

# Knowledge Graphs

Lecture 6 – Intelligent Applications with Knowledge Graphs and Deep Learning  
**6.6 Exploratory Search and Recommender Systems**

**Prof. Dr. Harald Sack**

FIZ Karlsruhe – Leibniz Institute for Information Infrastructure

AIFB – Karlsruhe Institute of Technology

**Autumn 2023**



# Knowledge Graphs

## Lecture 6: Intelligent Applications with Knowledge Graphs and Deep Learning

### 6.1 The Graph in Knowledge Graphs

Excursion 8: Distributional Semantics and Language Models

### 6.2 Knowledge Graph Embeddings

### 6.3 Knowledge Graph Completion

### 6.4 Knowledge Graphs and Language Models

### 6.5 Semantic Search

### 6.6 Exploratory Search and Recommender Systems

# The Retrieval Problem

- **Retrieval Problem:**
  - You are looking for **something specific**, i.e. you know what you are looking for.
- How to **specify your search request?**
  - E.g. for a (specific) book:  
*author name, title, etc.*
- Often you are using
  - (unique) identifier
  - descriptive metadata

Author: Jules Verne  
Title: From the Earth to the Moon



# The Retrieval Problem

## Index Lookup



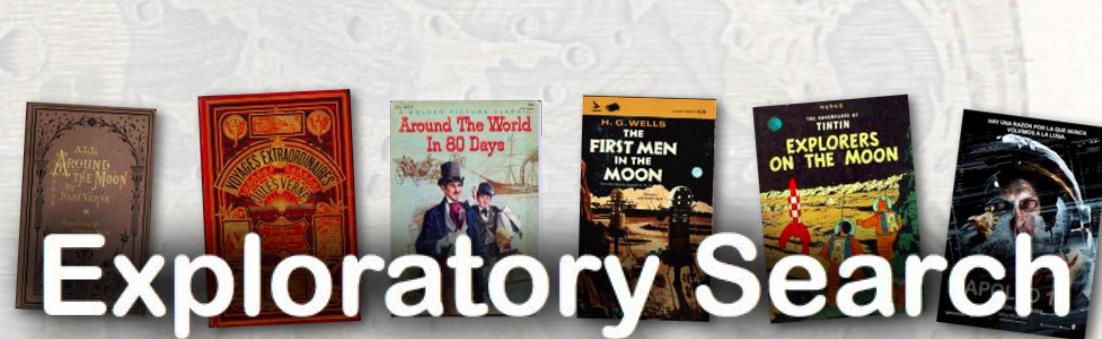
V E R N E, Jules.  
From the Earth to the Moon, Direct in  
97 Hours 20 Minutes and a Trip Round It,  
Sampson Low, Marston & Company,  
London (1873),  
viii, 323 p. plates.

GRC C.194.a.659, 12516.g.20

# Retrieval vs Exploration



- *Find another (“comparable”) book, (that will be of interest to me...).*
- *Find books of the same or of related topics.*
- *How did the author / the topic develop over time?*
- *What else would I like to read?*
- ...



# How to explore the Information Space

- If you **cannot find exactly** what you were looking for or if you **cannot exactly phrase** your search request, then you would be happy to at least **find something nearby**.
- **Similarity:**  
Discover things and documents **similar** (but not necessarily related) to your original search request.
- **Relatedness:**  
Discover things or documents that are closely **related** (but not necessarily similar) to your original search request.

# Exploratory Search via Linked Data



[http://dbpedia.org/resource/From\\_the\\_Earth\\_to\\_the\\_Moon](http://dbpedia.org/resource/From_the_Earth_to_the_Moon)

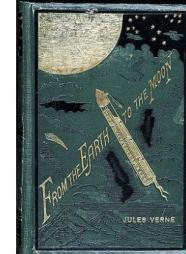


 DBpedia [Browse using](#) [Formats](#)

