On the Limits of Machine Knowledge: Completeness, Recall and Negation in Web-scale Knowledge Bases

Simon Razniewski, Hiba Arnaout, Shrestha Ghosh, Fabian Suchanek

1. Introduction & Foundations (Simon) – 20 min
2. Predictive recall assessment (Fabian) – 20 min
3. Counts from text and KB (Shrestha) – 20 min
4. **Negation (Hiba) – 20 min**
5. Wrap-up (Simon) – 5 min

Open-world Assumption

42 awards

Adams Prize

Pius XI Medal

Michelson–Morley Award

Royal Society Science Books Prize

Albert Einstein Medal

Oskar Klein Medal

Hughes Medal

Wolf Prize in Physics

[Wikidata](#) - **Awards won by** Stephen Hawking

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Nobel Prize in Physics?
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Wikidata doesn’t know!

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Problem

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Existing positive-only KBs are *unaware* of negation.

Wikidata - **Awards won by** Stephen Hawking

Problem

42 awards, 30000 awards

Existing positive-only KBs are *unaware* of negation.
Set of negative statements is quasi-infinite!

[Wikidata](#) - **Awards won by** Stephen Hawking

State-of-the-art: KBs that include negative statements

- **Edit history**
  - Collaborative KBs, e.g., Wikidata
  - Deleted statements
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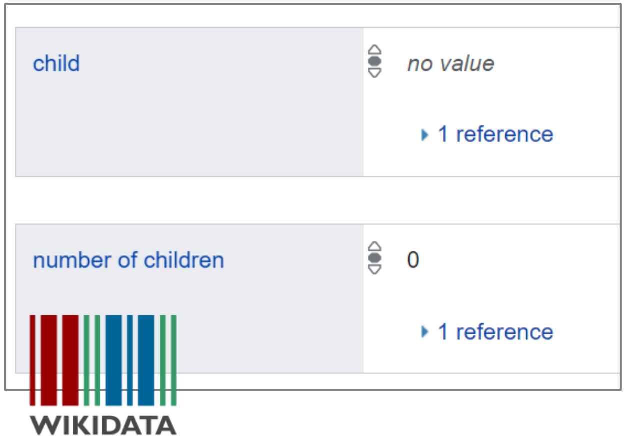

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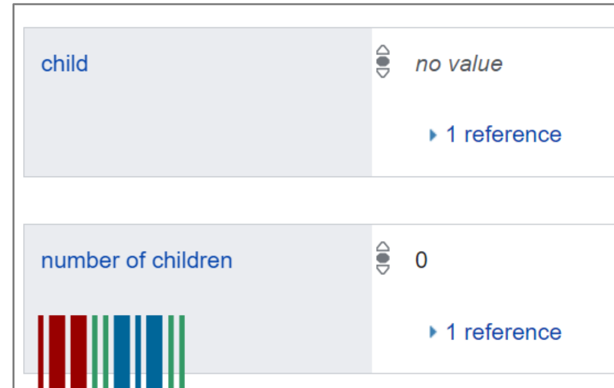

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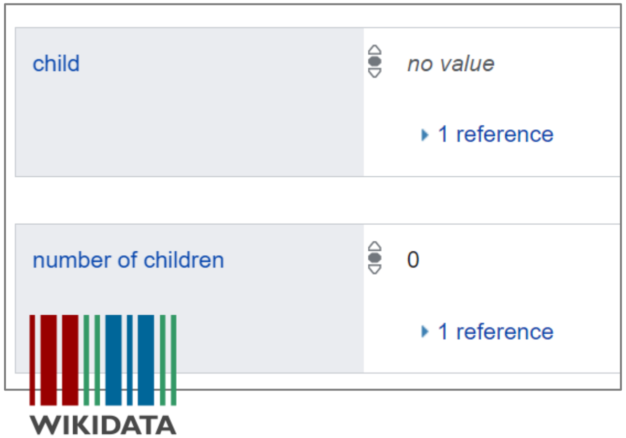

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WIKIDATA

Advantages: formalizes syntax for explicit negation addition, & some allows querying them (e.g., Wikidata SPARQL with o = no-value)
Limitations: inherit same challenges from positive KBC, covers small domains, no active collection of useful negations

Identify Interesting Negative Knowledge

Problem:

Existing positive-only KBs are *unaware* of negation.

