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Concept amalgamation of graph-based representation: a systematic literature review

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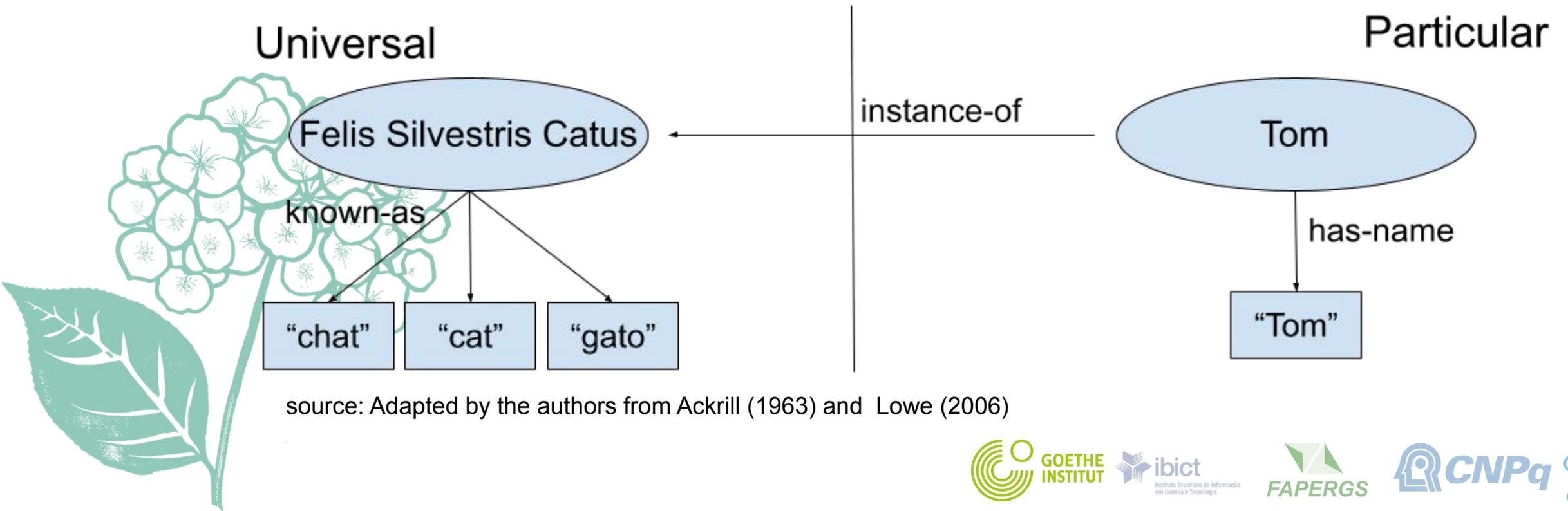


- KOS aim to manage knowledge from diverse sources.
- For example, different words may represent the same concept (Tudhope & Nielsen, 2006).
- Within KOS, **ontologies** represent the highest level of knowledge representation (Lima & Maculan, 2017), due to their precise modeling and ability to elicit structured relations from reality.



Ontology and Data Representation

- **Ontology** corresponds to a **model of universals** that outlines reality.
- **Individuals (particulars)** represent the **data instantiated** within this model.



This approach is applicable to AI techniques across domains:

- task-specific,
- linguistic,
- common-sense,
- strategic, and
- computational (programming languages).

Common graph-based structures include:

- causality graphs,
- knowledge graphs,
- semantic graphs,
- semantic networks.

Challenge:

- Despite the widespread use of ontologies,
- inconsistent terminology in graph-based models causes ambiguity.
- A deeper analysis is needed to clarify their overlaps and distinctions.

- What are the key conceptual distinctions between the terms **knowledge graph**, **causality graph**, **semantic network**, **semantic graph**, and **ontology** as used in LIS literature?
- This study **aims to identify and analyze the usage patterns of graph-based knowledge representation terms** in the field of LIS, highlighting similarities, differences, and recurring terminology, in order to enhance semantic clarity and and promote reflections on future conceptual standardization.

