

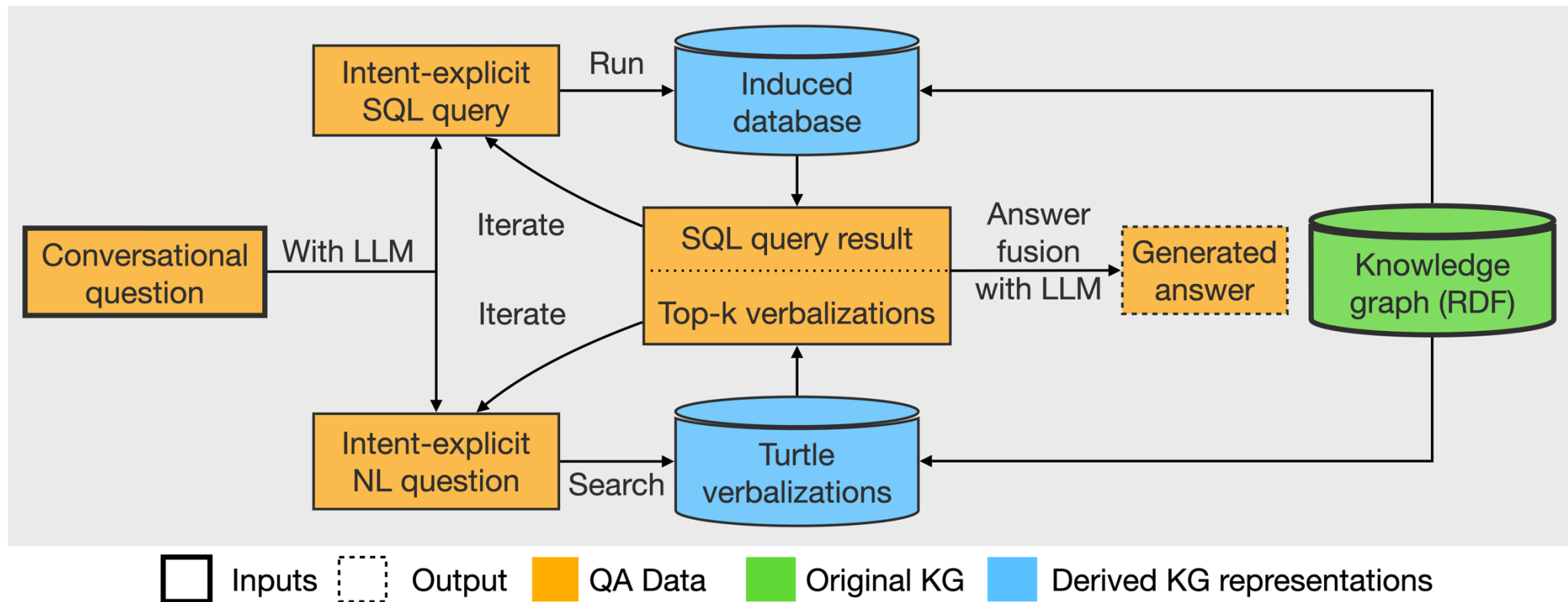
RAGONITE: Iterative Retrieval on Induced Databases and Verbalized RDF for Conversational QA over KGs with RAG

Rishiraj Saha Roy, Chris Hinze, Joel Schlotthauer, Farzad Naderi, Viktor Hangya, Andreas Foltyn, Luzian Hahn, and Fabian Kuech

Key idea: Make the most of your knowledge graph with RAGONITE!

Retrieval augmented generation for conversational question answering over knowledge graphs

- Traditional question answering over knowledge graphs with SPARQL only satisfies fact lookups
- Fusing** SQL results over **induced databases** and text search over **RDF verbalizations** unifies lookups, abstract and complex intents on KGs



Overview of novel KG-QA pipeline

Motivation and approach

- **Conversational question answering** with implicit **follow-up questions** most natural way of information access over **KGs**
- **KGs** store **vital knowledge** but primarily used for storage and **lookup** of facts (via SPARQL-like languages)
- Limitations
 - Information contained in KGs can be harnessed **for much more**
 - **SPARQL** generation via LLMs a **bottleneck**
- We propose **unified framework** for harvesting information in KGs
 - **Lookups** (*cost of 530e m sport saloon?*)
 - **Complex** intents, including **math** (*charging time of 225e Active Tourer less than avg over all bmws?*)
 - **Abstract** intents (*luxury features in x5?*)
- Achieved via **two-pronged pipeline** fusing **structured** and **unstructured** retrieval
 - Structured retrieval via SQL tackles **lookups and complex math**
 - Unstructured retrieval tackles lookups and **abstract NL intents**
- Retrieval tools can be invoked for **multiple iterations**

