Selected Applications of Graph-based Knowledge Representation

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Abstract. Graph-based conceptualization constitutes a natural mean for knowledge representation in several branches of Artificial Intelligence. From ontological descriptions of the universe of discourse to graphical depiction of business processes, graphs play an important role in modern intelligent systems. In this submission, we report on some of the research threads on graph-driven knowledge engineering carried out within KRaKEn Research Group at AGH University of Science and Technology.

Keywords: Knowledge Representation · Knowledge Engineering · Explainability · Transparency · Graphs

1 Introduction

Graphs, in their simple form a pair of sets of nodes and edges, are a mathematical abstraction that has found numerous applications in Computer Science as a convenient data structure and flexible representation method. In this paper, we review some of the recent developments in selected branches of knowledge management and engineering using graphs in KRaKEn (https://kraken.edu.pl/).

The paper is structured as follows. In Section 2, we present a graph-based solution for analysis of the relations in our research group. Section 3 shortly introduces our approach to using graphs for AI explainability. Section 4 provides an insight to our future works regarding using graph techniques for analyzing business process models. We conclude our paper in Section 5.

2 Graphs for Knowledge Representation and Processing

In order to explore the possibilities of knowledge representation and visualization with graphs, a use case of a research group has been analyzed [1]. A network of relations among team members, activities, research areas and teaching responsibilities has been modeled with a graph database (see Fig. 1), thus enabling flexible visualization possibilities (see Fig. 2) based on simple queries.

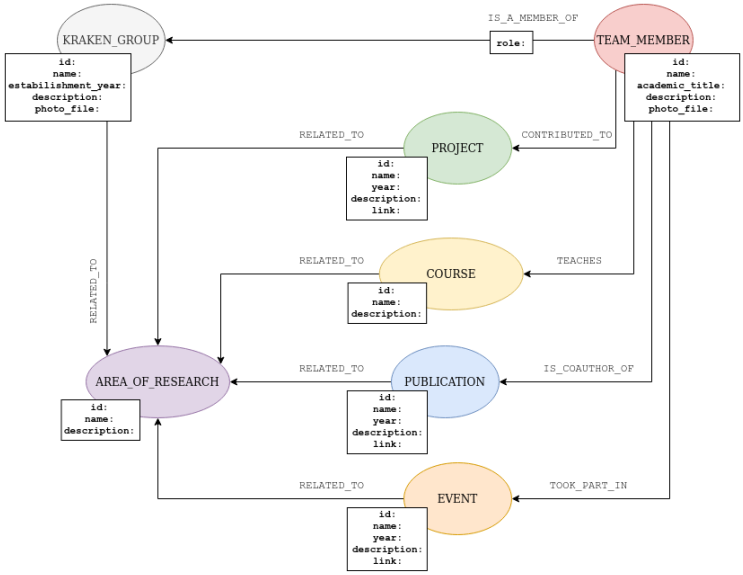

Fig. 1. Graph-based knowledge representation about the research team.

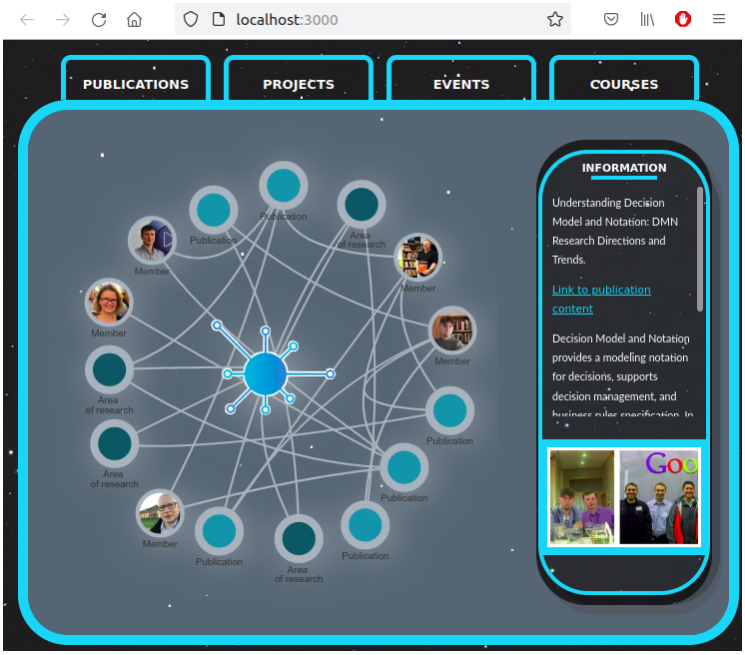

Fig. 2. View of a publication with links to its authors, metadata etc.

Possibilities of using graph-oriented knowledge has also been explored within the context of recommendation systems [2]. Both knowledge-based recommenders as well as content-based filtering systems can be conveniently designed and implemented when knowledge is modelled with graphs. In fact, recommendations can extensively use simple queries enriched with some similarity calculations.

```
MATCH (r:Resort)
WITH COLLECT({resort: r, score: 0}) AS resorts

MATCH (r:Resort)-[a:ACCOMMODATION]-(:Accommodation)
WHERE a.halfBoard <= 1000 OR a.fullBoard <= 1000
WITH DISTINCT r AS r, resorts, 4.0 AS s
WITH resorts + COLLECT({resort: r, score: s}) AS resorts

MATCH (r:Resort)-[:WINE_AND_DINE]-(w:WineAndDine)
WHERE w.type IN ["Underwater Restaurant", "Bar"]
WITH r, resorts, COUNT(w) * 5.0 / 2 AS s
WITH resorts + COLLECT({resort: r, score: s}) AS resorts

UNWIND resorts AS record
RETURN record.resort AS r, sum(record.score) / (4.0+5.0) * 100
AS score
ORDER BY score DESC
```

3 Graphs for Explainability

Despite providing high performance, deep learning techniques are often perceived as complicated and untrustworthy. To mitigate this issue, the domain of explainability and interpretability arouse. Its goal is to generate outputs along with explanations, which are understandable for experts and lay people.

Witch several methods existing, none of them utilised graphs. In [3], we propose a novel approach for explainable systems, which incorporates knowledge graphs for presentation of results. A node in such a graph stays for influence of a given feature and the thickness of its edge depicts importance of a specific connection. The use of graphs allows for highlighting two variables and their interactions.

4 Graphs for Business Process Analysis

Models of business processes provide knowledge representation that helps organizations visualize and optimize their processes, allowing them to achieve their business goals more effectively. Such models can be represented using various notations [4, 5]. Process model discovery is a group of popular methods for knowledge acquisition under the broad umbrella of process mining solutions [6]. Such mining techniques can generate models from the event logs without any *a priori* knowledge about the process.

In recent years, modern versions of the algorithms which allow for BPMN models discovery has been proposed, such as BPMN Miner [7], Split Miner [8], P-Miner [9]. As such discovered models constitute graphs, it is possible to compare and analyze the obtained models using graph similarity methods [10] and take advantage of the knowledge graphs techniques for such analysis [11]. Moreover, the classical process discovery algorithms work on the event logs. Graph based algorithms might be also helpful in enhancing the data [12], especially unstructured data for creating event logs.

5 Conclusions

In this paper, we give a brief overview of the selected research threads conducted in the KRaKEn Research Group at the AGH UST concerning graph-based knowledge representation. We show how graphs can be used for knowledge representation and processing, provide the explainability method, as well as be utilized for business process analysis.

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