## About: [From the Earth to the Moon](#)

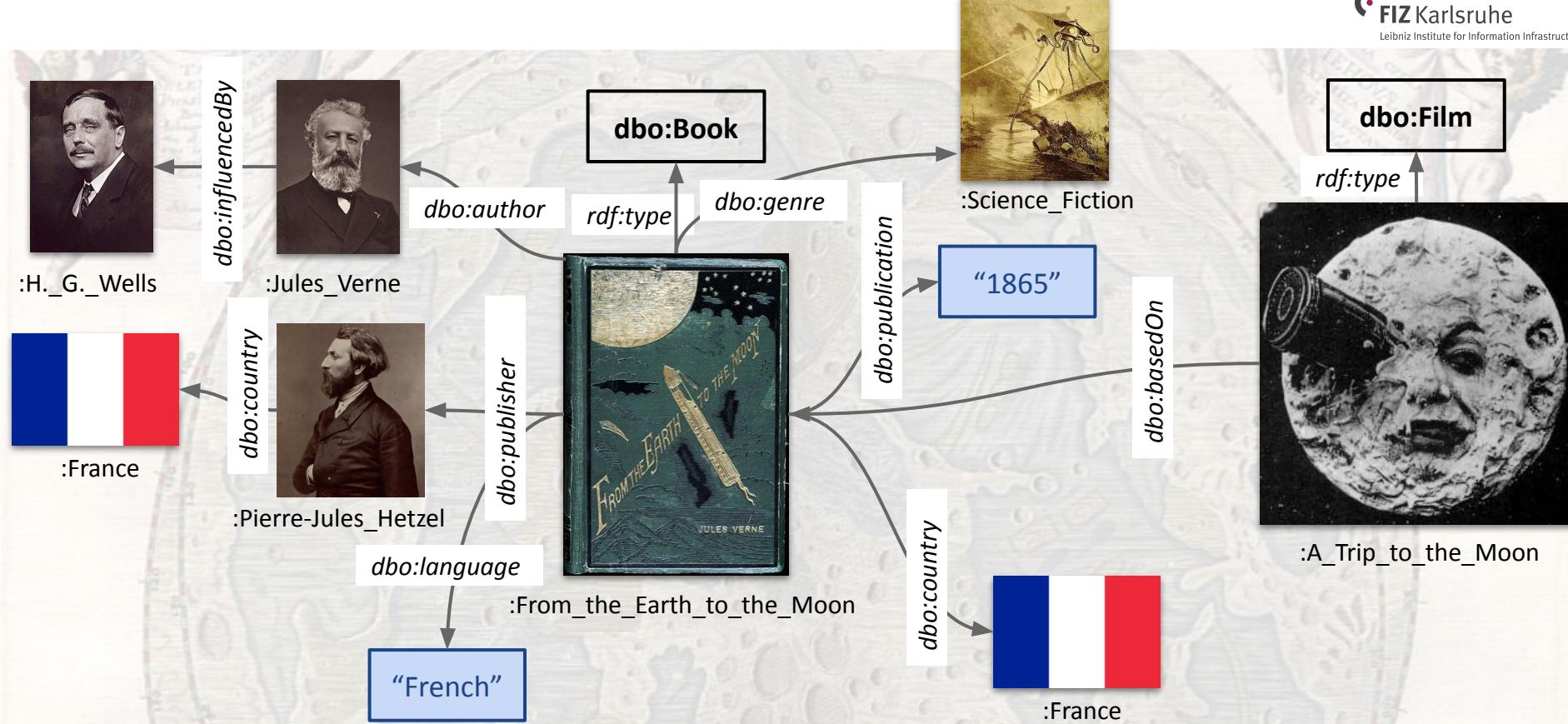
An Entity of Type: [book](#), from Named Graph: <http://dbpedia.org>, within Data Space: [dbpedia.org](#)

From the Earth to the Moon: A Direct Route in 97 Hours, 20 Minutes (French: *De la Terre à la Lune*, trajet direct en 97 heures 20 minutes) is an 1865 novel by Jules Verne. It tells the story of the Baltimore Gun Club, a post-American Civil War society of weapons enthusiasts, and their attempts to build an enormous Columbiad space gun and launch three people—the Gun Club's president, his Philadelphian armor-making rival, and a French poet—in a projectile with the goal of a Moon landing. Five years later, Verne wrote a sequel called *Around the Moon*.