Highlights in RAGONITE

Novel pipeline for unified IR over KGs

- Automated database induction
- Knowledge graph verbalization
- Iterative retrieval
- Branch integration
- Open LLM support
- Scope for heterogeneous QA

Automated database induction

Programmatic KG to DB conversion

- Original KG in RDF format
- Converted to a DBMS for harnessing SQL capabilities (Li et al. 2023)
 - More capable than SPARQL at math, user-defined functions, ...
 - LLMs better at SQL generation than SPARQL
- Database consists of tables like car, engines, fuels, equipment, ...
- Key steps
 - Inducing schema
 - Inserting data
 - Enhancing semantics

1. Knowledge graph represented as encapsulated Turtle facts

```
<http://is.fraunhofer.de/bmw/instance/bmw-ix3> a ns1:Car,
  ns1:CarModel,
  ns1:Product,
  ns1:Vehicle;
ns1:fuelType <http://ais.fraunhofer.de/bmw/instance/fuel-type/fullElectric>;
ns1:name "BMW iX3";
ns1:price "65160";
rdfs:label "BMW iX3";
ns1:url <https://www.bmw.co.uk/en/all-models/x-models/ix3/2021/bmw-ix3-highlights.html>.

<http://is.fraunhofer.de/bmw/instance/bmw-ix-m60> a ns1:Car,
  ns1:CarModel,
  ns1:Product,
  ns1:Vehicle;
ns1:fuelType <http://ais.fraunhofer.de/bmw/instance/fuel-type/fullElectric>;
ns1:length "4,953 mm";
ns1:name "BMW iX M60";
ns1:price "124605";
rdfs:label "BMW iX M60";
ns1:url <https://www.bmw.co.uk/en/all-models/m-models/ix-m60/2021/bmw-ix-m60-highlights.html>.

<http://is.fraunhofer.de/bmw/instance/fuel-type/fullElectric> a ns1:FuelType;
ns1:name "fullElectric".

<http://ais.fraunhofer.de/bmw/instance/bmw-3-series-saloon-m-models> a ns1:Car,
  ns1:CarModel,
  ns1:Product,
  ns1:Vehicle;
rdfs:label "BMW 3 Series Saloon M models";
ns1:equipment <http://is.fraunhofer.de/bmw/instance/equipment/Ambient%20interior%20lighting>,
  <http://is.fraunhofer.de/bmw/instance/equipment/HiFi%20loudspeaker%20system>,
  <http://is.fraunhofer.de/bmw/instance/equipment/LED%20headlights%20and%20LED%20rear%20lights>;
ns1:identifier "bmw-3-series-saloon-m-models";
ns1:name "BMW 3 Series Saloon M models";
```

2a. Automatically induced database from Turtle RDF "capsules"

Table: Car_CarModel_Product_Vehicle

id	fuelType	name	price	label	length	url
instance/bmw-ix3	instance/fuel-type/fullElectric	BMW iX3	65160	BMW iX3	NULL	https://www...
instance/bmw-ix-m60	instance/fuel-type/fullElectric	BMW iX M60	124605	BMW iX M60	4,935 mm	https://www...
...

Table: FuelType

id	name
instance/fuel-type/fullElectric	fullElectric
...	...

```
CREATE TABLE Car_CarModel_Product_Vehicle (
  id TEXT PRIMARY KEY,
  fuelType TEXT NOT NULL,
  name TEXT NOT NULL,
  price INTEGER NOT NULL,
  label TEXT NOT NULL,
  length TEXT,
  url TEXT NOT NULL,
  FOREIGN KEY (fuelType) REFERENCES FuelType(id)
)
```

```
CREATE TABLE FuelType (
  id TEXT PRIMARY KEY,
  name TEXT NOT NULL
)
```

Derived schema after incorporating manual annotations
(renaming tables and columns, dropping redundant columns,
removing units from raw values and adding comments to columns)

Table: base_car

baseCarId	fuelTypeId	name	price	length	url
instance/bmw-ix3	instance/fuel-type/fullElectric	BMW iX3	65160	NULL	https://www...
instance/bmw-ix-m60	instance/fuel-type/fullElectric	BMW iX M60	124605	4935	https://www...
...

