geo:asWKT ?cWKT17.
  ?c6 a <http://kr.di.uoa.gr/yago2geo/ontology/OSM\_lake>.
  ?c6 geo:hasGeometry ?cGeometry6.
  ?cGeometry6 geo:asWKT ?cWKT6.
  <http://yago-knowledge.org/resource/County\_Mayo> geo:hasGeometry ?iGeometry1.
  ?iGeometry1 geo:asWKT ?iWKT1 .
  FILTER (geof:sfTouches (?iWKT1, ?cWKT17))
  FILTER (geof:sfContains (?cWKT17, ?cWKT6))
}
```

EarthQA

- It is a question answering engine for **Earth observation data archives**.
- It has been developed as an extension of GeoQA2.



EarthQA in Operation

EarthQA

How It Works About 🌐 🇬🇧

Find Sentinel-1 products that show Etna in March 2018

Advanced Options

Info

Generated Query. Source Query

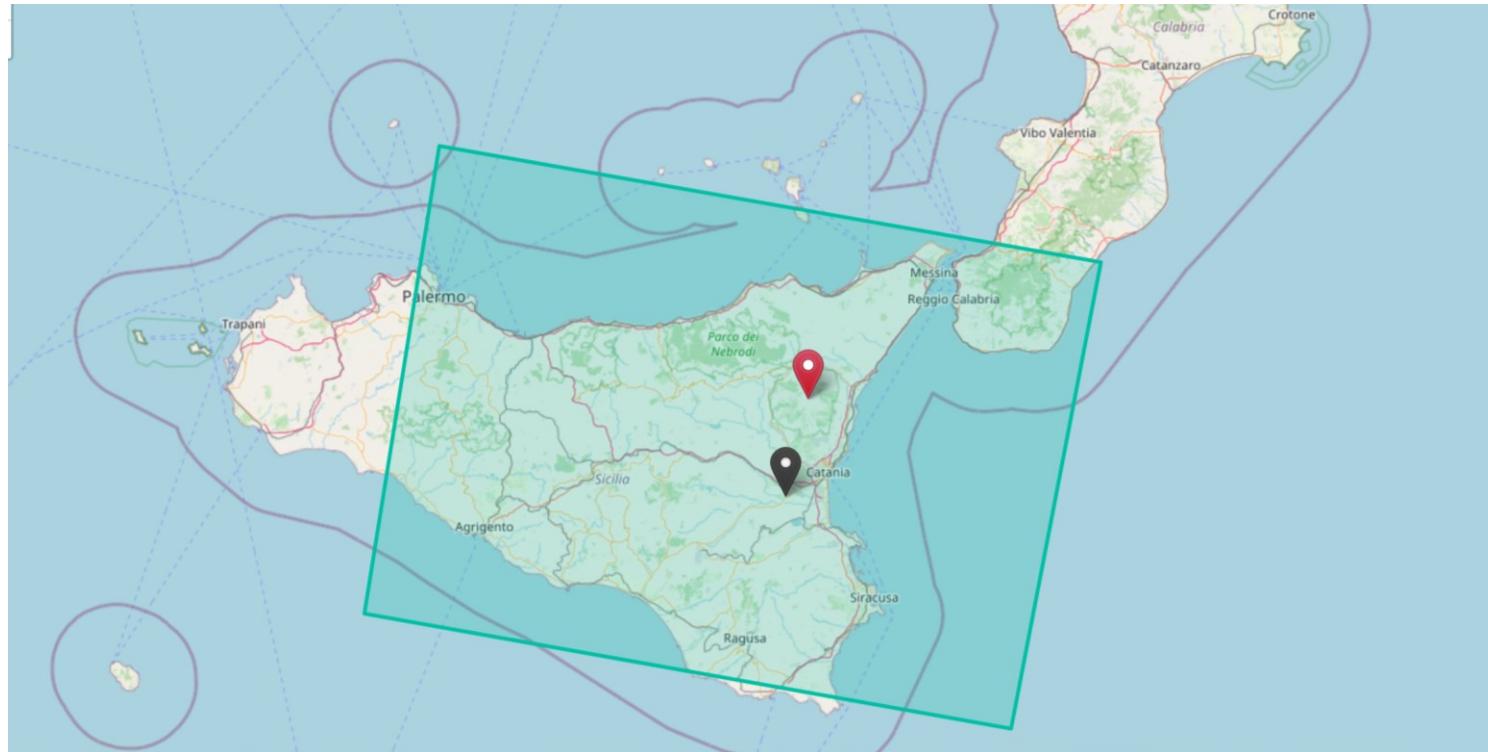
