CogNet2: A Multi-Level Frame Organized Knowledge Base Integrating Linguistic, World and Commonsense Knowledge

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Abstract

In this paper, we present CogNet2, an extension of the CogNet knowledge base, which combines the significant events form Wikidata, entities from YAGO4 and commonsense assertions from ATOMIC. It aims to unify knowledge of multiple levels of granularity. To efficiently integrate significant event and entity knowledge into CogNet, we construct significant event- and entity-centric frames, and then link them to the CogNet by automated labeling and crowd-sourced annotation. To enrich CogNet with more commonsense knowledge in social interaction, we construct frames with element restriction for fine-grained typical situations and integrate commonsense assertions about them. As a result, in comparison with CogNet1, CogNet2 increases 800+ new frames of significant events and entities, 30000+ new fine-grained frames with element restrictions, more than 204K new commonsense assertions. The scale of frame instances is up to 33.4M in total.

Keywords

Knowledge Graph, Commonsense Knowledge, World Knowledge, Linguistic Knowledge,

1. Introduction

Recent years have seen a rise of large-scale knowledge bases (KBs): (1) linguistic knowledge such as WordNet [1] and FrameNet [2] are mainly compiled by linguists to depict relations between different semantic units (concept or frame); (2) world knowledge collects facts about the real world, e.g., Wikidata [3] and DBpedia [4]; (3) commonsense knowledge aims to capture implicit general facts and regular patterns in daily life, including ConceptNet [5] and ATOMIC [6].

As data volume and variety have increased, it is challenging for systems to freely share and use data across different sources. Unifying data from the greatest possible variety of sources into a single data source has recently drawn growing attention from both academic

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and industrial communities. YAGO [7] uses linguistic resources WordNet to organize world knowledge from Wikipedia. FrameBase [8] integrates several world knowledge bases based on the frames from FrameNet. CogNet (edition 1.0) [1] [9] further adopts a three-level unified frame-styled representation architecture to bridge linguistic knowledge, world knowledge and commonsense knowledge, with the aim of joint query and utilization. For example, world knowledge of *pacific war* is represented as an instance of frame `Hostile_encounter`, and commonsense knowledge assertion "*buying book requires going to bookstore*" is represented as the relation between frame `Commerce_buy` and `Motion` with element restrictions.

Although frame-styled representations enable CogNet to unify different kinds of knowledge, current CogNet still has following limitations that can be further improved.

Lacking specific frames to describe significant events. CogNet contains many general frames to characterize events from the perspective of linguistics. For example, frame `Competition` is utilized to describe the "*sport*" events at a high level. However, significant "*sport*" events in world knowledge resources such as Wikidata are usually subdivided into "*running*", "*cycling*", "*ball game*", etc. Intuitively, dividing general frames into specific frames will be better to describe the significant events.

Neglecting entity-centric frames. CogNet mainly focuses on event-centric knowledge, but neglects entity-centric semantic structures. For the event "*Yao Ming won the FIBA Asia Cup MVP Award in 2005*", CogNet has relevant frame `Win_prize` to describe this event, and takes entity "*Yao Ming*" as one of its elements (i.e., `Competitor`). In fact, entity "*Yao Ming*" also has a frame structure, including elements such as "*name*", "*occupation*" and "*spouse*", which are critical for semantic understanding but not well organized in CogNet.

Lacking frames with element restrictions. Another important part of CogNet is commonsense knowledge, which often describes the connections between fine-grained situations. For example, "*buying a book* $\xrightarrow{prerequisite}$ *going to a bookstore*" is a piece of commonsense knowledge, where "*going to a bookstore*" and "*buying a book*" are fine-grained situations, which can be described using specific frames with element restrictions. For example, "*buying a book*" is a specific version of `Commerce_buy` where the `Goods` element is restricted to "`book`" type. CogNet has transformed event-related concepts from ConcpetNet into frame-with-element-restriction (FER) representations to integrate commonsense knowledge, yet the coverage is still sparse.

To address the aforementioned limitations, we propose CogNet2, a multi-level frame organized knowledge base, which aims to extend CogNet with significant events from Wikidata, entities from YAGO4 and commonsense assertions from ATOMIC.