Table: fuel_type

fuelTypeId	name
instance/fuel-type/fullElectric	fullElectric
...	...

```
CREATE TABLE base_car (
  baseCarId TEXT PRIMARY KEY,
  fuelTypeId TEXT NOT NULL,
  name TEXT NOT NULL, -- e.g. 'BMW iX3'
  price INTEGER NOT NULL, -- in euros
  length INTEGER, -- in millimeters
  url TEXT NOT NULL,
  FOREIGN KEY (fuelTypeId) REFERENCES fuel_type(fuelTypeId)
)
```

```
CREATE TABLE fuel_type (
  fuelTypeId TEXT PRIMARY KEY,
  name TEXT NOT NULL -- either 'fullElectric', 'hybrid', 'gasoline' or 'diesel'
)
```

Knowledge graph verbalization

Makes KG amenable for NL retrieval and reasoning

- Text search runs over passage verbalizations generated from KG in RDF Turtle format ([Oguz et al. 2022](#))
- Each RDF Turtle "shell" converted into an NL passage
- Simple and generalizable hand-crafted rules
- Reversed facts also included to increase scope of answerable questions

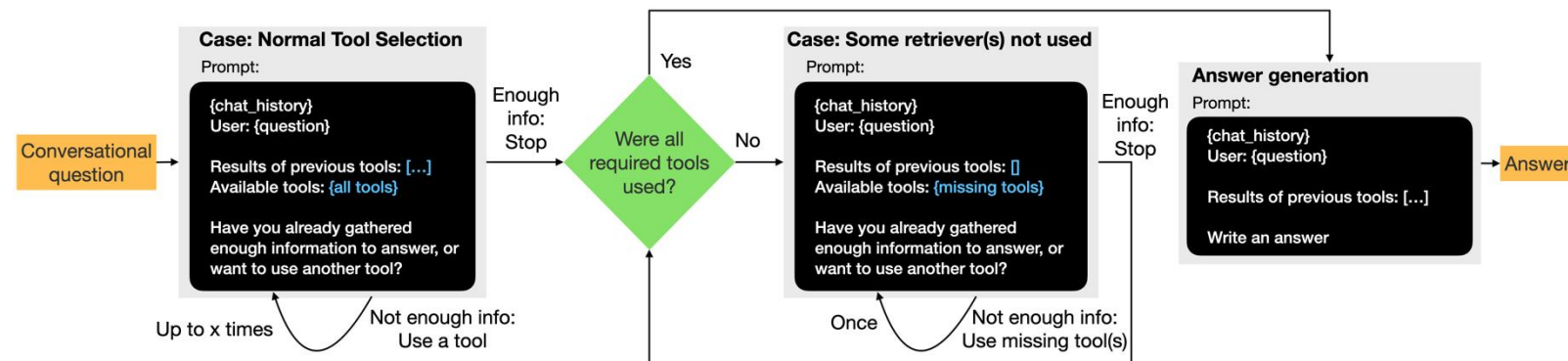
```
<http://iaais.fraunhofer.de/bmw/instance/variant/bmw-120-m-sport> a ns1:Car,  
    ns1:Product,  
    ns1:Vehicle ;  
    rdfs:label "BMW 120 M Sport" ;  
    ns1:EngineSpecification <http://iaais.fraunhofer.de/bmw/instance/variant/  
engine/bmw-120-m-sport> ;  
    ns1:height "1459 mm" ;  
    ns1:identifier "bmw-120-m-sport" ;  
    ns1:isVariantOf <http://iaais.fraunhofer.de/bmw/instance/  
bmw-1-series-(2024)> ;  
    ns1:length "4361 mm" ;  
    ns1:name "BMW 120 M Sport" ;  
    ns1:price "33065" ;  
    ns1:wheelbase "2670 mm" ;  
    ns1:width "1800 mm" .
```

BMW 120 M Sport is a Car. BMW 120 M Sport is a Product. BMW 120 M Sport is a Vehicle. BMW 120 M Sport has engine specification bmw-120-m-sport. bmw-120-m-sport is engine specification of BMW 120 M Sport. BMW 120 M Sport has height 1459 mm. 1459 mm is height of BMW 120 M Sport. BMW 120 M Sport is variant of bmw-1-series-(2024). bmw-1-series-(2024) has variant BMW 120 M Sport. BMW 120 M Sport has length 4361 mm. 4361 mm is length of BMW 120 M Sport. BMW 120 M Sport has price 33065 Euros. 33065 Euros is price of BMW 120 M Sport. BMW 120 M Sport has wheelbase 2670 mm. 2670 mm is wheelbase of BMW 120 M Sport. BMW 120 M Sport has width 1800 mm. 1800 mm is width of BMW 120 M Sport.