Input:

Open-world KB.

Task:

Explicitly add *salient* negative statements to KB.

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¬ (award; Nobel Prize in Physics)

¬ (award; Academy Awards for Best Actress)

¬ (headquarters location; Silicon Valley)

How to identify interesting negation?

PART1: Statistical Inferences

PART2: Text Extraction

PART3: Pretrained Language Models

How to identify interesting negation?

PART1: Statistical Inferences

★ **Infer from *existing* positive statements:**
Peer-based negation inference method.

PART2: Text Extraction

PART3: Pretrained Language Models

PART1: Statistical Inferences

Peer-based Negation Inference

Input:

Given entity e from KB.

Overview:

1. **Peer-based candidate retrieval**
2. **Correctness filtering by local completeness assumption**
3. **Supervised ranking for higher saliency**

Output:

Top interesting negative statements about e.

Arnaout, Razniewski, and Weikum, "Enriching KBs with interesting negative statements", AKBC'20

Collecting Highly Related Entities

What is a similar entity (peer) ?

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- **Cosine of low-dimensional latent representations**
  Wikipedia embeddings

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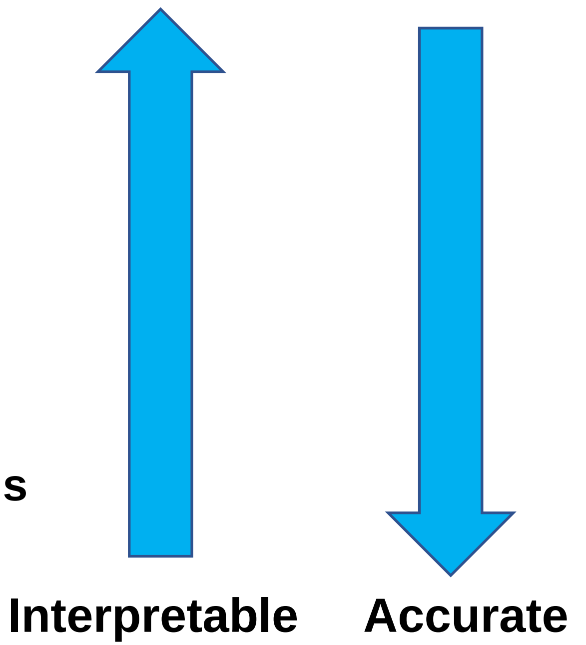

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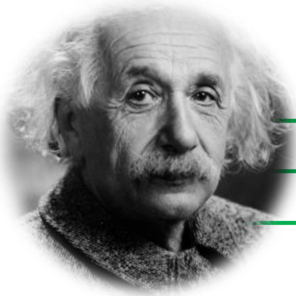
Retrieve Candidate Negations & Correctness Filter

entity

peer



(award; Copley Medal)

(award; Nobel Prize in Physics)

(hobby; reading)

(hobby; sailing)

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Every statement that applies to <u>at least</u> one peer is a *candidate negation*.

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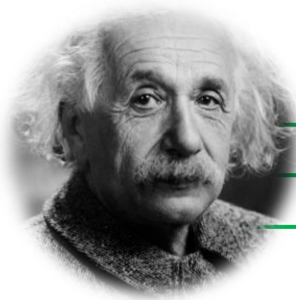

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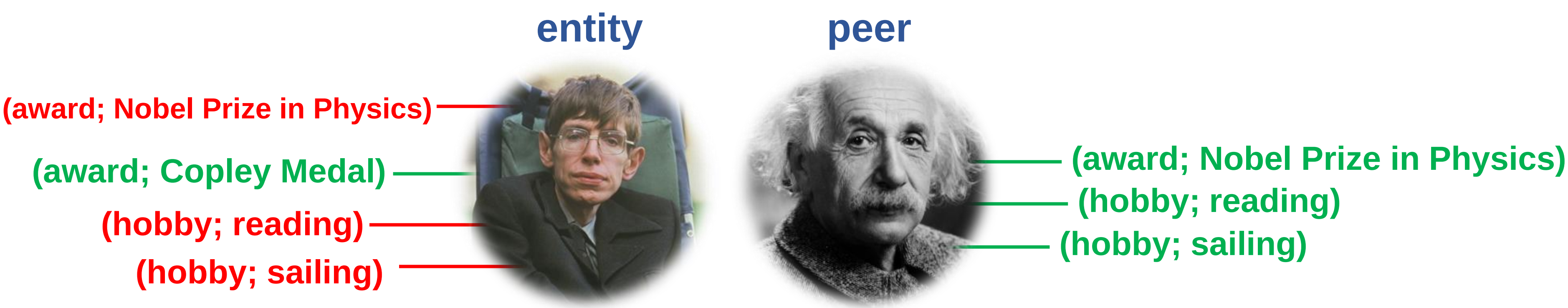