In summary, CogNet2 has three improvements as follows. **(1) Structure.** It increases specific frames for significant events and entities. **(2) Source.** It incorporates two new knowledge sources, YAGO4 and ATOMIC. **(3) Scale.** It consolidates a larger scale of world knowledge and commonsense knowledge instances. Currently, CogNet2 increases 800+ new frames, 30000+ new frames with element restrictions and more than 204K new commonsense assertions, and the scale of frame instances is up to 33.4M in total. The data and online demo is available at http://cognet.top/v2/.

[1] In this paper, we use CogNet to refer the edition 1.0

2. Method

Knowledge Hierarchy We illustrate the knowledge hierarchy and data model of CogNet2 in Figure 1. Frames constitute the first layer (the topmost dotted box) in the figure. We take the frames from FrameNet as the higher-level types, which are connected with their elements and definition texts. We take the lexical units and the extended specific frames from Wikidata and YAGO4 as the lower-level types (hatched rectangle). Those frames constitute the taxonomy of CogNet2. The second layer (the middle dotted box) in the figure consists of the "frame with element restriction (FER)" nodes, which are fine-grained frames that has type restrictions on some elements. We connect FER nodes with their restriction statements, and represent commonsense knowledge assertions as relations between FER nodes. At the third layer (the bottom dotted box), the frame instances record world knowledge about specific events or entities.

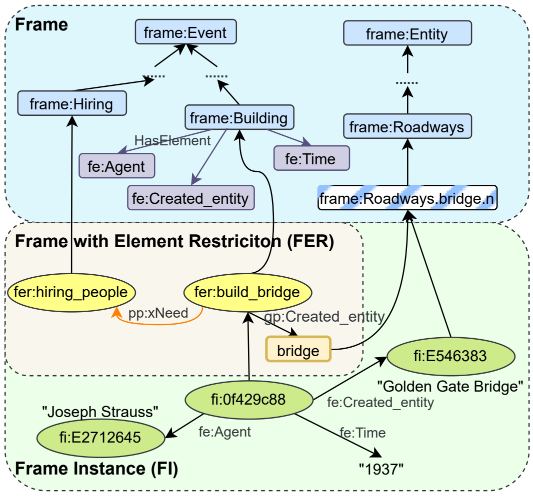

Figure 1: Illustration of the Data Model.

Significant Event-Centric Frame Construction We collect specific frames about significant events from Wikidata to elaborate the general frames in FrameNet. We select event classes that have more than 10 direct instances as specific frames, and link specific frames regarding to significant events to the corresponding general frames with automated labeling and crowd-sourced annotation. Finally, we extract event instances from Wikidata based on SPARQL rules, and link them to corresponding specific frames.

Entity-Centric Frame Construction CogNet usually takes entities as elements in an event-centric frame. We utilize YAGO schema to form the entity-centric frames where schema names are frame names and properties are frame elements. Then human annotators link entity-centric frames to CogNet. Finally,we enrich CogNet with entity instances from YAGO4 based on SPARQL rules.

Incorporating Commonsense Knowledge we consolidate CogNet with ATOMIC to enrich more fine-grained situations and corresponding social commonsense knowledge. Since the nodes in ATOMIC are freely expressed in natural language phrases, we first normalize the phrases to remove duplicates, and then ask human workers to conduct frame semantics annotation, which assigns each phrase with its frame type and elements. Finally, we use the annotation results to construct FER nodes and automatically link them with frame instances.

3. Online Platform

We provide an online platform to facilitate the query of CogNet2 (http://cognet.top/v2/) . The data of CogNet2 are downloadable in RDF turtle format (under a CC-BY-SA 4.0 license) and can be query with the online SPARQL service. In addition, we also provide a convenient browser. It provides an easy-to-use key word query engine to access frames and instances. Each frame, FER or frame instance has a corresponding information page to show their descriptions and connections to other nodes. Besides, the platform enables to explore the knowledge taxonomy from the top to bottom, traversing from abstract frames to concrete instances.

4. Related Work

There are continuous efforts to integrate different linguistic knowledge resources [10, 11, 12], commonsense knowledge resources CSKG [13]. And bridging knowledge resources at different abstraction levels [7, 8]. Inspired by previous work, CogNet [9] explored to utilize semantic frames to combine commonsense knowledge and world knowledge. To improve its coverage and granularity, this paper further enriches semantic frames with significant and fine-grained event and entity types from more sources, making better integration of different kinds of knowledge.