Query #1 of 1 total queries EODATA

```
select distinct ?x where { ?hex
<http://ws.creodias.eu/metadata/attribute#feature> ?x . ?hex ?pred
<http://dbpedia.org/resource/Mount_Etna> . ?x
<http://ws.creodias.eu/metadata/attribute#title> ?title . ?x
<http://ws.creodias.eu/metadata/attribute#geometry> ?geom . ?x
<http://ws.creodias.eu/metadata/attribute#bbox> ?bbox . ?x}
```

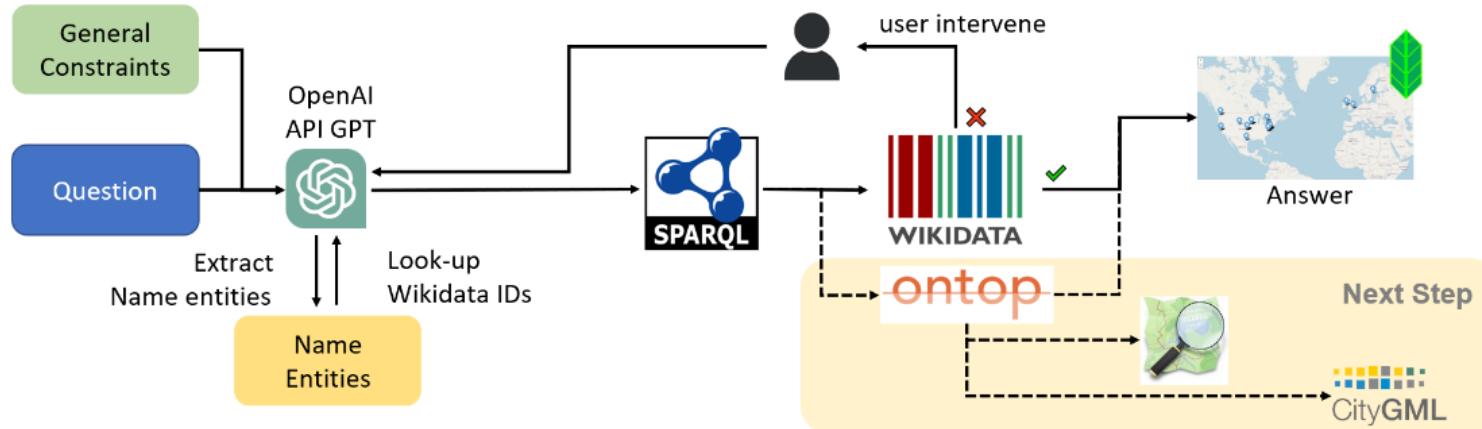
Map

+
-

EarthQA in Operation



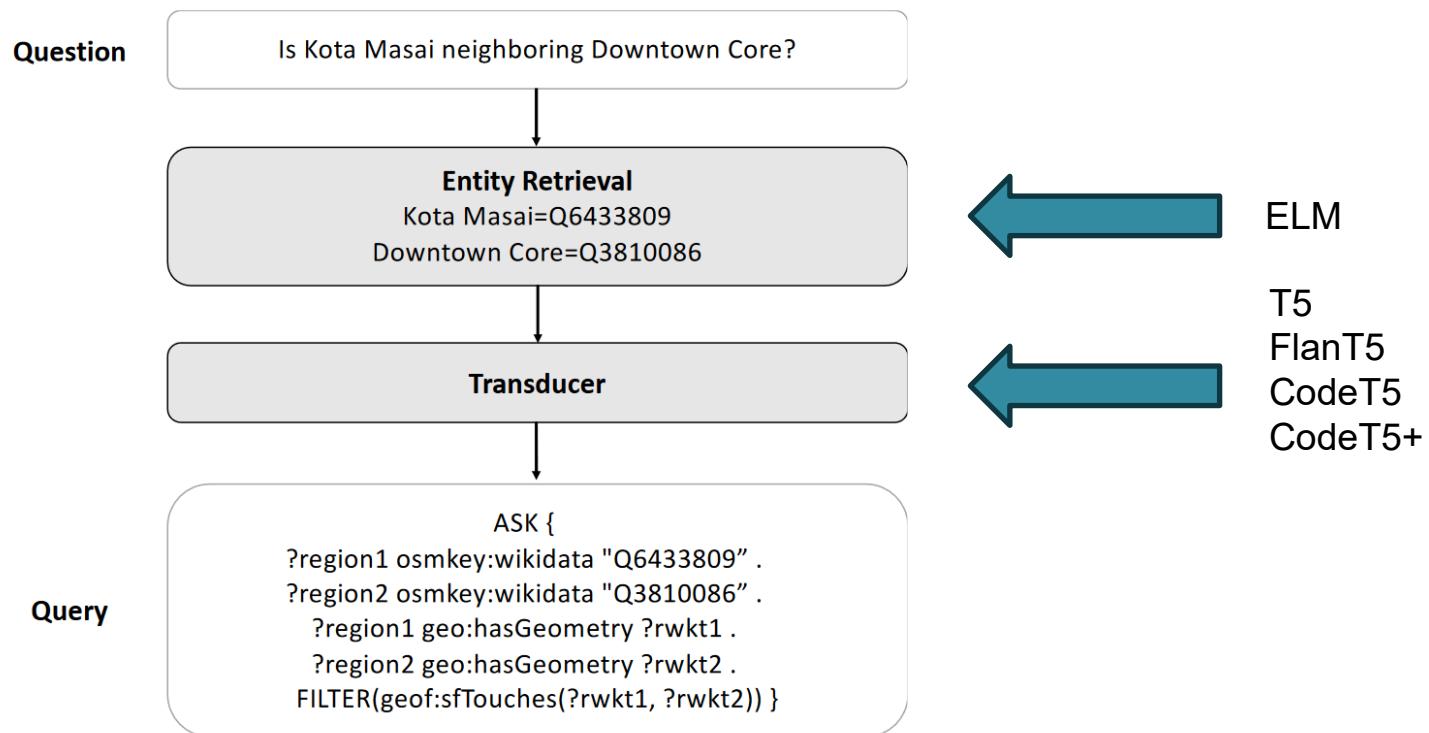
GeoQAMap



Comments

- GeoQAMap is work in progress.
- The paper (Feng et al. 2023) discusses how to deal with questions of types C and F of the benchmark GeoQuestions1089 (details later).