- This study adopted a Systematic Literature Review (SLR) methodology inspired by Kitchenham (2004)
- It followed three main phases:
 - (i) *planning* - defining the aim and protocol of the review;
 - (ii) *conducting* - identifying relevant research, selecting studies, and assessing their quality;
 - (iii) *reporting* - synthesizing and summarizing the collected information.



- This study aims to examine the differences and similarities among recurring terms used in graph-based knowledge representation.
- **The research questions (RQs) are:**
 - (RQ1) Do authors use different terms to refer to the same concept?
 - (RQ2) What are the distinctions between these approaches?
- **Main search terms:** (i) knowledge graph, (ii) causality graph, (iii) semantic network, (iv) semantic graph, and (v) ontology.
- **Complementary terms:** (i) definition, (ii) concept, and (iii) conceptualization.

<i>Field</i>	<i>String</i>
Title	"knowledge graph" OR "causality graph" OR "semantic network" OR "semantic graph" OR "ontolog*"
Title	definition OR concept*

Database Selection Criteria and Sources

"The scientific databases were selected based on the following criteria:

- (i) open access or accessibility via the Comunidade Acadêmica Federada (CAFe);
- and
- (ii) availability of filters for publications in Library and Information Science.

Selected Databases:

- (i) Web of Science (WoS)
- (ii) Library, Information Science & Technology Abstracts (LISTA)
- (iii) Base de Dados Referenciais de Artigos de Periódicos em Ciência da Informação (Brapci)

Inclusion and Exclusion Criteria

The inclusion criteria:

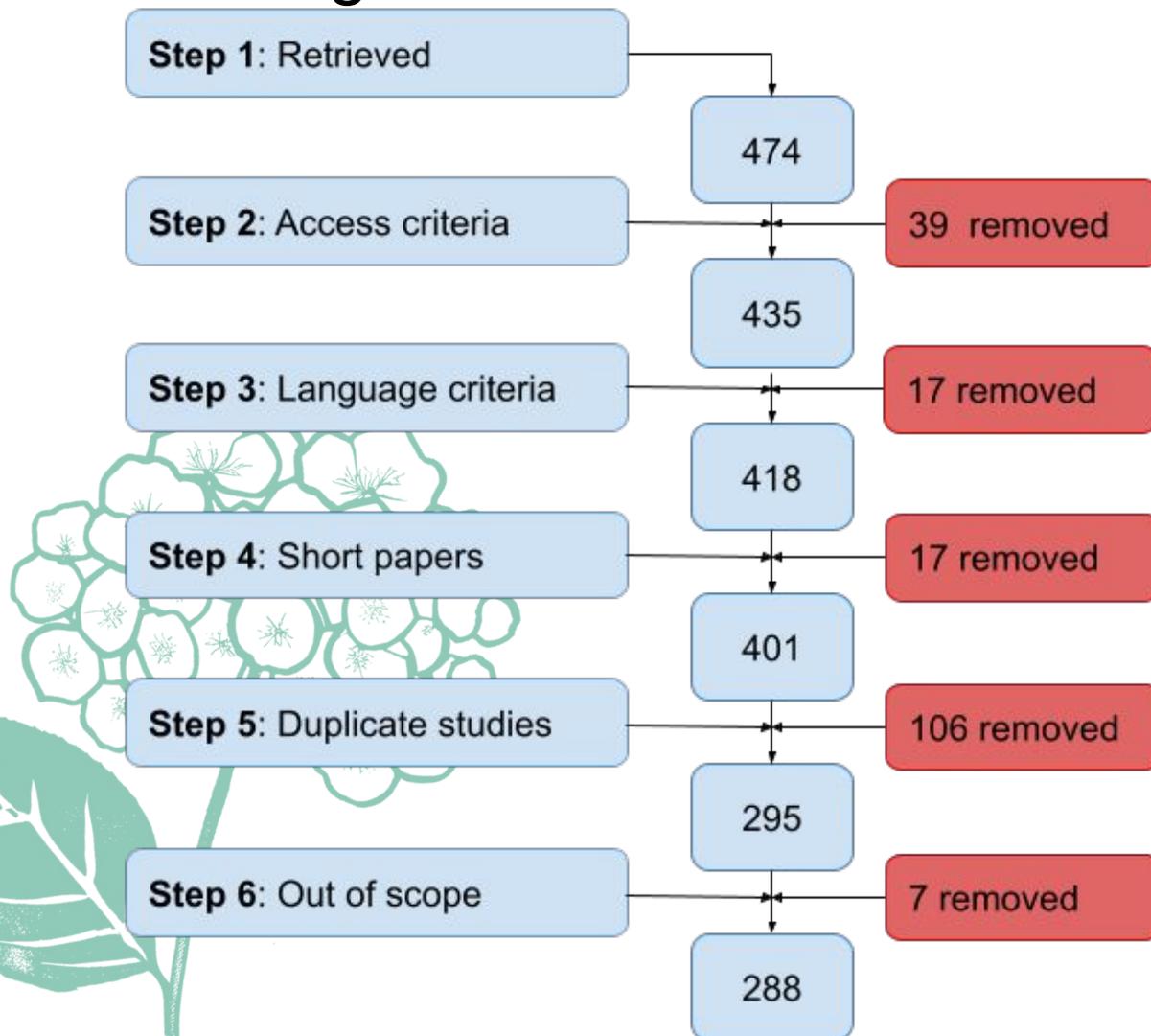
- (i) Publications from 2019 to 2023;
- (ii) Full-text availability online
- (iii) Papers addressing: knowledge graphs (KG), causality graphs, semantic networks, semantic graphs, or ontologies