Iterative retrieval

Structured and unstructured retrieval tools may be invoked more than once

- RAGONITE has multiple tools or functions at its disposal
 - SQL query execution
 - Dense retriever
 - Lexical retriever
- Each tool can be called multiple times until satisfactory results are retrieved
- Each tool must be used at least once
- Increases robustness to "failed" retrievals
- Also for satisfying multi-hop intents (*average price of x7 cars with climate control*)
- Previous results included in the query generation LLM's prompt for next iteration



Branch integration

Fusion automated via LLMs

- Merging results from structured and unstructured retrieval via LLM agent
- Precludes need for
 - Deciding based on question which branch(es) to prefer
 - Deciding based on retrieval results which branch(es) to prefer
- No hard-coded rules in system
- Fully automated via LLM based on input question and conversation so far

Open LLM support

On-premise open models

- Uses GPT-4o via API as default
- Seamless support for Llama and other local models





Heterogeneous QA

QA over text and KG

- Having RDF verbalizations in pipeline facilitates incorporation of additional text
- No special support required
- Additional text snippets, for example, from the Web, can be simply added to our corpus
- Integration works well with about 400 passages from bmw.co.uk

Evaluation

Comparing natural alternatives

- BMW KG
 - 3442 facts: 466 entities, 27 predicates, 7 types, 1295 literals
 - 7 tables via DB induction, 466 passages via RDF verbalization
- QA pairs
 - 30 diverse questions wrt entities, predicates, types
 - Conducted as six conversations with five turns each
 - Equal distribution of all three intent classes: lookup, complex, abstract
- Four variants compared
 - SPARQL-only: 4/30  (fails in most cases due to LLM's inability at good query generation, NERD failures)
 - SQL-only: 18/30  (fails when question has ad hoc entity mentions like *gran coupe sport 220 i m* and not *bmw-220i-m-sport-gran-coupé*)
 - Verbalization-only: 24/30  (fails with complex math, like minimum over averages of grouped car prices)
 - SQL+Verbalization iterative: 28/30 
- Average runtime is **6 seconds** per question, end-to-end
- **Detailed** runtimes and accuracies available at <https://github.com/Fraunhofer-IIS/RAGonite/blob/main/btw25-bmw/data/bmw-eval-results.pdf>

+ New Chat

My Chats

What character... ⋮

What is the price ran...

How powerful are th...

What is the BMW Co...

What is the Coupe se...

What is the average ...

What is the cheapest...

Deleted Chats

User

What characterizes the BMW Coupe series?

Ragonite

The BMW Coupe series is characterized by its various models, such as the BMW 2 Series Coupé, BMW 4 Series Coupé, and BMW 8 Series Coupé. Each of these models incorporates a range of advanced equipment and features:

1. ****BMW 2 Series Coupé****: Includes features like automatic air conditioning with 2-zone control, BMW Live Cockpit Plus with BMW Curved Display, BMW Operating System 8 with navigation, cruise control with brake function, LED headlights and rear lights, as well as various driver assistance and interior equipment [2].

2. ****BMW 4 Series Coupé****: Offers features such as automatic air conditioning with 2-zone control, BMW Live Cockpit Plus with a curved display, BMW Operating System with navigation, cruise control with brake functions, LED headlights and rear lights, and equipment categories such as suspension, driver assistance, and interior [4].

3. ****BMW 8 Series Coupé****: This model includes equipment such as adaptive LED headlights, adaptive suspension, ambient interior lighting, automatic air conditioning with 2-zone control, BMW Live Cockpit Professional with navigation and head-up display, and a wide range of high-quality interior and exterior features such as the M Aerodynamics package, M Sport braking system, and multifunction seats [6].

Overall, the Coupe series focuses on advanced technology, performance, and luxury, with each model offering a distinct set of high-end features tailored to enhance the driving experience.

1. Input conversational question

User

Sounds like these are sleek sedans. Is an average X1 model taller than a Coupe?

Ragonite

Yes, an average BMW X1 model is generally taller than a BMW Coupe. The BMW X1 models have a height of approximately 1616 mm [1]. In contrast, the BMW Coupe models, such as the BMW 420i M Sport Gran Coupe and BMW M440i xDrive Gran Coupe, have a height of about 1442 mm [4][6]. Therefore, the X1 is taller than the Coupe series.

3. Generated answer via search result fusion

User

What fuel type does it support?

Ask Ragonite about BMW cars...

What is the power of the engine of BMW X1 models?

What electric cars does BMW have?

How are Touring and Tourer models different?

Which of them produces the least amount of CO2?

Sounds like these are sleek sedans. Is an average X1 model taller than a Coupe?