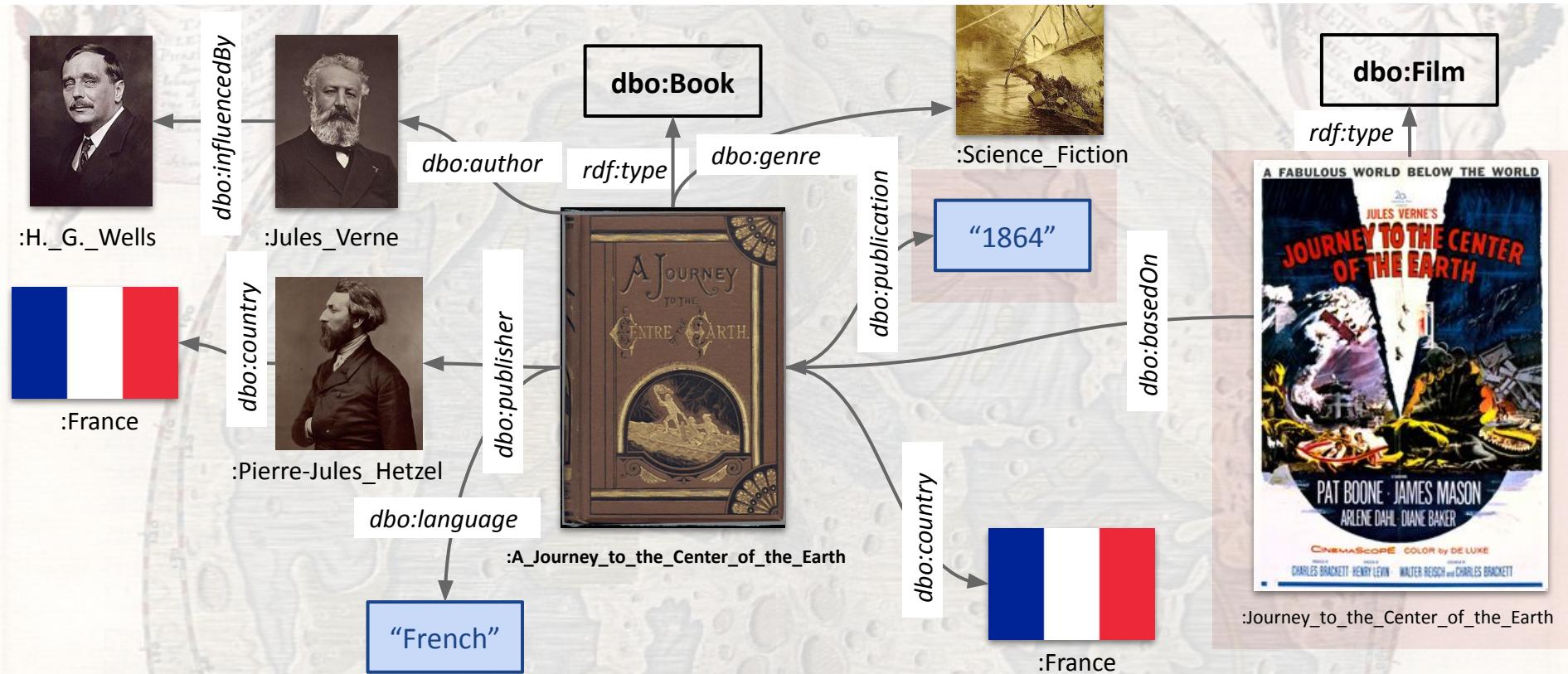


Property	Value
<a href="#">dbo:abstract</a>	<ul style="list-style-type: none"> <li>• Von der Erde zum Mond ist ein Roman des französischen Autors Jules Verne. Der Roman wurde erstmals 1865 unter dem französischen Titel <i>De la Terre à la Lune</i> von dem Verleger Pierre-Jules Hetzel veröffentlicht. Die erste deutschsprachige Ausgabe erschien 1873. Es handelt sich um ein frühes Werk des Science-Fiction-Genres, das die Mondfahrt um etwa hundert Jahre vorwegnimmt. Allerdings geht es hier vor allem noch um die Vorbereitung des Abenteuers. Der Roman Reise um den Mond (<i>Autour de la Lune</i>) von 1870 setzte die Geschichte fort. (de)</li> <li>• From the Earth to the Moon: A Direct Route in 97 Hours, 20 Minutes (French: <i>De la Terre à la Lune</i>, trajet direct en 97 heures 20 minutes) is an 1865 novel by Jules Verne. It tells the story of the Baltimore Gun Club, a post-American Civil War society of weapons enthusiasts, and their attempts to build an enormous Columbiad space gun and launch three people—the Gun Club's president, his Philadelphian armor-making rival, and a French poet—in a projectile with the goal of a Moon landing. Five years later, Verne wrote a sequel called <i>Around the Moon</i>. The story is also notable in that Verne attempted to do some rough calculations as to the requirements for the cannon and in that, considering the comparative lack of empirical data on the subject at the time, some of his figures are remarkably accurate. However, his version of a space gun for a non-rocket spacelaunch turned out to be impractical for safe human space travel since a much longer barrel would have been required to reach escape velocity while limiting acceleration to survivable limits for the passengers. The character of Michel Ardan, the French member of the party in the novel, was inspired by the real-life photographer Félix Nadar. (en)</li> </ul>
<a href="#">dbo:author</a>	<ul style="list-style-type: none"> <li>• <a href="#">dbr:Jules_Verne</a></li> </ul>
<a href="#">dbo:illustrator</a>	<ul style="list-style-type: none"> <li>• <a href="#">dbr:Émile-Antoine_Bayard_and_Alphonse-Marie_de_Neuville</a></li> </ul>
<a href="#">dbo:literaryGenre</a>	<ul style="list-style-type: none"> <li>• <a href="#">dbr:Science_fiction</a></li> </ul>
<a href="#">dbo:mediaType</a>	<ul style="list-style-type: none"> <li>• <a href="#">dbr:Hardcover</a></li> </ul>