GeoKBQA



Comments

- A benchmark dataset for evaluation geospatial question answering engines has been constructed (details later).
- GeoKBQA uses ELM for entity recognition and disambiguation and different versions of T5 for query generation.
- No comparison with other systems is being done.

Evaluating Geospatial Question Answering Engines

- I will discuss three benchmark datasets that have been used for the evaluation of the above geospatial question answering engines:
 - GeoQuestions201
 - GeoQuestions1089
 - The dataset of Yang et al. (2024)

GeoQuestions201

- GeoQuestions201 contains 201 question-query-answer triples
- Questions crowdsourced from students
- Target knowledge graph created by interlinking:
 - DBpedia
 - OpenStreetMap (UK and Ireland)
 - Global Administrative Areas (UK and Ireland)
- Wide variety of questions
- Has been used as a gold standard to test the effectiveness of GeoQA, Li et al. (2021) and Hamzei et al. (2022).
- Available at https://geoqa.di.uoa.gr/geospatial_gold_standard.html.

The GeoQuestions1089 dataset

- **GeoQuestions1089** contains 1089 question-query-answer triples
- Questions crowdsourced from students
- Expanding on **GeoQuestions201**, in both complexity and scope
- Target knowledge graph:
 - **YAGO2**
 - **YAGO2geo** (UK, Ireland, USA and Greece)
- Available at <https://github.com/AI-team-UoA/GeoQuestions1089> .

GeoQuestions1089 categories

The questions of dataset **GeoQuestions1089** fall under the following nine categories:

- A. Asking for a thematic or a spatial attribute of a **feature**

Example:

- Where is **Loch Goil** located?
- What is the geometry of **Loch Goil** ?

GeoQuestions 1089 categories

B. Asking whether a **feature** is in a **geospatial relation** with another **feature** or **features**

Example:

- Is Liverpool **east of Ireland**?
- Is New York City **in France**?

GeoQuestions 1089 categories

C. Asking for features of a given class that are in a geospatial relation with another feature

Examples:

- Which counties border county Lincolnshire?
- Which hotels are less than 2km from George Best Belfast City Airport?

GeoQuestions 1089 categories

D. Asking for features of a given class that are in a **geospatial relation** with **any features of another class**

Example:

- Which churches are **near** castles?

GeoQuestions 1089 categories

E. Asking for features of a given class that are in a geospatial relation with unspecified features of another class, and either one or all, is/are in geospatial relation with a feature specified explicitly

another Examples:

- Which churches are near a castle in Scotland?
- In Greece, which beaches are near villages?

GeoQuestions 1089 categories

F. As in categories C, D and E above, plus more thematic and/or geospatial **attributes** of the features expected as answers

Example:

- Which mountains in Scotland are higher than 1000 meters?

GeoQuestions 1089 categories

G. Questions with **quantities** and aggregates

Examples:

- What is the total area of lakes in Oxfordshire?
- How many lakes are there in Epirus?
- How many people live in villages in Attica?

GeoQuestions 1089 categories

H. Questions with **superlatives or comparatives**

Examples:

- Which is the largest island in Greece?
- Is the largest island in France larger than Crete?

GeoQuestions 1089 categories

I. Questions with **quantities/aggregates**, and **superlatives/comparatives**

Examples:

- Which city in the UK has the most hospitals?
- Is the total size of lakes in Greece larger than lake Loch Lomond in Scotland?

Comparison to GeoQuestions201

- **GeoQuestions201:**
 - mostly simple questions that can be answered with simple queries
- **GeoQuestions1089**
 - numerous complex questions that use more advanced SPARQL constructs to be answered
 - **nested queries**
 - Which is the 10th largest town in Alaska?
 - **NOT EXISTS filters**
 - Which islands don't have any lakes but have forests?
 - **arithmetic calculations**
 - How many times bigger is the Republic of Ireland than Northern Ireland?

Using the dataset to evaluate geospatial QA engines

- We used the dataset **GeoQuestions1089** to benchmark the QA engines **GeoQA2** and the system of Hamzei et al. (2022).

Evaluation: Methodology

- Methodology and Metrics:
 - The engines generate a query from a natural language question.
 - If the generation is successful it is run against an RDF store .
 - The result is compared to the gold result included in [GeoQuestions1089](#). For the generated query to be considered correct, the results must match exactly.

Evaluation: Results

Category	Hamzei et al.			GeoQA2		
	Generated Queries	Correct Answers	Correct Answers*	Generated Queries	Correct Answers	Correct Answers*
Type-A	89.71%	10.85%	12.10%	84%	47.42%	56.45%
Type-B	95.68%	53.23%	55.63%	76.25%	58.99%	77.35%
Type-C	97.75%	30.33%	31.03%	79.21%	44.38%	56.02%
Type-D	100%	12%	12.00%	56%	12%	21.42%
Type-E	99.25%	7.40%	7.46%	80%	31.85%	39.81%
Type-F	79.16%	4.10%	5%	66.66%	16.66%	25%
Type-G	98.27%	11.49%	11.69%	74.13%	32.18%	43.41%
Type-H	97.18%	7.74%	7.97%	71.12%	26.05%	36.63%
Type-I	92%	0%	0.00%	84%	20%	23.80%
Total	95.77%	18.97%	19.81%	76.99%	38.54%	50.06%

* percentage of correct answers over the number of generated queries

Comments

- Consider the user question: “**Where is Dublin located?**”
- Questions:
 - Shall we include Dublin, Ireland?