2a. Iterative SQL querying

SQLite Database Query

[1] SELECT cv.height FROM car_variant cv JOIN base_car bc ON cv.baseCarId = bc.baseCarId WHERE bc.name LIKE '%X1%';

SQLite Database Query

[2] SELECT cv.height FROM car_variant cv JOIN base_car bc ON cv.baseCarId = bc.baseCarId WHERE bc.name LIKE '%Coupe%';

Vector Search

BMW X1 average height compared to BMW Coupe models

2b. Text search over verbalizations

[3] bmw x1 xdrive25e sport

bmw x1 xdrive25e sport

bmw x1 xdrive25e sport is a Car. bmw x1 xdrive25e sport is a Product. bmw x1 xdrive25e sport is a Vehicle. bmw x1 xdrive25e sport has EngineSpecification bmw x1 xdrive25e sport. bmw x1 xdrive25e sport is EngineSpecification of bmw x1 xdrive25e sport. bmw x1 xdrive25e sport has height 1616 mm. 1616 mm is height of bmw x1 xdrive25e sport. bmw x1 xdrive25e sport has identifier bmw x1 xdrive25e sport. bmw x1 xdrive25e sport is identifier of bmw x1 xdrive25e sport. bmw x1 xdrive25e sport has is variant of bmw x1. bmw x1 is variant of bmw x1 xdrive25e sport. bmw x1 xdrive25e sport has length 4500 mm. 4500 mm is length of bmw x1 xdrive25e sport. bmw x1 xdrive25e sport has name BMW X1 xDrive25e Sport. BMW X1 xDrive25e Sport is name of bmw x1 xdrive25e sport. bmw x1 xdrive25e sport has price 42670 Euros. 42670 Euros is price of bmw x1 xdrive25e sport. bmw x1 xdrive25e sport has wheelbase 2692 mm. 2692 mm is wheelbase of bmw x1 xdrive25e sport. bmw x1 xdrive25e sport has width 1845 mm. 1845 mm is width of bmw x1 xdrive25e sport.

[4] bmw 420i m sport gran coupe

[5] bmw x1 sdrive18d sport

[6] bmw m440i xdrive gran coupe

[7] bmw x1 sdrive20i sport

What fuel type does it support?

SQLite Database Query

[1] SELECT DISTINCT fuel_type.name FROM car_variant JOIN engine ON car_variant.engineId = engine.engineId JOIN fuel_type ON eng...

SQLite Database Query

[2] SELECT DISTINCT fuel_type.name FROM car_variant JOIN engine ON car_variant.engineId = engine.engineId JOIN fuel_type ON eng...

Vector Search

fuel type supported by BMW X1 model

[3] bmw x1 xdrive25e sport

[4] bmw m4 cs

Page 12

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Example question 1: Fact lookups satisfied via both branches

Payload of x7 xdrive40d?

RAGONITE BMW ITERATIVE RETRIEVAL

+ New Chat

My Chats

payload of x7 x...

payload of x7 xdrive...

payload of x7 xdrive...

payload of x7 xdrive...

payload of x7 xDrive...

average price of the ...

average price of the i...

payload of x1 sDrive...

payloads of x3 cars?

top speed of x1 sDriv...

payload of x1 sDrive...

do you have payload ...

do you have payload ...

do you have info on t...

payload of x1

wheel colors for x5?

price of x7 cars with ...

height distribution of...

average price of x7 c...

What is the average ...

User

payload of x7 xdrive40d?

Ragonite

The payload of the BMW X7 xDrive40d is 835 kg. [Source 1, Source 2]

User

average price of x7 variants?

Ragonite

The average price of BMW X7 variants is 102,000 euros. [Source 1]

User

cool features?

Ragonite

The BMW X7 boasts several cool features, including:

1. Comfort highlights like 6 seats, automatic climate control with 5-zone control, and a Bowers and Wilkins diamond surround sound system. [Source 2]

2. Innovative highlights such as the BMW Operating System 8, Comfort Access, and smartphone integration. [Source 2]

3. Interior design highlights with aesthetics and technology in the cockpit, glass application CraftedClarity, and a spacious and comfortable rear. [Source 2]

These features emphasize luxury, comfort, and technological innovation in the design of the BMW X7.

Ask Ragonite about BMW cars...

What is the power of the engine of BMW X1 models?

What electric cars does BMW have?

What power do they have?

Which of them produces the least amount of CO2?

payload of x7 xdrive40d?

1. Retrieval: Tool Selection LLM Completion

1. Retrieval: Sqlite Tool SQLite Query

Query

SELECT payload FROM car_variant WHERE name = 'BMW X7 xDrive40d';

Result

payload

835

2. Retrieval: Tool Selection LLM Completion

2. Retrieval: Document Database Tool VectorDB Query

Query

What is the payload capacity of the BMW X7 xDrive40d?