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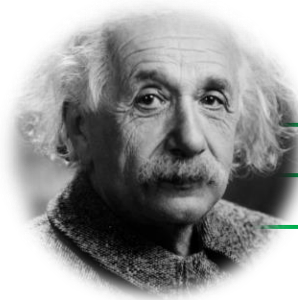

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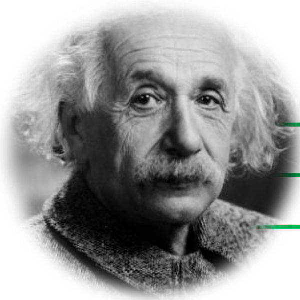

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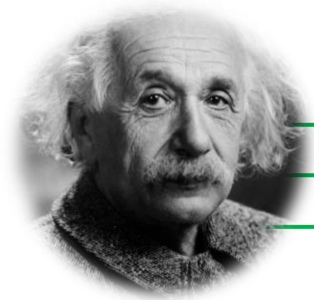

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Significantly boosts correctness of deductions: **57 to 84%.**

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Supervised Learning-to-rank Model

Candidates = [¬ (handedness; left); ¬ (citizen; U.S.); ¬ (award; Nobel Prize in Physics)]

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A. **Scoring features include:**
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   Is it interesting that Stephen Hawking never received a Nobel in Physics?
   .. is not left-handed?

C. **Train supervised model to predict annotator scores**
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★ **Pattern-based query log extraction.**
Mining common factual mistakes from Wikipedia updates.

PART3: Pretrained Language Models

PART2: Text Extraction

Mine Negations from User Query Logs

Romero et al., "Commonsense Properties from Query Logs and Question Answering Forums", CIKM'19
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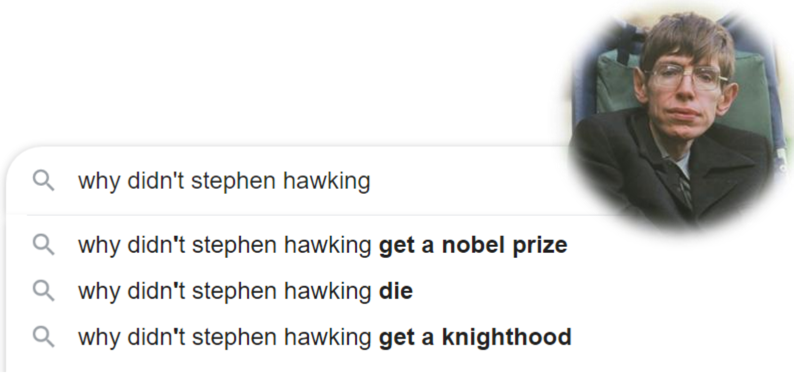