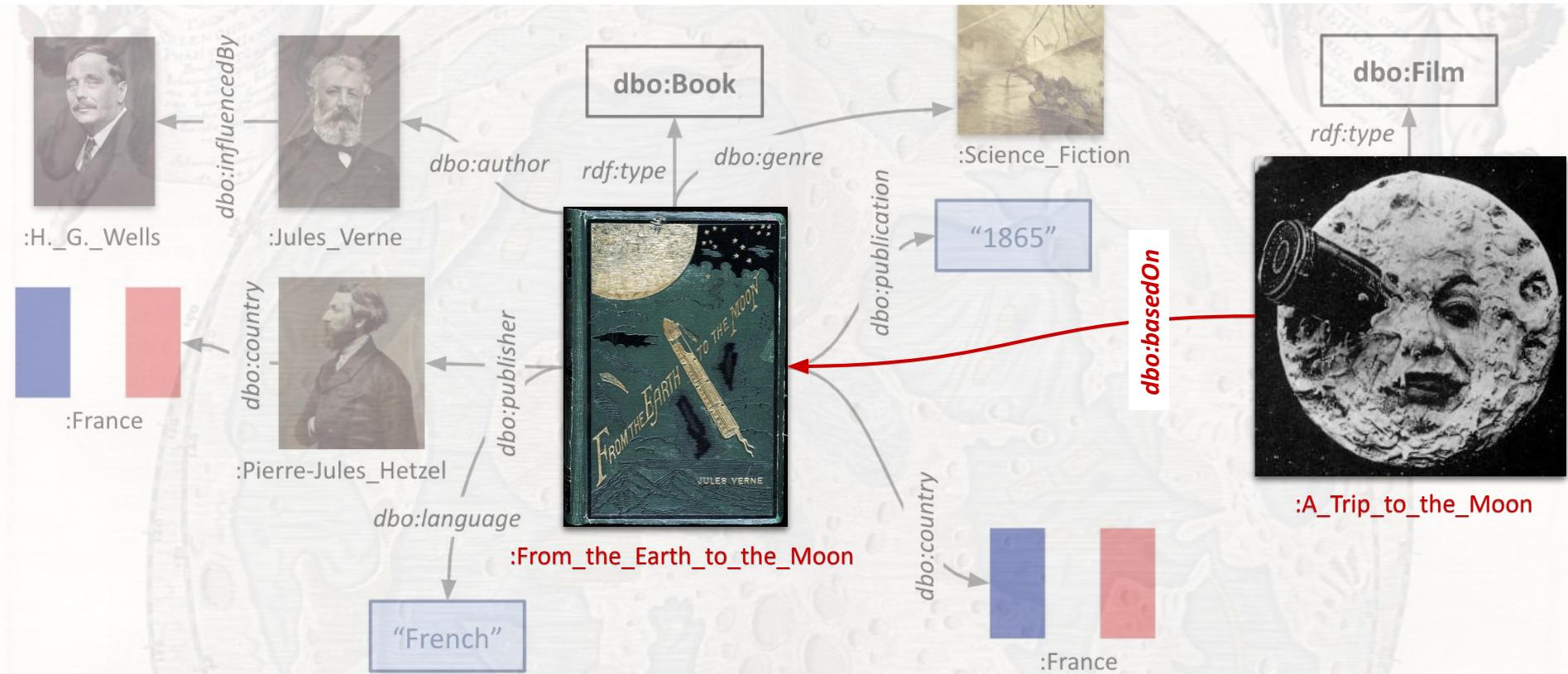
# Similarity vs Relatedness



# Similarity



# Relatedness



# Exploratory Search Strategies

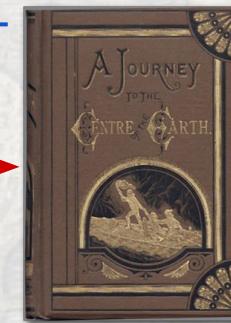
:From\_the\_Earth\_to\_the\_Moon



*rdf:type*

**dbo:Book**

*rdf:type*

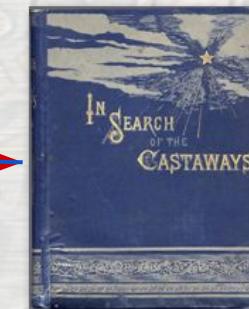


*dbo:subsequentWork*

**:A\_Journey\_to\_the\_Center\_of\_the\_Earth**

*rdf:type*

*dbo:previousWork*



**:In\_Search\_of\_the\_Castaways**

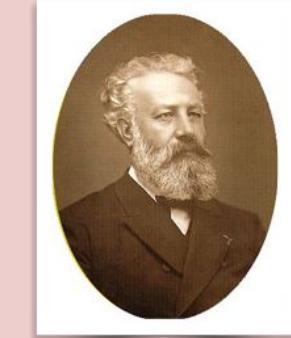
Combining **similarity** and **relatedness**.