 - Shall we include Dublin, Ohio?
 - Shall we include the Kingdom of Dublin? (https://en.wikipedia.org/wiki/Kingdom_of_Dublin)
- Answer by Hamzei et al. : Yes, and all the other Dublins that exist in the knowledge graph!
- Answer by GeoQA: only Dublin, Ireland should be included.

ChatGPT for GeoQuestions1089

- It is interesting to see whether chatbots such as ChatGPT, Gemini or Claude can answer correctly the questions of the benchmark GeoQuestions1089.

Examples

A screenshot of a web browser window titled "ChatGPT". The address bar shows the URL "chatgpt.com/c/584804bc-629c-428b-93cc-b8557a39898f". The main content area displays a conversation. A user message bubble contains the question "Is Kythira within Attica?". A response message bubble from ChatGPT begins with "No, Kythira is not within Attica. Kythira is an island located to the south of the Peloponnese peninsula in Greece, specifically situated off the southeastern tip of the Peloponnese. It is administratively part of the region of Attica, but geographically, it is not within the traditional boundaries of the Attica region, which includes the city of Athens and its surrounding area on the Greek mainland." Below the response are several small, illegible icons.

Category B question.

Correct answer.

Examples

A screenshot of a web browser window titled "ChatGPT". The URL bar shows "chatgpt.com/c/d9a85c6e-eb6f-4b92-bb5b-0a2c79672810". The main content area displays a conversation. A user message is highlighted in yellow: "Where is Kilkenny located?". The AI response is also highlighted in yellow: "Kilkenny is located in the southeast of Ireland. It is the county town of County Kilkenny and is situated along the River Nore. The city is known for its well-preserved medieval buildings and vibrant cultural scene. Kilkenny is approximately 120 kilometers (75 miles) southwest of Dublin, Ireland's capital." Below the response are several small icons for interacting with the message.

Category A question.

Partially correct answer. It would be nice to have the exact geometry of Kilkenny as well (this is what the benchmark has as answer).

Examples

ChatGPT ▾

How many lakes overlap with Greek municipalities?



In Greece, there are several lakes that overlap with municipalities. Here are some of the notable examples:

1. **Lake Trichonida** - This is the largest natural lake in Greece and it overlaps with the municipalities of Agrinio, Thermo, and Makryneia in the Aetolia-Acarnania regional unit.
2. **Lake Vegoritida** - This lake is situated in the northern part of Greece and overlaps with the municipalities of Amyntaio, Edessa, and Arnissa in the Florina and Pella regional units.
3. **Lake Prespa** - Located in the northwest, Lake Prespa overlaps with the municipalities of Prespes in the Florina regional unit and has shared borders with North Macedonia and Albania.
4. **Lake Volvi** - Found in the northern part of Greece, this lake overlaps with the municipalities of Volvi and Lagkadas in the Thessaloniki regional unit.
5. **Lake Pamvotida (Ioannina Lake)** - This lake is located in the Epirus region and overlaps with the municipality of Ioannina.
6. **Lake Orestiada** - Situated in the northwest, this lake overlaps with the municipality of Kastoria.

These examples demonstrate that several Greek lakes overlap with one or more municipalities, impacting local administration and often requiring cooperative management across municipal boundaries.

Category G
question.

Incorrect answer.

Example – Yesterday around Noon

The screenshot shows a web browser window titled "ChatGPT" with the URL "chatgpt.com/c/6c5b8c37-0f7b-43ff-be6c-fe800d3229eb". The interface includes a sidebar with a "Today" section containing a message about Corsica being smaller than Crete, and a "Previous 7 Days" section listing "Kilkenny: Located in Ireland", "User Request: Summarize conversat", and "Kythira not in Attica". The main chat area shows a user message asking if the largest island in France is larger than Crete, and ChatGPT responding that Crete is larger.

Today

Corsica smaller than Crete

Previous 7 Days

Kilkenny: Located in Ireland

User Request: Summarize conversat

Kythira not in Attica

ChatGPT

Is the largest island in France larger than Crete?

No, the largest island in France, Corsica, is not larger than Crete. Corsica has an area of approximately 8,680 square kilometers, whereas Crete has an area of around 8,336 square kilometers. Therefore, Corsica is slightly smaller than Crete.

Category H question.
Incorrect.

Example (cont'd)

The screenshot shows a ChatGPT interface in a web browser. The title bar says "ChatGPT". The address bar shows the URL "chatgpt.com/c/add989a7-67cf-4810-b9bd-dce6438bc53f". The main area has a sidebar on the left with "Today" and "Previous 7 Days" sections, and a message input field on the right.

User Message: are you sure?

ChatGPT Response: I apologize for the error. Let's correct that information:
Crete is indeed larger than Corsica. The correct areas are:

- **Crete:** Approximately 8,336 square kilometers.
- **Corsica:** Approximately 8,722 square kilometers.

Therefore, Corsica, the largest island in France, is actually smaller than Crete.

Below the message input field, there is a poll asking "Is this conversation helpful so far?" with thumbs up and thumbs down icons.

Let's Try Another Example!

The screenshot shows a ChatGPT interface in a web browser. The URL in the address bar is `chatgpt.com/c/9b6892d9-88ff-425e-ba6e-ea732cde4efd`. The main conversation area shows the following exchange:

Is the largest island of Greece larger than Cyprus?