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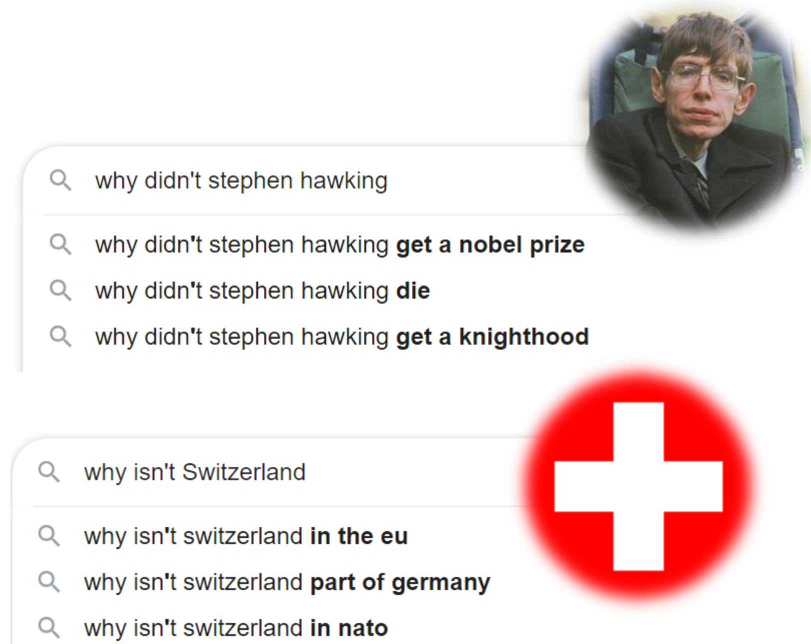

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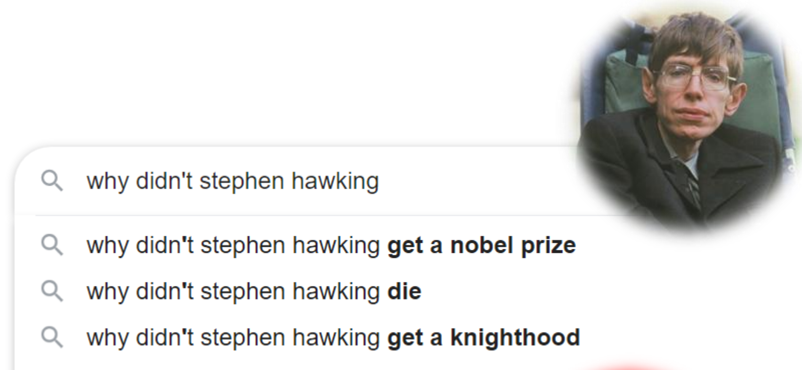

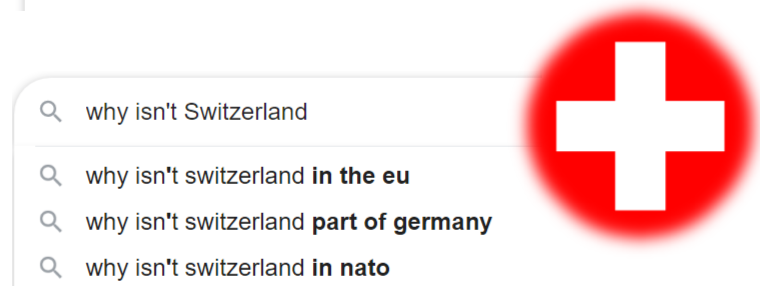

- **Advantage: High precision**
- **Limitation: Very low recall**

Romero et al., “[Commonsense Properties from Query Logs and Question Answering Forums](#)”, CIKM’19
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PART3: Pretrained Language Models

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Mine Text Revisions

Karagiannis et al., "Mining an "Anti-Knowledge Base" from Wikipedia Updates with Applications to Fact Checking and Beyond", PVLDB'19

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- **Anti-knowledge base (AKB)**
  Create a knowledge base of *common factual mistakes*
  Complement the positive-only KB

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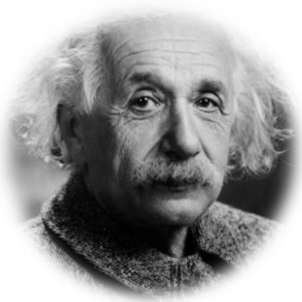

Revision 505

Einstein was born in Vienna.

Revision 506

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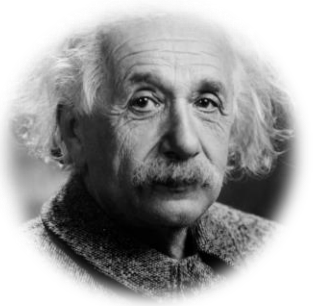
- **Advantage: High correctness**

- **Limitation:**
  Updates occur for a variety of reasons
  60% are not factual corrections
  controversial, synonyms, spelling mistake, etc.