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References

[1] G. A. Miller, Wordnet: a lexical database for english, Communications of the ACM 38 (1995) 39–41. URL: https://dl.acm.org/doi/abs/10.1145/219717.219748.

[2] C. F. Baker, C. J. Fillmore, J. B. Lowe, The Berkeley FrameNet project, in: Proceedings of the 36th Annual Meeting of the Association for Computational Linguistics and 17th International Conference on Computational Linguistics, 1998, pp. 86–90. URL: https://aclanthology.org/P98-1013.

[3] D. Vrandečić, M. Krötzsch, Wikidata: a free collaborative knowledgebase, Communications of the ACM 57 (2014) 78–85. URL: https://dl.acm.org/doi/10.1145/2629489.

[4] J. Lehmann, R. Isele, M. Jakob, A. Jentzsch, D. Kontokostas, P. N. Mendes, S. Hellmann, M. Morsey, P. Van Kleef, S. Auer, et al., Dbpedia–a large-scale, multilingual knowledge base extracted from wikipedia, Semantic web 6 (2015) 167–195. URL: https://content.iospress.com/articles/semantic-web/sw134.

[5] R. Speer, J. Chin, C. Havasi, Conceptnet 5.5: An open multilingual graph of general knowledge, in: Proceedings of the AAAI conference on artificial intelligence, 2017. URL: https://ojs.aaai.org/index.php/AAAI/article/view/11164.
[6] M. Sap, R. Le Bras, E. Allaway, C. Bhagavatula, N. Lourie, H. Rashkin, B. Roof, N. A. Smith, Y. Choi, Atomic: An atlas of machine commonsense for if-then reasoning, in: Proceedings of the AAAI conference on artificial intelligence, 01, 2019, pp. 3027–3035. URL: https://ojs.aaai.org/index.php/AAAI/article/view/4160.
[7] M. Fabian, K. Gjergji, W. Gerhard, et al., Yago: A core of semantic knowledge unifying wordnet and wikipedia, in: Proceedings of the 16th International World Wide Web, 2007, pp. 697–706. URL: https://www2007.org/papers/paper391.pdf.
[8] J. Rouces, G. de Melo, K. Hose, Framebase: Representing n-ary relations using semantic frames, in: Proceedings of the Semantic Web. Latest Advances and New Domains, 2015, pp. 505–521. doi:10.1007/978-3-319-18818-8_31.
[9] C. Wang, Y. Chen, Z. Xue, Y. Zhou, J. Zhao, Cognet: Bridging linguistic knowledge, world knowledge and commonsense knowledge, in: Proceedings of the AAAI Conference on Artificial Intelligence, 2021, pp. 16114–16116. URL: https://ojs.aaai.org/index.php/AAAI/article/view/18029.
[10] M. L. De Lacalle, E. Laparra, G. Rigau, Predicate Matrix: extending SemLink through WordNet mappings, in: Proceedings of the Ninth International Conference on Language Resources and Evaluation, 2014, pp. 903–909. URL: http://www.lrec-conf.org/proceedings/lrec2014/pdf/589_Paper.pdf.
[11] F. Corcoglioniti, M. Rospocher, A. P. Aprosio, S. Tonelli, PreMOn: a Lemon Extension for Exposing Predicate Models as Linked Data, in: N. Calzolari, K. Choukri, T. Declerck, S. Goggi, M. Grobelnik, B. Maegaard, J. Mariani, H. Mazo, A. Moreno, J. Odijk, S. Piperidis (Eds.), Proceedings of the Tenth International Conference on Language Resources and Evaluation, 2016, pp. 877–884. URL: https://aclanthology.org/L16-1141.
[12] A. Gangemi, M. Alam, L. Asprino, V. Presutti, D. R. Recupero, Framester: A Wide Coverage Linguistic Linked Data Hub, in: E. Blomqvist, P. Ciancarini, F. Poggi, F. Vitali (Eds.), Proceedings of the Knowledge Engineering and Knowledge Management, Lecture Notes in Computer Science, 2016, pp. 239–254. doi:10.1007/978-3-319-49004-5_16.
[13] F. Ilievski, P. Szekely, B. Zhang, Cskg: The commonsense knowledge graph, in: The Semantic Web: 18th International Conference, ESWC 2021, 2021, pp. 680–696. doi:10.1007/978-3-030-77385-4_41.