# Exploratory Search Strategies

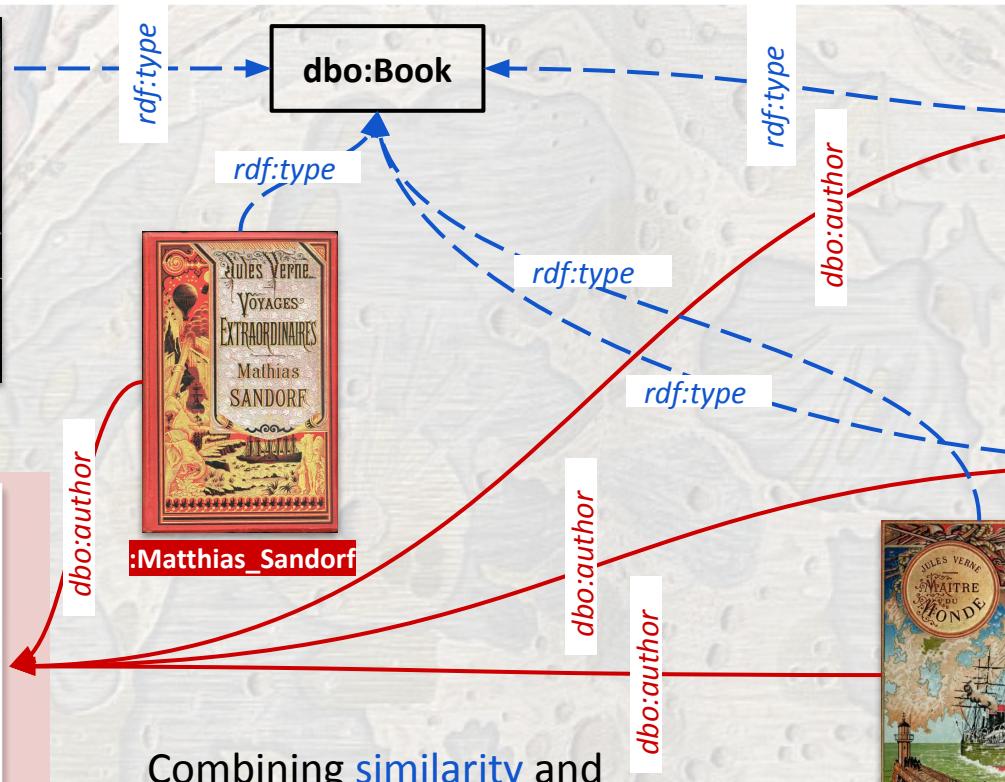
:From\_the\_Earth\_to\_the\_Moon



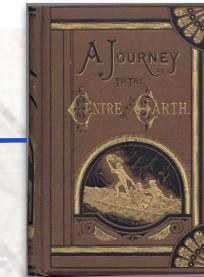
*dbo:author*



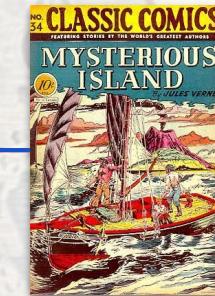
:Jules\_Verne



Combining **similarity** and  
relatedness **one hop away**.



:A\_Journey\_to\_the\_Center\_of\_the\_Earth

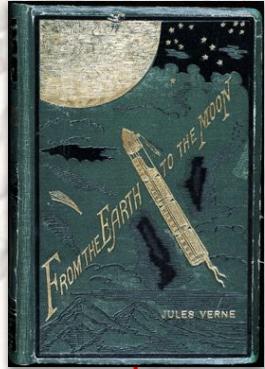


:The\_Mysterious\_Island

:Master\_of\_the\_World\_(novel)

# Exploratory Search Strategies

:From\_the\_Earth\_to\_the\_Moon



*dbo:author*



:Jules\_Verne

*rdf:type*

*rdf:type*

*rdf:type*

:H.\_G.\_Wells

*rdf:type*

*dbo:influenced*

*rdf:type*

*rdf:type*

*rdf:type*

*dbo:author*

*dbo:author*

Combining **similarity** and  
**relatedness** **two hops away**.

*rdf:type*

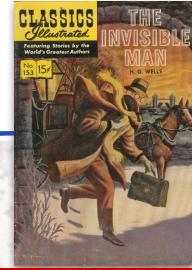
*rdf:type*

*rdf:type*

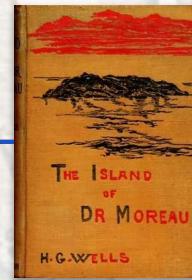
*dbo:author*

*dbo:author*

*dbo:author*



:The\_Invisible\_Man



:The\_Island\_of\_Doc\_Moreau



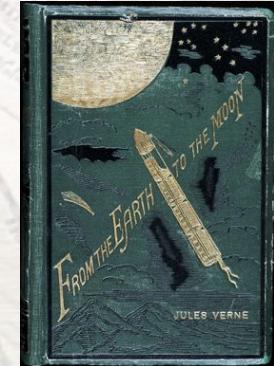
:The\_War\_of\_the\_Worlds

# From Exploration to Recommendation

- **Exploratory Search** represents the activities carried out by searchers who are either:
  - **unfamiliar with the domain** of their goal (i.e. need to learn about the topic in order to understand how to achieve their goal),
  - **unsure about the ways** to achieve their goals (either the technology or the process),
  - or even **unsure about their goals** in the first place.
- **Recommender Systems** seek to predict the preference a user would give to an item.