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★ **Generating meaningful commonsense negative knowledge: Generate corruptions & estimate contradictions.**

PART3: Pretrained Language Models

Generating Meaningful Negative Commonsense Knowledge

Safavi and Koutra, “Generating Negative Commonsense Knowledge”, KR2ML at NeurIPS’20

Generating Meaningful Negative Commonsense Knowledge

- **Two-step framework:**

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1) **Generate corruptions**
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   source: ConceptNet

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PART3: Pretrained Language Models

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(horse, IsA, expensive pet)
(cat, IsA, expensive pet)
(goldfish, IsA, expensive pet)
(horse, IsA, expensive car)

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Projects

Wiki*nega*ta ***(online platform)***

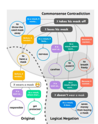
Browse interesting negations about Wikidata entities

Neguess ***(online quiz-game)***

Entity guessing game with negative clues

Anti-KB ***(dataset)***

Ranked common factual mistakes from Wikipedia

ANION ***(dataset)*** 

Commonsense KB focusing on negated events

Google Hotel Search ***(online platform)***

Hotel booking with negative features asserted

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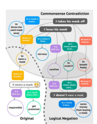

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d5demos.mpi-inf.mpg.de/negation/

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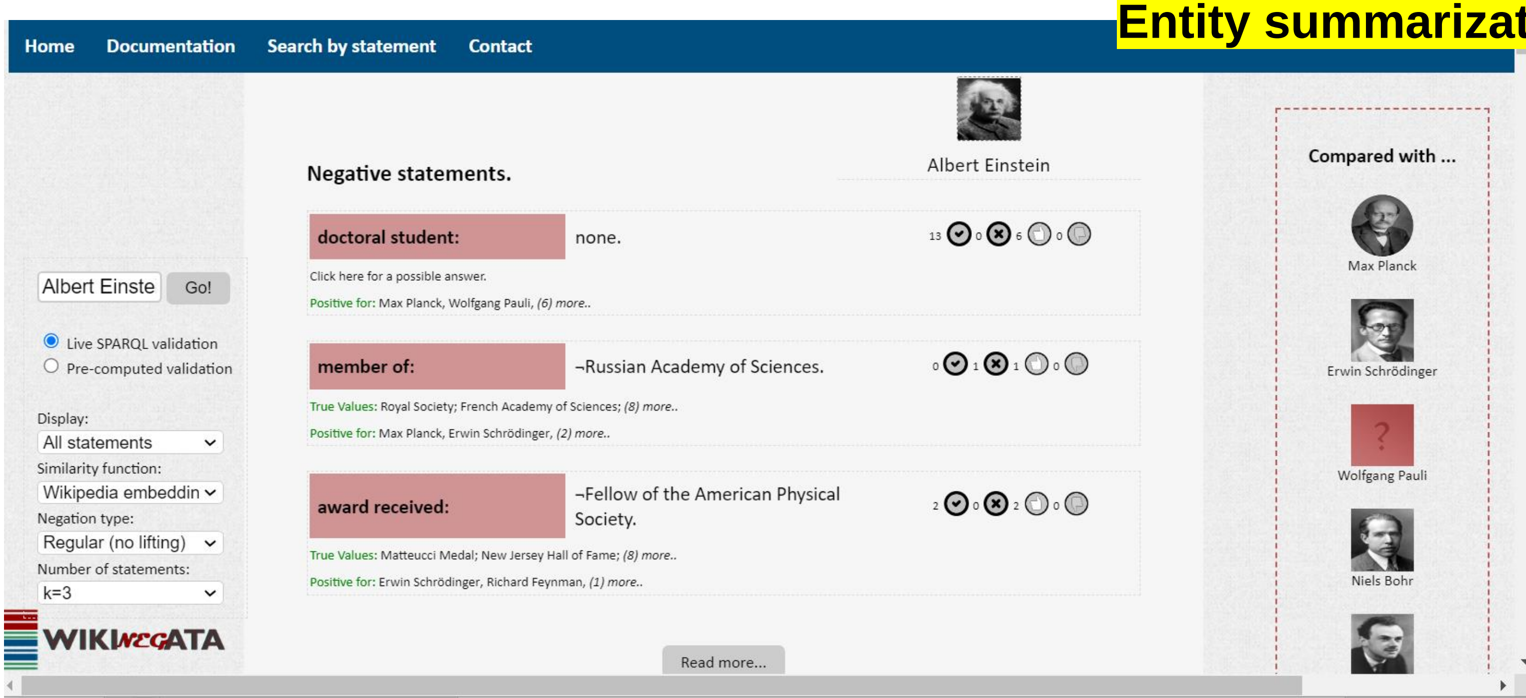
  Come to the demo session [Blocks 1 & 3]!!
- **Built upon the peer-based negation inference.**
- **Interesting negations about 0.5M Wikidata entities.**