• Exclusion criteria:

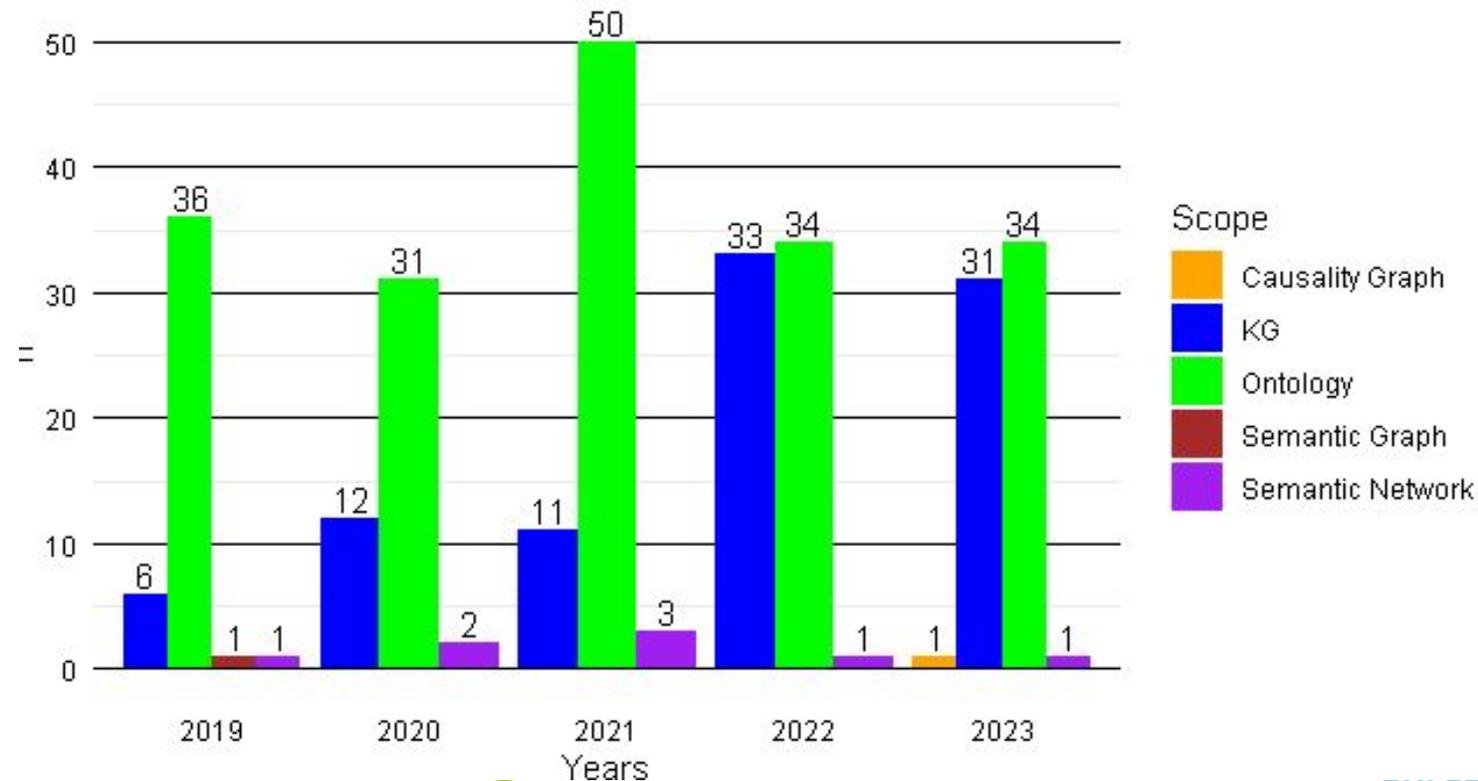
- (i) Duplicate studies (only the most complete version retained)
- (ii) Short articles (fewer than 5 pages)
- (iii) Not written in Portuguese, Spanish, or English
- (iv) Redundant content across versions (the most comprehensive version considered)



- Conducting Review



- Quantitative overview of the **288** studies
- Main scopes of the studies are as follows:
 - (i) **185** studies on ontology; (ii) 93 studies on knowledge graphs (KG);
 - (iii) **8** studies on semantic networks;
 - (iv) **1** study on causality graphs;
 - (v) **1 study** on semantic graphs.



- Primary Focus

Causality Graphs	Semantic Graphs	Semantic Networks	KG	Ontologies
Formalizing cause-and-effect relationships to distinguish correlation from causation.	Structured representation of evolving event sequences and their semantic and contextual relationships.	Analytical tools to reveal underlying meaning in structural data patterns, primarily used in textual data analysis.	Structured representations of general knowledge about real-world entities, concepts, and their relationships.	Formal and explicit specifications of shared conceptualizations to define entities, attributes, and relationships, focusing on common vocabulary and interoperability .



- Detailed Structure

Causality Graphs	Semantic Graphs	Semantic Networks	KG	Ontologies
Use directed edges to indicate causal influences between variables.	Described as a directed tree, with nodes representing events and edges capturing semantic relationships.	Represent interconnected concepts, often based on word co-occurrence patterns.	Typically represented as triples (subject, predicate, object).	Formally define entities, attributes, relationships, and constraints, support the construction of domain models, and adopt an open-world assumption. Use standardized languages like OWL .



- Purpose and Primary Applications

Causality Graphs	Semantic Graphs	Semantic Networks	KG	Ontologies
Cornerstones for decision-making by analyzing cause-and-effect systems.	Help distill large datasets into storylines and interpret complex sequences.	Applied in textual data analysis (like social networks and scientific publications) and scientometrics .	Serve as a foundation for various AI applications (semantic search, recommendation, QA) and transforming data into actionable insights .	Crucial for semantic interoperability, data fusion, the Semantic Web, and conceptual modeling .