Results

ID

http://iaais.fraunhofer.de/bmw/instance/variant/bmw-x7-xdrive40d

Title

bmw x7 xdrive40d

Content

bmw x7 xdrive40d is a Car. bmw x7 xdrive40d is a Product. bmw x7 xdrive40d is a Vehicle. bmw x7 xdrive40d has empty weight 2565 Kg. 2565 Kg is empty weight of bmw x7 xdrive40d. bmw x7 xdrive40d has fuel capacity 80 l. 80 l is fuel capacity of bmw x7 xdrive40d. bmw x7 xdrive40d has height 1.835 m. 1.835 m is height of bmw x7 xdrive40d. bmw x7 xdrive40d has identifier bmw x7 xdrive40d. bmw x7 xdrive40d is identifier of bmw x7 xdrive40d. bmw x7 xdrive40d has is variant of bmw x7. bmw x7 is variant of bmw x7 xdrive40d. bmw x7 xdrive40d has length 5.181 m. 5.181 m is length of bmw x7 xdrive40d. bmw x7 xdrive40d has luggage compartment volume 750 to 2120 l. 750 to 2120 l is luggage compartment volume of bmw x7 xdrive40d. bmw x7 xdrive40d has maximum weight 3325 Kg. 3325 Kg is maximum weight of bmw x7 xdrive40d. bmw x7 xdrive40d has name BMW X7 xDrive40d. BMW X7 xDrive40d is name of bmw x7 xdrive40d. **bmw x7 xdrive40d has payload 835 kg.** 835 kg is payload of bmw x7 xdrive40d. bmw x7 xdrive40d has price 104000.00 Euros. 104000.00 Euros is price of bmw x7 xdrive40d. bmw x7 xdrive40d has top speed 245 km/h. 245 km/h is top speed of bmw x7 xdrive40d. bmw x7 xdrive40d has vehicle engine bmw x7 xdrive40d. bmw x7 xdrive40d is vehicle engine of bmw x7 xdrive40d. bmw x7 xdrive40d has wheelbase 3.105 m. 3.105 m is wheelbase of bmw x7 xdrive40d. bmw x7 xdrive40d has width 2.218 m. 2.218 m is width of bmw x7 xdrive40d.

URL

Score

0.535

ID

http://iaais.fraunhofer.de/bmw/instance/variant/bmw-x7-xdrive40i

Title

bmw x7 xdrive40i

Content

bmw x7 xdrive40i is a Car. bmw x7 xdrive40i is a Product. bmw x7 xdrive40i is a Vehicle. bmw x7 xdrive40i has empty weight 2490 Kg. 2490 Kg is empty weight of bmw x7 xdrive40i. bmw x7 xdrive40i has fuel capacity 83 l. 83 l is fuel capacity of bmw x7 xdrive40i. bmw x7 xdrive40i has height 1.835 m. 1.835 m is height of bmw x7 xdrive40i. bmw x7 xdrive40i has identifier bmw x7 xdrive40i. bmw x7 xdrive40i is identifier of bmw x7 xdrive40i. bmw x7 xdrive40i has is variant of bmw x7. bmw x7 is variant of bmw x7 xdrive40i. bmw x7 xdrive40i has length 5.181 m. 5.181 m is length of bmw x7 xdrive40i. bmw x7 xdrive40i has luggage compartment volume 750 to 2120 l. 750 to 2120 l is luggage compartment volume of bmw x7 xdrive40i. bmw x7 xdrive40i has maximum weight 3215 Kg.

Example question 2: Math computations satisfied via SQL

Average price of x7 variants?

RAGONITE BMW ITERATIVE RETRIEVAL

+ New Chat

My Chats

payload of x7 x...

payload of x7 xdrive...

payload of x7 xdrive...

payload of x7 xdrive...

payload of x7 xDrive...

average price of the ...

average price of the i...

payload of x1 sDrive...

payloads of x3 cars?

top speed of x1 sDriv...

payload of x1 sDrive...

do you have payload ...

do you have payload ...

do you have info on t...

payload of x1

wheel colors for x5?

price of x7 cars with ...

height distribution of...

average price of x7 c...

What is the average ...

User

payload of x7 xdrive40d?

Ragonite

The payload of the BMW X7 xDrive40d is 835 kg. [Source 1, Source 2]

User

average price of x7 variants?

Ragonite

The average price of BMW X7 variants is 102,000 euros. [Source 1]

User

cool features?

Ragonite

The BMW X7 boasts several cool features, including:

1. Comfort highlights like 6 seats, automatic climate control with 5-zone control, and a Bowers and Wilkins diamond surround sound system. [Source 2]

2. Innovative highlights such as the BMW Operating System 8, Comfort Access, and smartphone integration. [Source 2]

3. Interior design highlights with aesthetics and technology in the cockpit, glass application CraftedClarity, and a spacious and comfortable rear. [Source 2]

These features emphasize luxury, comfort, and technological innovation in the design of the BMW X7.

Ask Ragonite about BMW cars...

What is the power of the engine of BMW X1 models?

What electric cars does BMW have?

What power do they have?

Which of them produces the least amount of CO2?

0.667

2. Retrieval: Document Database Tool Lexical Search

3. Retrieval: Tool Selection LLM Completion

Answer Generation LLM Completion

average price of x7 variants?