Entity summarization



Arnaout et al., "[Wikinegata: A Knowledge Base with Interesting Negative Statements](#)", VLDB'21

WIKINEGATA

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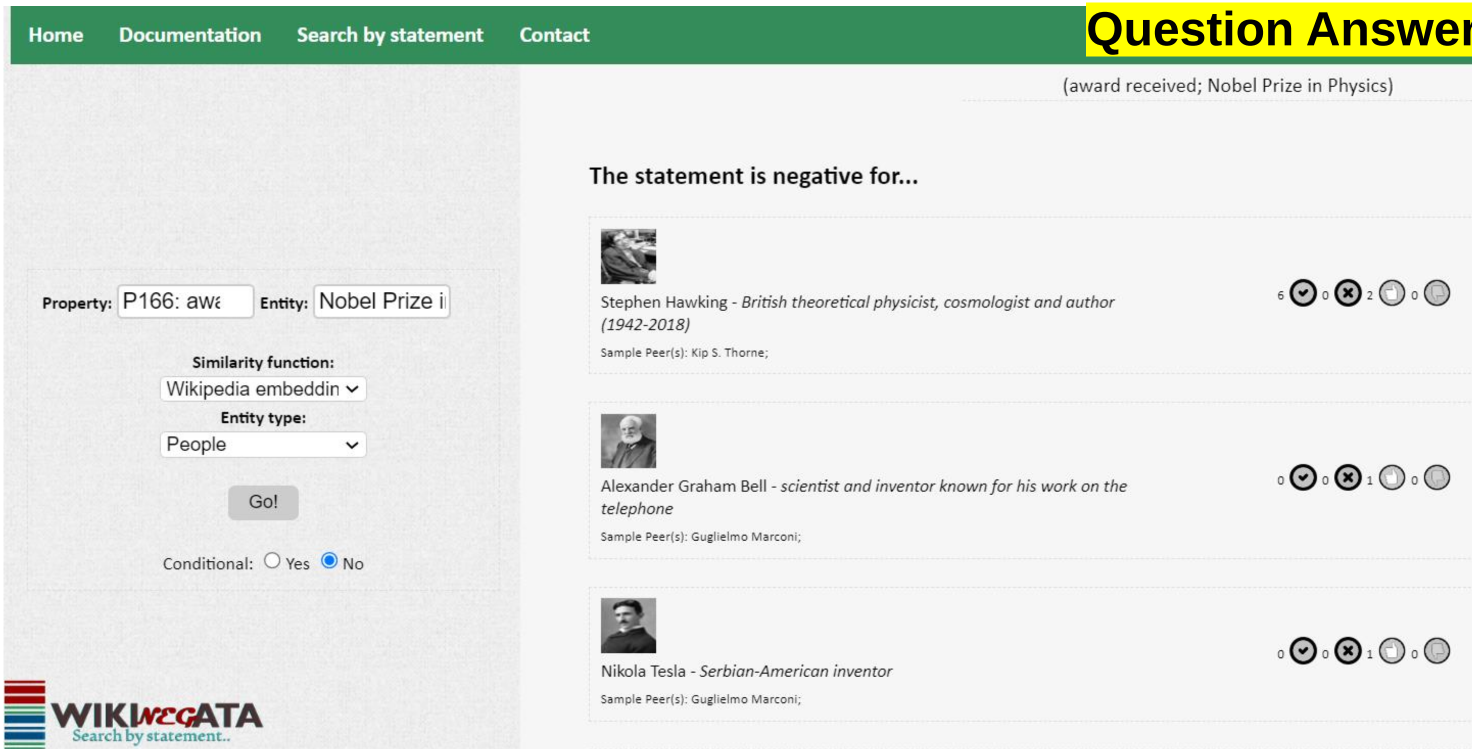
Question Answering