Yes, the largest island of Greece, Crete, is larger than Cyprus.

Crete has an area of approximately 8,336 square kilometers (3,219 square miles), making it the largest Greek island and the fifth largest island in the Mediterranean Sea.

In comparison, Cyprus has an area of about 9,251 square kilometers (3,572 square miles), which makes it larger than Crete.

So, while Crete is the largest island in Greece, Cyprus is larger than Crete.

Below the conversation, there are several small icons: a person icon, a document icon, a gear icon, a question mark icon, a checkmark icon, and a lightning bolt icon.

On the left sidebar, there is a list of recent conversations:

- Today
- Crete Larger Than Cyprus
- Corsica Vs Crete
- Corsica smaller than Crete
- Previous 7 Days
- Kilkenny: Located in Ireland
- User Request: Summarize conversai
- Kythira not in Attica

At the bottom left, there is a "Upgrade plan" button with the text "Get GPT-4, DALL-E, and more". At the bottom center, there is a note: "ChatGPT can make mistakes. Check important info." and a help icon.

Let's Check Wikipedia

ChatGPT Corsica - Wikipedia

en.wikipedia.org/wiki/Corsica

MAIN ARTICLE: HISTORY OF CORSICA

Contents [hide]

(Top)

> History

> Geography

Climate

> Ecology

Demographics

Immigration

Languages

Cuisine

Art

Sport

Administration

Economy

> Transport

Politics

See also

Notes

Bibliography

Prehistory and antiquity [edit]

Main article: [Prehistory of Corsica](#)

Corsica has been occupied since the Mesolithic era. The permanent human presence in Corsica is documented in the Neolithic period from the 6th millennium BC.^[4]

After a brief occupation by the Carthaginians, colonization by the ancient Greeks, and an only slightly longer occupation by the Etruscans, it was incorporated by the Roman Republic at the end of the First Punic War and, with Sardinia, in 238 BC became a province of the Roman Republic.^[5] The Romans, who built a colony in Aléria, considered Corsica as one of the most backward regions of the Roman world. The island produced sheep, honey, resin and wax, and exported many slaves, not well considered because of their fierce and rebellious character.^[5] Moreover, it was known for its cheap wines, exported to Rome, and was used as a place of relegation, one of the most famous exiles being the Roman philosopher Seneca.^[6]

Corsica was integrated into Roman Italy by Emperor Diocletian (r. 284–305). Administratively, the island was divided into *pagi*, which in the Middle Ages became the *pievi*, the basic administrative units of the island until 1768.^[5]

Middle Ages [edit]

Main article: [Medieval Corsica](#)

In the fifth century, the western half of the Roman Empire collapsed, and the island was invaded by the Vandals and the Ostrogoths.^[5] Briefly recovered by the Byzantine Empire, it soon became part of the Kingdom of the Lombards. This made it a dependency of the March of Tuscany, which used it as an outpost against the Saracens.^[7] Pepin the Short, king of the Franks and Charlemagne's father, exiled the Lombards and nominally granted Corsica to



Location of Corsica within France

Country	France
Prefecture	Ajaccio
Departments	2 Corse-du-Sud (2A) Haute-Corse (2B)
Government	Gilles Simeoni (Femu a Corsica) Marie-Antoinette Maupertuis Amaury de Saint-Quentin
Area	Total 8,722 km ² (3,368 sq mi)
Population	(2024) ^[1] Total 355,528 Density 41/km ² / 110/sq mi

Let's Check Wikipedia

ChatGPT W Crete - Wikipedia

en.wikipedia.org/wiki/Crete

Contents hide

(Top)

Name

Physical geography and climate

Human geography

History

Tourism

Fauna and flora

Mythology

Culture

Notable people

See also

References

General and cited sources

External links

ISLAND IN THE MEDITERRANEAN SEA, after Sicily, Sardinia, Cyprus, and Corsica. Crete lies about 160 km (99 mi) south of the Greek mainland, and about 100 km (62 mi) southwest of Anatolia. Crete has an area of 8,450 km² (3,260 sq mi) and a coastline of 1,046 km (650 mi). It bounds the southern border of the Aegean Sea, with the Sea of Crete (or North Cretan Sea) to the north and the Libyan Sea (or South Cretan Sea) to the south. Crete covers 260 km from west to east but is narrow from north to south, spanning three longitudes but only half a latitude.

Crete and a number of islands and islets that surround it constitute the Region of Crete (Greek: Περιφέρεια Κρήτης), which is the southernmost of the 13 top-level administrative units of Greece, and the fifth most populous of Greece's regions. Its capital and largest city is Heraklion, on the north shore of the island. As of 2021, the region had a population of 624,408.^[4] The Dodecanese are located to the northeast of Crete, while the Cyclades are situated to the north, separated by the Sea of Crete. The Peloponnese is to the region's northwest.

Crete was the center of Europe's first advanced civilization, the Minoans, from 2700 to 1420 BC. The Minoan civilization was overrun by the Mycenaean civilization from mainland Greece. Crete was later ruled by Rome, then successively by the Byzantine Empire, Andalusian Arabs, the Venetian Republic, and the Ottoman Empire. In 1898 Crete, whose people had for some time wanted to join the Greek state, achieved independence from the Ottomans, formally becoming the Cretan State. Crete became part of Greece in December 1913.