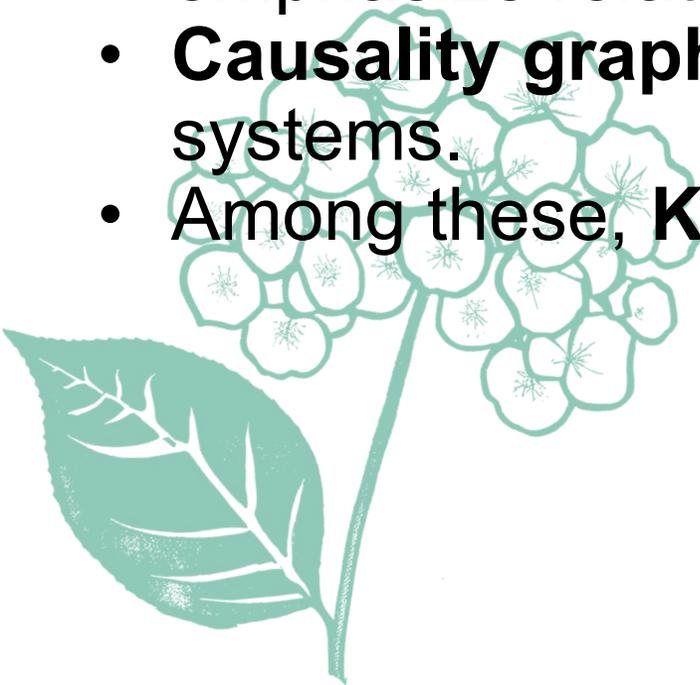


- Relationship Between Them

Causality Graphs	Semantic Graphs	Semantic Networks	KG	Ontologies
Not explicitly detailed in the literature	Not explicitly detailed in the literature	Not explicitly detailed in the literature	KG can draw upon ontologies to enhance semantic capture.	Extract knowledge graphs from the dataset



- Ontologies are the most prominent term in LIS literature, typically associated with domain modeling.
- In recent years, **KG** has gained prominence, while the use of other terms has remained relatively stable.
- The terms **semantic graph** and **semantic network** are used to emphasize relationships between nodes.
- **Causality graphs** focus on cause-and-effect relationships with systems.
- Among these, **KG** and **ontologies** are more **intrinsic connected**.



Research Overview

- **Objective:** Identify and analyze usage patterns of terms related to graph-based knowledge representation in LIS.
- **Method:** Systematic Literature Review (SLR) of 288 selected studies (from 474 initially retrieved).
- **Key Finding:** All forms of graph-based representations are often grouped under the term **Knowledge Graphs (KG)**.

Key Results

- **Rise in KG Publications:** Notable increase since 2022, contrasting with the steady volume of publications on **ontologies**.
- **Ontologies:** Emphasize **explicit, shared domain modeling**.
- **Semantic Graph & Semantic Network:** Used for **specific relational applications** in LIS.
- **Causality Graphs:** Applied to **cause-and-effect** analyses.
- **Conclusion:** Further studies are needed to deepen conceptual distinctions across terms.

- The **guiding question** has been addressed, and the **research problem resolved**.
- This study contributes to **conceptual clarity** in graph-based knowledge representation, supporting advancements in **semantic data integration, knowledge management, and AI applications**.

Limitations

- Exclusion of **foundational pre-2019 studies**.
- **Database selection** may limit diversity of perspectives.

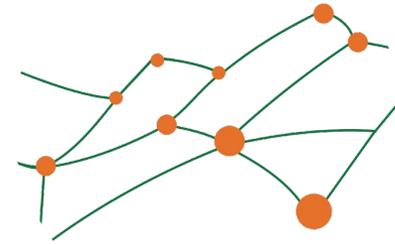
Final Remark

- Despite limitations, the findings offer **valuable insights** for future research and practical innovation in **Library and Information Science** and related domains.

Agradecimentos



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