# What should I read next??

- Imagine, you want to read Jules Verne's "From the Earth to the Moon", but it is currently not available in your library.
  - What to do?
    - General idea to work with:  
Retrieve **similar books** sharing properties & property values with "*From the Earth to the Moon*".
- Can easily be achieved via **SPARQL** and e.g. DBpedia or Wikidata.



# What should I read next??

```
SELECT ?book (COUNT(DISTINCT ?o) as ?count)
WHERE {
  dbr:From_the_Earth_to_the_Moon ?p ?o .
  ?book rdf:type dbo:Book ;
    ?p ?o .
}
GROUP BY ?book
ORDER BY DESC(?count)
```



The actual query is a  
bit more complicated.  
But you will figure it  
out easily ... ;-)

[SPARQL query](#)

# What should I read next?



author	book	score
"Jules_Verne"	"In_Search_of_the_Castaways"	42
"Jules_Verne"	"Godfrey_Morgan"	41
"Jules_Verne"	"Michael_Strogoff"	41
"Jules_Verne"	"Tribulations_of_a_Chinaman_in_China"	40
"Jules_Verne"	"Two_Years'_Vacation"	40
"Jules_Verne"	"The_Green_Ray"	39
"Jules_Verne"	"The_Castaways_of_the_Flag"	39
"Jules_Verne"	"The_Mighty_Orinoco"	39
"Jules_Verne"	"A_Drama_in_Livonia"	39
"Jules_Verne"	"Mathias_Sandorf"	37
"Jules_Verne"	"The_Lighthouse_at_the_End_of_the_World"	36
"Frank_Herbert"	"Dune_(novel)"	34
"Pierre_Boulle"	"Planet_of_the_Apes_(novel)"	33
"Émile_Zola"	"L'Assommoir"	33
"Émile_Zola"	"L'Argent"	33
"Émile_Zola"	"Le_Rêve_(novel)"	33
"Émile_Zola"	"La_Curée"	33
"Émile_Zola"	"Nana_(novel)"	33
"Émile_Zola"	"Au_Bonheur_des_Dames"	33
"Émile_Zola"	"La_Bête_humaine"	33
"H._G._Wells"	"The_Island_of_Doctor_Moreau"	32
"Stephen_King"	"Cycle_of_the_Werewolf"	32
"Stephen_King"	"The_Running_Man_(novel)"	32
"Victor_Hugo"	"The_Man_Who_Laughs"	32
"Émile_Zola"	"Pot-Bouille"	32
"Jules_Verne"	"Clovis_Dardentor"	32
"Honoré_de_Balzac"	"Père_Goriot"	32
"Émile_Zola"	"La_Faute_de_l'Abbé_Mouret"	32
"Guy_de_Maupassant"	"Bel_Ami"	32
"Victor_Hugo"	"Les_Misérables"	32
"Honoré_de_Balzac"	"Eugénie_Grandet"	32
"Jules_Verne"	"César_Cascabel"	32
"Ray_Bradbury"	"Fahrenheit_451"	31
"Agatha_Christie"	"Murder_on_the_Orient_Express"	31
"Stephen_King"	"Needful_Things"	31
"H._G._Wells"	"The_First_Men_in_the_Moon"	31
"Charles_Dickens"	"Nicholas_Nickleby"	31
"Voltaire"	"Candide"	31
"Honoré_de_Balzac"	"Le_Père_Goriot"	31

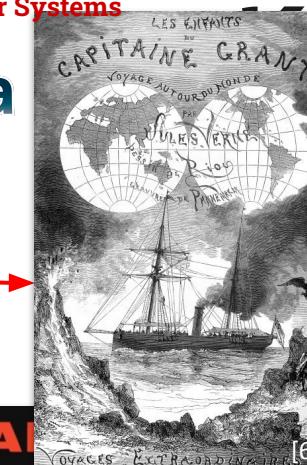
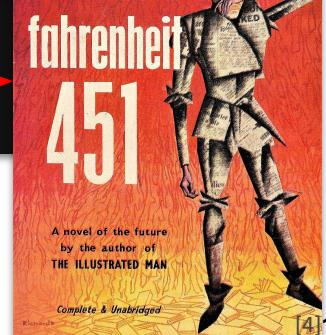
PLAY

OF THE APES

Pierre Boulle

AUTHOR  
THE BRIDGE OVER  
THE RIVER KWAI

RAY BRADBURY



[5]

17



Thank you very much for  
your Attention!