The island is mostly mountainous, and its character is defined by a high mountain range crossing from west to east. It includes Crete's highest point, Mount Ida, and the range of the White Mountains (Lefka Ori) with 30 summits above 2,000 metres (6,600 ft) in altitude and the Samaria Gorge, a World Biosphere Reserve. Crete forms a significant part of the economy and cultural heritage of Greece, while retaining its own local cultural traits (such as its own poetry and music). The Nikos Kazantzakis airport at Heraklion and the Daskalogiannis airport at Chania serve international travelers. The Minoan palace at Knossos is also located in Heraklion.^[5]



NASA photograph of Crete



Geography

Location	Eastern Mediterranean
Coordinates	35°12.6'N 24°54.6'E
Area	8,450 km ² (3,260 sq mi)
Area rank	88
Highest elevation	2,456 m (8058 ft)
Highest point	Mount Ida (Psiloritis)

Let's Check Wikipedia

ChatGPT

W Cyprus - Wikipedia

en.wikipedia.org/wiki/Cyprus

Contents hide

(Top)

Etymology

> History

> Geography

> Government and politics

> Economy

> Demographics

> Culture

See also

References

External links

led to the capture of the present-day territory of Northern Cyprus and the displacement of over 150,000 Greek Cypriots^{[24][25]} and 50,000 Turkish Cypriots.^[26] A separate Turkish Cypriot state in the north was established by unilateral declaration in 1983; the move was widely condemned by the international community, with Turkey alone recognising the new state. These events and the resulting political situation are matters of a continuing dispute.

Cyprus is a major tourist destination in the Mediterranean.^{[27][28][29]} The country has an advanced high-income economy. The Republic of Cyprus has been a member of the Commonwealth since 1961 and was a founding member of the Non-Aligned Movement until it joined the European Union on 1 May 2004.^[30] On 1 January 2008, the Republic of Cyprus joined the eurozone.^[31]

Etymology

The earliest attested reference to Cyprus is the 15th century BC Mycenaean Greek κύπριος, *ku-pi-ri-jo*,^[32] meaning "Cypriot" (Greek: Κύπριος), written in Linear B syllabic script.^[33] The classical Greek form of the name is Κύπρος (*Kýpros*).

The etymology of the name is unknown. Suggestions include:

- the Greek word for the Mediterranean cypress tree (*Cupressus sempervirens*), κυπάρισσος (*kypárrisos*)
- the Greek name of the henna tree (*Lawsonia alba*), κύπρος (*kýpros*)
- an Eteocypriot word for copper. It has been suggested, for example, that it has roots in the Sumerian word for copper (*zubar*) or for bronze (*kubar*), from the large deposits of copper ore found on the island.^[34]

Through overseas trade, the island has given its name to the Classical Latin word for copper

Vernaculars	Cypriot Greek • Cypriot Turkish
Ethnic groups	Greek Cypriots Turkish Cypriots Armenian Cypriots Maronite Cypriots
Religion (2020; including Northern Cyprus)	72.3% Christianity 25.0% Islam 1.9% no religion 0.8% other ^[2]
Demonym(s)	Cypriot
Government	Unitary presidential republic <ul style="list-style-type: none">President Nikos ChristodoulidesVice-President Vacant^[b]President of the House of Representatives Anita Demetriou
Legislature	House of Representatives
Independence from the United Kingdom	
• London-Zürich Agreements	19 February 1959
• Independence proclaimed	16 August 1960
• Independence Day	1 October 1960
• Joined the EU	1 May 2004
Area	
• Total ^[c]	9,251 km ² (3,572 sq mi) (162nd)
• Water (%)	0.11 ^[3]

<https://en.wikipedia.org/wiki/Cyprus#>

Example (cont'd) - 18:28 yesterday

The screenshot shows a ChatGPT interface in a web browser. The title bar says "ChatGPT". The URL bar shows the session ID: "chatgpt.com/c/c4aebc3e-9a68-4d3c-8710-1d927154e780". The main area has a sidebar on the left with links like "Today", "Largest French island: Corsica.", "Crete Larger Than Cyprus", "Corsica Vs Crete", "Corsica smaller than Crete", "Previous 7 Days", "Kilkenny: Located in Ireland", "User Request: Summarize conversat", and "Kythira not in Attica". The main chat area has a message from the user: "Is the largest island of France larger than Crete?". ChatGPT responds: "Yes, the largest island of France, Corsica, is larger than Crete. Here are the details:

- **Corsica:** It has an area of approximately 8,680 square kilometers.
- **Crete:** It has an area of approximately 8,336 square kilometers.

Therefore, Corsica is indeed larger than Crete." At the bottom, there's a feedback box: "Is this conversation helpful so far? Like Dislike X".

Example (cont'd) – 18:30 yesterday

The screenshot shows a ChatGPT interface in a web browser. The title bar says "ChatGPT". The URL bar shows "chatgpt.com/c/355b4b39-8b9d-4820-96cc-111c5706063f". The main area has a sidebar on the left with a list of previous messages: "Today" (Crete Larger than Cyprus, ...), "Largest French island: Corsica.", "Crete Larger Than Cyprus", "Corsica Vs Crete", "Corsica smaller than Crete", "Previous 7 Days" (Kilkenny: Located in Ireland), "User Request: Summarize conversat", and "Kythira not in Attica". The main content area shows a message from ChatGPT: "Yes, the largest island of Greece, Crete, is larger than Cyprus. Here are the specifics:

- **Crete:** The largest island of Greece, with an area of approximately 8,336 square kilometers.