1. Retrieval: Tool Selection LLM Completion

1. Retrieval: Sqlite Tool SQLite Query

Query

SELECT AVG(price) AS average_price FROM base_car WHERE name LIKE '%X7%';

Result

average_price

102000

2. Retrieval: Tool Selection LLM Completion

2. Retrieval: Document Database Tool VectorDB Query

2. Retrieval: Document Database Tool Lexical Search

3. Retrieval: Tool Selection LLM Completion

Answer Generation LLM Completion

cool features?

1. Retrieval: Tool Selection LLM Completion

1. Retrieval: Sqlite Tool SQLite Query

2. Retrieval: Tool Selection LLM Completion

2. Retrieval: Document Database Tool VectorDB Query

Example question 3: Informal intents satisfied via verbalizations

Cool features (of x7)?

RAGONITE BMW ITERATIVE RETRIEVAL

+ New Chat

My Chats

payload of x7 x...

payload of x7 xdrive...

payload of x7 xdrive...

payload of x7 xdrive...

payload of x7 xDrive...

average price of the ...

average price of the i...

payload of x1 sDrive...

payloads of x3 cars?

top speed of x1 sDriv...

payload of x1 sDrive...

do you have payload ...

do you have payload ...

do you have info on t...

payload of x1

wheel colors for x5?

price of x7 cars with ...

height distribution of...

average price of x7 c...

What is the average ...

User

payload of x7 xdrive40d?

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What is the power of the engine of BMW X1 models?

What electric cars does BMW have?

What power do they have?

Which of them produces the least amount of CO2?

ID

http://iais.fraunhofer.de/bmw/instance/bmw-x7

Title

bmw x7

Content

bmw x7 is a Car. bmw x7 is a Car Model. bmw x7 is a Product. bmw x7 is a Vehicle. bmw x7 has accessory 20 22 BMW light alloy wheel V spoke style 750 reflex silver 2C complete winter wheel. 20 22 BMW light alloy wheel V spoke style 750 reflex silver 2C complete winter wheel is accessory of bmw x7. bmw x7 has accessory 21 22 BMW light alloy wheel Y spoke style 752 Jet Black. 21 22 BMW light alloy wheel Y spoke style 752 Jet Black is accessory of bmw x7. bmw x7 has accessory BMW clothes hanger for travel 26 comfort system. BMW clothes hanger for travel 26 comfort system is accessory of bmw x7. bmw x7 has accessory BMW roof box 520 black 2Ftitanium silver. BMW roof box 520 black 2Ftitanium silver is accessory of bmw x7. bmw x7 has description The BMW X7 fascinates from the first encounter with its combination of superior power, luxurious comfort and expressive design language.. The BMW X7 fascinates from the first encounter with its combination of superior power, luxurious comfort and expressive design language. is description of bmw x7. bmw x7 has fuel type diesel. diesel is fuel type of bmw x7. bmw x7 has fuel type gasoline. gasoline is fuel type of bmw x7. bmw x7 has identifier bmw x7. bmw x7 is identifier of bmw x7. bmw x7 has innovative highlight Comfort highlight 3A 6 seats. Comfort highlight 3A 6 seats is innovative highlight of bmw x7. bmw x7 has innovative highlight Comfort highlight 3A Automatic climate control with 5 zone control. Comfort highlight 3A Automatic climate control with 5 zone control is innovative highlight of bmw x7. bmw x7 has innovative highlight Comfort highlight 3A Bowers and Wilkins diamond surround sound system. Comfort highlight 3A Bowers and Wilkins diamond surround sound system is innovative highlight of bmw x7. bmw x7 has innovative highlight Innovative highlight 3A BMW operating system 8. 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http://iais.fraunhofer.de/bmw/instance/variant/engine/bmw-x7-xdrive40i

Title

bmw x7 xdrive40i

Content

bmw x7 xdrive40i is a Engine Specification. bmw x7 xdrive40i has acceleration time 5.8 s. 5.8 s is acceleration time of bmw x7 xdrive40i. bmw x7 xdrive40i has

Example question 3: Informal intents satisfied via verbalizations

Cool features (of x7)?

RAGONITE BMW ITERATIVE RETRIEVAL

+ New Chat

My Chats

payload of x7 x...

payload of x7 xdrive...

payload of x7 xdrive...

payload of x7 xdrive...

payload of x7 xDrive...

average price of the ...

average price of the i...

payload of x1 sDrive...

payloads of x3 cars?

top speed of x1 sDriv...

payload of x1 sDrive...

do you have payload ...

do you have payload ...

do you have info on t...

payload of x1

wheel colors for x5?

price of x7 cars with ...

height distribution of...

average price of x7 c...

What is the average ...

User

payload of x7 xdrive40d?