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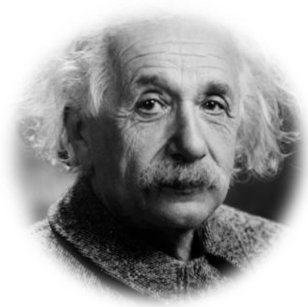
Can you Neguess?

neguess.mpi-inf.mpg.de

- **Entity-guessing game with interesting negations as clues.**

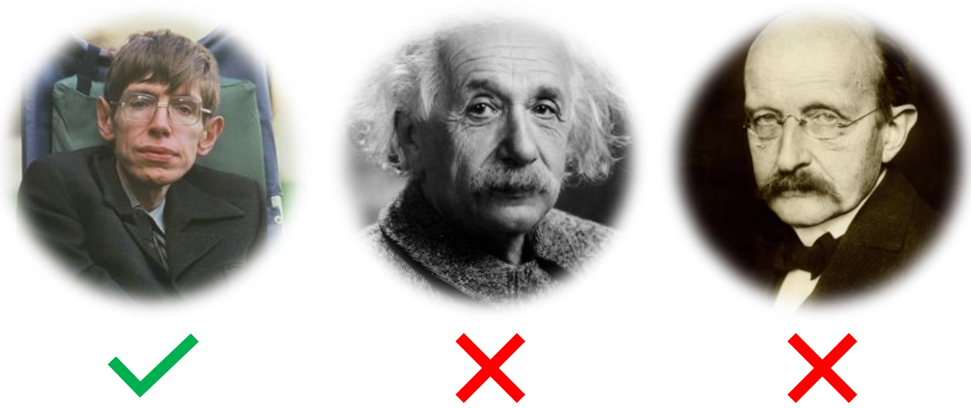

Clue1: was *not* educated at Trinity College.
Clue2: did *not* win Nobel Prize in Physics.
Clue3: is *not* German.

Biswas Bikram et al., "Neguess: Wikidata-entity guessing game withnegative clues", ISWC'21

Can you Neguess?

neguess.mpi-inf.mpg.de

- **Entity-guessing game with interesting negations as clues.**



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Projects

Wiki*nega*ta ***(online platform)***

Browse interesting negations about Wikidata entities

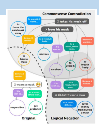
Neguess ***(online quiz-game)***

Entity guessing game with negative clues

★ **Anti-KB** ***(dataset)***

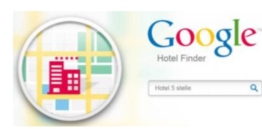
Ranked common factual mistakes from Wikipedia

ANION ***(dataset)***



Commonsense KB focusing on negated events

Google Hotel Search ***(online platform)***



Hotel booking with negative features asserted

Anti-knowledge base

Data available upon request

- **Dataset of common factual mistakes: mined from Wikipedia change log.**
- **<u>116k</u> likely mistakes where people confuse entities or numbers**

Penicillin was discovered in 1928 by Scottish scientist <u>Alexander Baldwin</u>.

<u>Alexander Flemming</u>.

Confidence score = 0.619

Karagiannis et al., "<u>Mining an "Anti-Knowledge Base" from Wikipedia Updates with Applications to Fact Checking and Beyond</u>", PVLDB'19

Projects

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Entity guessing game with negative clues

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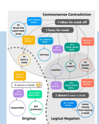