- **Cyprus:** An independent country and an island in the eastern Mediterranean Sea, with an area of about 9,251 square kilometers.

Therefore, Cyprus is actually larger than Crete." At the bottom, there's a feedback box asking "Is this conversation helpful so far?" with upvote, downvote, and close buttons.

In Case you are Wondering ☺

The screenshot shows a ChatGPT interface in a web browser. The URL in the address bar is chatgpt.com/c/355b4b39-8b9d-4820-96cc-111c5706063f. The sidebar on the left lists previous conversations: "Crete Larger than Cyprus", "Largest French island: Corsica.", "Crete Larger Than Cyprus", "Corsica Vs Crete", "Corsica smaller than Crete", "Previous 7 Days", "Kilkenny: Located in Ireland", "User Request: Summarize conversat", and "Kythira not in Attica". The main chat area shows a user question: "Which are the five largest islands in the Mediterranean?" followed by a response from ChatGPT: "The five largest islands in the Mediterranean Sea are:

1. Sicily (Italy) - Approximately 25,711 square kilometers.
2. Sardinia (Italy) - Approximately 24,090 square kilometers.
3. Cyprus (Independent country) - Approximately 9,251 square kilometers.
4. Corsica (France) - Approximately 8,741 square kilometers.
5. Crete (Greece) - Approximately 8,336 square kilometers.

". Below the response are several small icons for audio, file, reply, and other functions.

Results

Category	Correctly Answered	Partially Correctly Answered
Category A	15.4%	59.4%
Category B	61.4%	0%
Category C	31.3%	51.1%
Category D	23.8%	52.4%
Category E	18.8%	63%
Category F	4%	8%
Category G	6.3%	3.4%
Category H	38.7%	0%
Category I	4%	0%
Total	22.6%	26.4%

Let's Try Gemini!

The screenshot shows a web browser window for the Gemini app at gemini.google.com/app/2e072d7041e2422e. The interface includes a sidebar with a menu icon, a search bar, and a user profile icon. The main area displays a conversation between a user and Gemini. The user asks, "Is the largest island of France larger than Crete?" Gemini responds with a detailed answer, mentioning Corsica's area of approximately 8,680 square kilometers and Crete's area of around 8,330 square kilometers, concluding that Corsica is larger by about 350 square kilometers. Below the conversation, there's a prompt input field with a microphone icon and a note about Gemini's privacy policy.

Gemini

gemini.google.com/app/2e072d7041e2422e

Gemini ▾

See the latest updates to the [Gemini Apps Privacy Hub](#)

Is the largest island of France larger than Crete?

The largest island of France is Corsica, with an area of roughly 8,680 square kilometers [Wikipedia list of islands of France].

Crete, on the other hand, boasts an area of around 8,330 square kilometers [Wikipedia Crete].

Therefore, Corsica is indeed larger than Crete by approximately 350 square kilometers.

Enter a prompt here

Gemini may display inaccurate info, including about people, so double-check its responses. [Your privacy and Gemini Apps](#)

Let's Try Gemini!

The screenshot shows a web browser window titled "Gemini" with the URL "gemini.google.com/app/2e072d7041e2422e". The main content area is titled "Gemini" and features a dark blue banner at the top with the text "See the latest updates to the [Gemini Apps Privacy Hub](#)". Below the banner, a user profile picture and the question "Is the largest island of Greece larger than Cyprus?". To the right are buttons for "Show drafts" and a microphone icon. The response starts with a blue diamond icon and the text "Yes, the largest island of Greece, Crete, is larger than Cyprus." followed by two bulleted facts about their sizes. A note below states that despite Cyprus having a higher numerical value, Crete is geographically bigger due to its complex political situation. At the bottom, there is a prompt input field "Enter a prompt here" with a microphone icon and a plus sign icon, and a footer note about privacy.

Gemini

gemini.google.com/app/2e072d7041e2422e

Gemini

Try Gemini Advanced

See the latest updates to the [Gemini Apps Privacy Hub](#)

Is the largest island of Greece larger than Cyprus?

Show drafts

Yes, the largest island of Greece, Crete, is larger than Cyprus.

- Crete has an area of approximately 8,312 square kilometers [Wikipedia List of European islands by area].
- Cyprus has an area of roughly 9,251 square kilometers [Wikipedia List of European islands by area].

Even though Cyprus has a higher number, Crete is geographically bigger. There might be some confusion because the political situation in Cyprus is complex, with a portion being claimed by Turkey.

Enter a prompt here

Gemini may display inaccurate info, including about people, so double-check its responses. [Your privacy and Gemini Apps](#)

The Dataset of Yang et al. (2024)

- It was created as part of the GeoKBQA engine work.
- It starts from GeoQuestions1089 and:
 - Reorganizes the GeoQuestions1089 classes based on their corresponding GeoSPARQL queries to create templates that will be used for question generation.
 - Substitutes entities, classes, and spatial functions to augment the diversity of schema items and spatial functions, and to expand the scale of the dataset.
 - Paraphrases the resulting geospatial questions using ChatGPT (GPT-3.5 Turbo) to enhance natural language diversity.
 - Selects question–query pairs based on successful queries to the OpenStreetMap database, choosing pairs that yield results.
- 4468 question-query pairs are generated in this way.