Ragonite

The payload of the BMW X7 xDrive40d is 835 kg. [Source 1, Source 2]

User

average price of x7 variants?

Ragonite

The average price of BMW X7 variants is 102,000 euros. [Source 1]

User

cool features?

Ragonite

The BMW X7 boasts several cool features, including:

1. Comfort highlights like 6 seats, automatic climate control with 5-zone control, and a Bowers and Wilkins diamond surround sound system. [Source 2]

2. Innovative highlights such as the BMW Operating System 8, Comfort Access, and smartphone integration. [Source 2]

3. Interior design highlights with aesthetics and technology in the cockpit, glass application CraftedClarity, and a spacious and comfortable rear. [Source 2]

These features emphasize luxury, comfort, and technological innovation in the design of the BMW X7.

Ask Ragonite about BMW cars...

What is the power of the engine of BMW X1 models?

What electric cars does BMW have?

What power do they have?

Which of them produces the least amount of CO2?

ID

http://iais.fraunhofer.de/bmw/instance/bmw-x7

Title

bmw x7

Content

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Illustrating iterative retrieval for complex intents

RAGONITE
by Allinga

BMW Tools (+Texts) GPT4o

/ How does the average price of an X5 differ from an X7?

Chat

Pipelines

Playground

Docs



Start New Chat

My Chats

How does the average ...

What is the price of the BM...

What information do we ha...

Do BMW Touring models ha...

What is the average acceler...

What is the charging time o...

What is the Coupe series al...

What is the price of the BM...

What is the cheapest X1 se...



User

How does the average price of an X5 differ from an X7?



Ragonite

The average price of a BMW X5 is €70,685, while the average price of a BMW X7 is €89,202.50. This means the BMW X7 is generally more expensive than the BMW X5. [Source 1, Source 2]



User

What luxury features make the X7 so much more expensive?



Ragonite

The BMW X7's higher price can be attributed to its luxurious features, which include:

- **High-Grade Materials****: The interior of the BMW X7 impresses with its use of especially high-grade materials, adding to the overall luxurious feel of the vehicle. [Source 4]
- **Optional 'CraftedClarity' Glass Applications****: Exclusive accents like the optional 'CraftedClarity' glass applications for the gear selection lever, iDrive Controller, and start/stop button enhance the luxury experience. [Source 4]
- **Standard and Innovative Features****: The BMW X7 comes equipped with numerous luxurious and innovative features such as:
 - Comfort highlight with 6 seats.
 - Automatic climate control with 5-zone control.
 - Bowers and Wilkins diamond surround sound system.
 - BMW Operating System 8 with navigation.
 - Comfort access and Smartphone integration.
 - Aesthetics and technology-oriented cockpit design.
 - Spacious and comfortable rear seating. [Source 2]

These luxury features combine to make the BMW X7 a more premium offering compared to other models like the BMW X5, contributing to its higher price.



Pipeline

Details

Tool Pipeline

BMW Tools (+Texts)...

What do they cost?

What power do they have?

Which of them produces the least amount of CO2?

How does the average price of an X5 differ from an X7?

1. Retrieval: Tool Selection LLM Completion

1. Retrieval: SQL Tool SQL Query

Query

SELECT AVG(price) FROM car_variant WHERE baseCarId = (SELECT baseCarId FROM base_car WHERE name = 'BMW X5');

Result

AVG(price)

70685

2. Retrieval: Tool Selection LLM Completion

2. Retrieval: SQL Tool SQL Query

Query

SELECT AVG(price) FROM car_variant WHERE baseCarId = (SELECT baseCarId FROM base_car WHERE name = 'BMW X7');

Result

AVG(price)

89202.5

3. Retrieval: Tool Selection LLM Completion

4. Retrieval: Tool Selection LLM Completion

4. Retrieval: Document Database Tool VectorDB Query

4. Retrieval: Document Database Tool Lexical Search

Answer Generation LLM Completion

Time Measurements

What luxury features make the X7 so much more expensive?

1. Retrieval: Tool Selection LLM Completion

1. Retrieval: SQL Tool SQL Query

2. Retrieval: Tool Selection LLM Completion

Summary

Looking forward to your feedback!

- RAGONITE is a transparent RAG pipeline – every step is scrutable by end-user
- Adopts novel alternative for ConvQA over KGs by iterative retrieval and merging structured and unstructured query results
- Text2SPARQL has been investigated in the past: we adopt a novel alternative of exploiting Text2SQL, where LLMs do much better, over a DB programmatically induced from KG
 - SQL for KG-QA brings more complex math intents in scope
- By converting KG to verbalized form followed by dense retrieval, we show that information in knowledge graphs is useful for abstract intents
- RAGONITE is agentic system, future work would include reflection mechanisms without compromising efficiency

Thank you!