Commonsense KB focusing on negated events

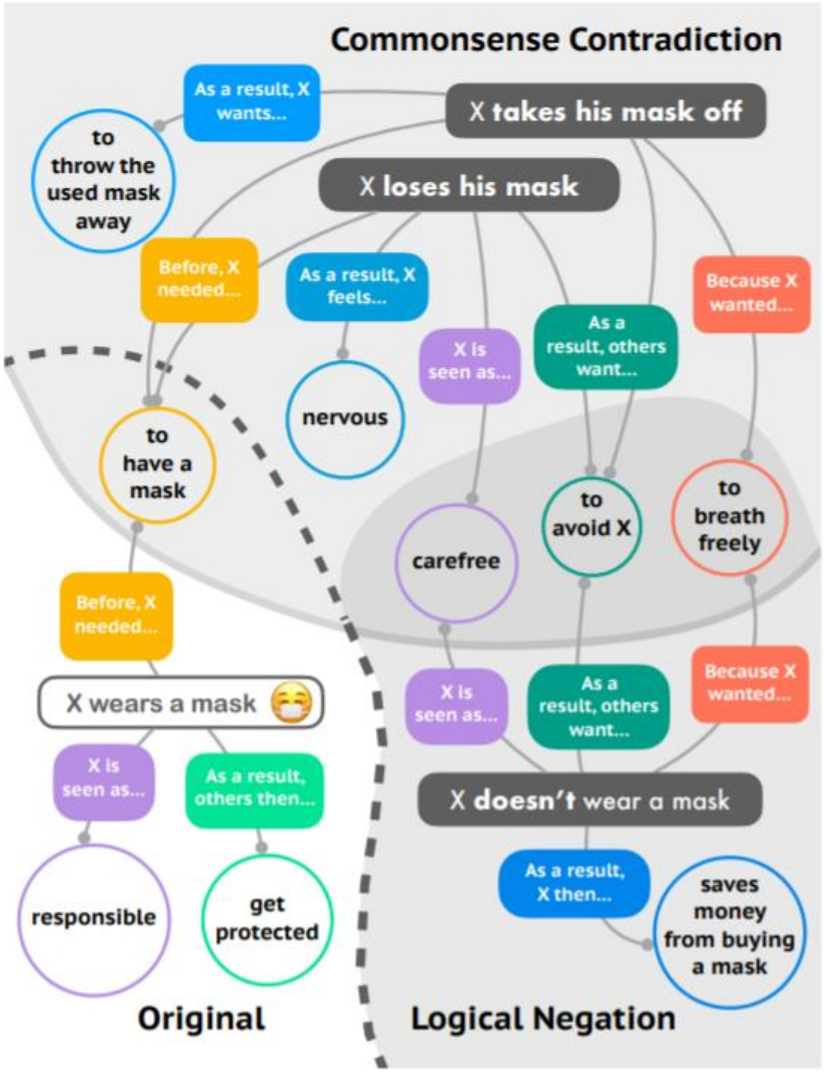
<u>Google Hotel Search</u> ***(online platform)***

Hotel booking with negative features asserted

ANION

- **A new commonsense knowledge graph with 624K if-then rules.**

https://github.com/liweijiang/anion



Jiang et al., "[I'm Not Mad: Commonsense Implications of Negation and Contradiction]()", NAACL'21

Projects

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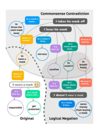

Commonsense KB focusing on negated events

★ **Google Hotel Search** ***(online platform)***

Hotel booking with negative features asserted

Data crawled from:

- Hotel websites
- Third-party services
- User reviews

Internet

- ✓ Wi-Fi free
- ✓ Wi-Fi in public areas

Policies & payments

- ✓ Smoke-free property
- ✓ Credit cards
- ✓ Debit cards
- ✓ Cash

Services

- ✓ Front desk 24-hour
- ✓ Baggage storage
- ✓ Full-service laundry
- ✓ Lift
- ✓ Social hour
- ✓ Wake up calls
- ✓ Gift shop
- ✓ Housekeeping daily
- ✓ Turndown service

Accessibility

- ✓ Accessible
- ✓ Accessible lift

Food and drink

- ✓ Restaurant
- ✓ Bar
- ✓ Table service
- ✓ Room service
- ✓ Breakfast extra charge
- ✓ Breakfast buffet

Activities

- ✓ Bicycle hire extra charge
- ✓ Boutique shopping

Pools

- ⊘ No pools
- ⊘ No hot tub

Parking & transport

- ✓ Parking extra charge
- ✓ Self parking extra charge

Wellness

- ⊘ No spa

Pets

- ⊘ No pets

https://www.google.com/travel/hotels/

Takeaway: negation

- Current KBs lack negative knowledge
- Rising interest in the explicit addition of negation to OW KB.
- Negations highly relevant in many applications including:
  - Commercial decision making (e.g., hotel booking)
  - General-domain question answering systems (e.g., is Switzerland a member of the EU?)
- Methodologies include:
  - Statistical inference
  - Text extraction
  - Pretrained LMs.