Example

[Step 1]

Which [class] [spatial_nl] [region]?

```
PREFIX geof: <http://www.opengis.net/def/function/geosparql/>
PREFIX osmkey: <https://www.openstreetmap.org/wiki/Key>
PREFIX osm: <https://www.openstreetmap.org/>
PREFIX geo: <http://www.opengis.net/ont/geosparql#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX strdf: <http://strdf.di.uoa.gr/ontology#>
```

```
SELECT DISTINCT ?class WHERE {
?region1 osmkey:wikipedia "[wikidata]" .
?region1 geo:hasGeometry ?rwkt1 .
?class osmkey: "[osmkeyType]" .
?class geo:hasGeometry ?cwk1 .
FILTER(?spatial_query(?rwkt1, ?cwk1))
}
```

[class]

[Class] – [Osmkey] – [OsmKeyType]
school – osmkey:amenity – school
park – osmkey:amenity – park
hotel – osmkey:amenity – hotel
Hospital – osmkey:amenity – hospital
college – osmkey:amenity – college
mosque – osmkey:amenity – mosque
river – osmkey:waterway – river
island – osmkey:place – island
university – osmkey:amenity – university
...

Substitution list
[spatial_nl]

(spatial_nl) – (spatial_query)
intersects – geo:sIntersects
Neighbours – geo:sTouches
Borders – geo:sTouches
exist in – geo:sWithin
Crosses – geo:sCrosses
next to – geo:sTouches
adjacent to – geo:sTouches
are contained in – geo:sContains

[region]

[Region] – [Wikid]
Downtown Core - Q3810086
Loyang - Q2160488
Taman Ungku Tun Aminah - Q7680664
Marina South - Q10605488
Kallang - Q4216446
Tampoi - Q1151281
Jurong East - Q1714023
...

[Step 2]

Which road cross Jurong Island?

```
PREFIX geof: <http://www.opengis.net/def/function/geosparql/>
PREFIX osmkey: <https://www.openstreetmap.org/wiki/Key>
PREFIX osm: <https://www.openstreetmap.org/>
PREFIX geo: <http://www.opengis.net/ont/geosparql#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX strdf: <http://strdf.di.uoa.gr/ontology#>
```

```
SELECT DISTINCT ?class WHERE {
?region1 osmkey:wikipedia "'Q14439130'" .
?region1 geo:hasGeometry ?rwkt1 .
?class osmkey:route "road" .
?class geo:hasGeometry ?cwk1 .
FILTER(?geo:sCrosses(?rwkt1, ?cwk1))
}
```

[Step 3]

Which road cross Jurong Island?
Can you tell me which road crosses Jurong Island?
What road crosses Jurong Island?

```
PREFIX geof: <http://www.opengis.net/def/function/geosparql/>
PREFIX osmkey: <https://www.openstreetmap.org/wiki/Key>
PREFIX osm: <https://www.openstreetmap.org/>
PREFIX geo: <http://www.opengis.net/ont/geosparql#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX strdf: <http://strdf.di.uoa.gr/ontology#>
```

```
SELECT DISTINCT ?class WHERE {
?region1 osmkey:wikipedia "'Q14439130'" .
?region1 geo:hasGeometry ?rwkt1 .
?class osmkey:route "road" .
?class geo:hasGeometry ?cwk1 .
FILTER(?geo:sCrosses(?rwkt1, ?cwk1))
}
```

ChatGPT

Results

- The dataset is used to evaluate GeoKBQA targeting OpenStreetMap data of Singapore. The results are the following:

	T5 Base Model (220M)		T5 Large Model (770M)	
	ELQ	Golden	ELQ	Golden
T5	51.7857	71.6518	75.8929	79.0179
FLAN-T5	62.2768	73.4375	78.5714	80.5804
CodeT5	84.375	83.4821	91.5179	92.6339
CodeT5+	93.3036	92.4107	93.0804	94.1964

Open Problems

- Answering **spatiotemporal questions** over knowledge graphs
- Example: What are today the names and borders of the countries that made up Yugoslavia in 1991? Show the borders on a map.
- Question: are there spatiotemporal knowledge graphs (i.e., graphs that show the evolution of spatial regions over time)?
 - **GeoChangeViz.** See https://ceur-ws.org/Vol-3632/ISWC2023_paper_423.pdf

Open Problems

- Utilizing existing large language models in geospatial question answering engines (e.g., detect query intent, improve GeoSPARQL query generation etc.).

Open Problems

- Investigating whether current LLMs can do spatial reasoning
 - Cohn et al. (2023) <https://arxiv.org/abs/2304.11164>
 - Anthony Cohn (2023) <https://arxiv.org/abs/2309.15577>

Open Problems

- Developing foundation models for geodata and use them for toponym and location recognition and disambiguation, entity resolution, spatial reasoning, question answering etc.
 - Mai et al. (2023) <https://arxiv.org/abs/2304.06798>
 - Balsebre et al. (2024) <https://arxiv.org/abs/2403.09059>

Advertisement – European Summer School in AI 2024

- Takes place in Athens
 - July 15 to 26, 2024 (2 weeks)
 - 30 week-long courses
 - 11 two hour long advanced tutorials
 - EurAI travel grants covering registration are available
-
- Visit <https://essai2024.di.uoa.gr/> for more!



Thank you!

Visit the web page of my group: <https://ai.di.uoa.gr/>
Follow us on twitter @AITeamUoA, @mkoubarakis