Next Lecture...

# Knowledge Graphs

## 6 Intelligent Applications with Knowledge Graphs and Deep Learning / 6.6 Exploratory Search and Recommender Systems

## Bibliographic References:

- J. Waitelonis, H. Sack (2012), [Towards exploratory video search using linked data](#), Multimedia Tools and Applications, Volume 59, Number 2 (2012), 645–672, Springer Netherlands.

## Picture References:

- [1] “On this romantic painting in the style of Goya we see a pensive woman together together giant octopus who melancholically entangles the knowledge graph that extends into the vast empty space of the universe to the galaxies and stars.”, created via ArtBot, Deliberate, 2023, [CC-BY-4.0],  
<https://tinybots.net/artbot>
- [2] Front cover of *Verne, Jules. (1874). From the Earth to the Moon : direct in ninety-seven hours and twenty minutes, and a trip round it.*, New York, Scribner, Armstrong, [Public Domain] via WikiCommons, [https://upload.wikimedia.org/wikipedia/commons/c/c4/From\\_the\\_Earth\\_to\\_the\\_Moon\\_Jules\\_Verne.jpg](https://upload.wikimedia.org/wikipedia/commons/c/c4/From_the_Earth_to_the_Moon_Jules_Verne.jpg)
- [3] Dr. Markus Gossler, The subject catalogue ("Schlagwortkatalog") of the University Library of Graz. [CC BY-SA 3.0],  
<https://upload.wikimedia.org/wikipedia/commons/7/7e/Schlagwortkatalog.jpg>
- [4] FAHRENHEIT 451 by Ray Bradbury, Corgi 1957. 160 pages. Cover by John Richards.[CC-BY 2.0], via WikiCommons,  
[https://commons.wikimedia.org/wiki/Category:Fahrenheit\\_451?uselang=de#/media/File:FAHRENHEIT\\_451\\_by\\_Ray\\_Bradbury,\\_Corgi\\_1957.\\_160\\_pages.\\_Cover\\_by\\_John\\_Richards.jpg](https://commons.wikimedia.org/wiki/Category:Fahrenheit_451?uselang=de#/media/File:FAHRENHEIT_451_by_Ray_Bradbury,_Corgi_1957._160_pages._Cover_by_John_Richards.jpg)
- [5] Cover of Planet of the Apes, by Pierre Boulle, American first edition hardcover. [Public Domain], via WikiCommons,  
[https://commons.wikimedia.org/wiki/Category:Planet\\_of\\_the\\_Apes\\_\(novel\)#/media/File:Planet\\_of\\_the\\_Apes\\_book\\_cover.jpg](https://commons.wikimedia.org/wiki/Category:Planet_of_the_Apes_(novel)#/media/File:Planet_of_the_Apes_book_cover.jpg)
- [6] An illustration from the novel "In Search of the Castaways; or Captain Grant's Children" by Jules Verne drawn by Édouard Riou, 1868, [Public Domain], via WikiCommons, [https://commons.wikimedia.org/wiki/Category:In\\_Search\\_of\\_the\\_Castaways#/media/File:The\\_Children\\_of\\_Captain\\_Grant\\_by\\_%C3%89douard\\_Riou\\_001.jpg](https://commons.wikimedia.org/wiki/Category:In_Search_of_the_Castaways#/media/File:The_Children_of_Captain_Grant_by_%C3%89douard_Riou_001.jpg)
- [7] “On this impressionistic painting in the style of Monet we see a pensive woman together together giant octopus who melancholically entangles the knowledge graph that extends into the vast empty space of the universe to the galaxies and stars.”, created via ArtBot, Deliberate, 2023, [CC-BY-4.0],  
<https://tinybots.net/artbot>