

GRAPH-ONTOLOGY MODEL OF COGNITIVE-SIMILAR INFORMATION RETRIEVAL (on the requirements tracing task example). *N.V. Maksimov¹, O.L. Golitsina¹, K.V. Monankov¹, N.A. Bal¹.*

¹National Research Nuclear University MEPhI, Moscow, Russia. e-mail: nv-maks@yandex.ru, kmonankov@yandex.ru, baln757@mail.ru



NATIONAL RESEARCH
NUCLEAR UNIVERSITY

Summary

This study discusses technologies for meaningful text analysis using an example related to the technical requirements tracing task, which is characterized by both the search for specific requirements and the identification of contradictions both between different "instances" of a particular parameter, and between the declared and achieved values. Such search is characteristic of cognitive operations performed by a person in the process of analyzing and synthesizing knowledge.

Introduction

One of the tools for analyzing scientific and technical documentation is the technology of automatic construction of ontologies for texts in natural language [1]. Such tools synthetically combine linguistic, statistical and cognitive approaches and allow to build an oriented graph of the document ontology containing vertices corresponding to all entities presented in the text in accordance with their location, and edges corresponding to typed relationships between entities.

References

1. Maksimov, N.V., Golitsina, O.L., Monankov, K.V., et al.: Semantic Search Tools Based on Ontological Representations of Documentary Information. *Autom. Doc. Math. Linguist.* 53(4), 167-178 (2019).
2. Maksimov, N.V., Golitsina, O.L., Monankov, K.V., et al.: Knowledge Representation Models and Cognitive Search Support Tools. *Procedia Computer Science* 169, 81-89 (2020).
3. Golitsyna, O. L., Maksimov, N. V., Okropishina, O. V., et al.: The Ontological Approach to the Identification of Information in Tasks of Document Retrieval. *Autom. Doc. Math. Linguist.* 46(3), 125-132 (2012).
4. Maksimov, N.V., Gavrilkina, A.S., Andronova, V.V., et al.: Systematization and identification of semantic relations in ontologies for scientific and technical subject areas. *Autom. Doc. Math. Linguist.* 52(6), 306-317 (2018).
5. Golitsina, O. L., Maksimov, N. V., Okropishina, O. V., et al.: An Ontological Approach to Information Identification in Tasks of Document Retrieval: A Practical Application. *Autom. Doc. Math. Linguist.* 47(2), 46-61 (2013).

The Ontology Definition

The Ontology is a set of three interconnected systems (by GST) [3]: $O = \langle S_f, S_c, S_t \rangle$:

- $S_f = \langle M_f, A_f, R_f, Z_f \rangle$ — is the functional system;
- $S_c = \langle M_c, A_c, R_c, Z_c \rangle$ — is the system of concepts;
- $S_t = \langle M_t, A_t, R_t, Z_t \rangle$ — is the terminology system;
- $\equiv$ — the operation of comparing elements of different systems at the level of signs.

The Aspect Definition

An aspect is formally specified by the corresponding "aspect ontology", where the functional system is $S_a = \langle M_a, A_a, R_a, Z_a \rangle$.

An aspect is operationally defined by its characteristic set of basic concepts (entity names), by a set of classes of functional relations and their modalities as characteristic properties.

Technology of forming a semantic aspect subgraph

The result of the aspect projection operation is the intersection of the original and aspect ontologies. The algorithm includes the following actions:

1. In the graph of the functional system of the original ontology, it is necessary to find arcs corresponding to relations with given properties.
2. Construct a subgraph including vertices incident to the found arcs.
3. To expand the set of basic concepts, add to the subgraph the arcs incident to the included vertices, corresponding to the meta-relations, and the incident vertices to them.

An example of the "requirements" aspect ontology

In the example, the "requirement" aspect is used, which is defined by the relationship classes $R_a = \langle \text{"comparison"}, \text{"change"}, \text{"restriction"} \rangle$, and/or the relationship should have the modality property $A_a = \langle \text{"need"} \rangle$.

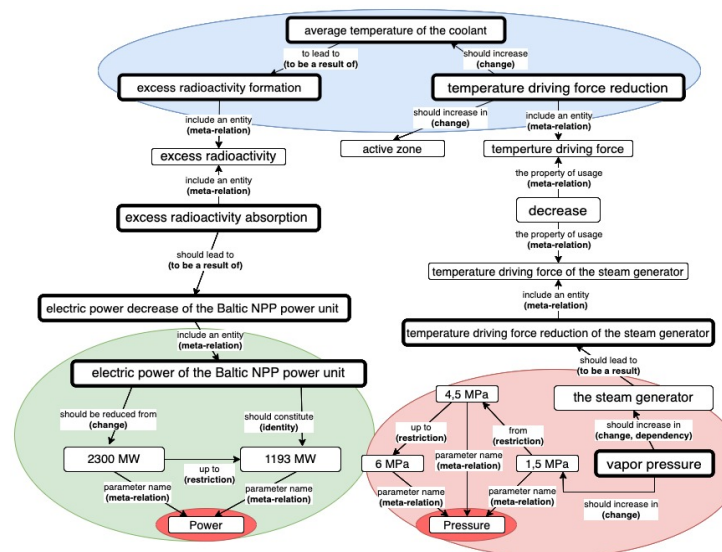


Fig. 1. Subgraph of the document ontology. Vertices with bold font found by the query "power" and the vertices associated with them in the "requirement" aspect. Arcs named relationship name and class. The font size inside the vertices of the graph depends on the frequency of occurrence of the term within the document.

As a result of visual analysis, the relationship between the parameters "Power" and "Pressure", formed by the functional relations "Be the result", can thus be revealed: "Vapor pressure" – "Should increase in" – "The steam generator" – "Should lead to" ("To be a result") – "Temperature driving force reduction of the steam generator" – "meta-relations" – "Temperature driving force reduction" – "Should increase in" – "Average temperature of the coolant" – "Should lead to" ("To be a result") – "Excess radioactivity formation" – "meta-relations" – "Excess radioactivity absorption" – "Should lead to" ("To be a result") – "Electrical power decrease of the Baltic NPP power unit", that is, an increase in steam pressure leads to a decrease in the power of the power unit.

Conclusion

The use of aspect projections allows moving from graph vertices to relevant fragments of the source text on a compact set of concepts (as entry points to the search process). In turn, combining the found fragments allows to form an image of the problem being solved, as well as check it for compliance with the logic of the target problem and consistency of facts. And building a graph based on the text formed from different fragments of relevant documents allows to verify for consistency and compliance with the target task.

Using the developed tools, it becomes possible to identify the relationship between parameters of the object, which were not in the immediate vicinity in the text. The example shows the technical requirements extraction technology, based on the application of the search for the graph vertices and the identification of the dependence of the monitored parameters.

The use of the developed tools as part of an information retrieval system with full-text semantic indexing makes it possible to move from the tasks of classical information retrieval to the implementation of cognitive-similar information retrieval process as building a path on a multi-meta-hypergraph of an ontology, that is dynamically formed on the basis of ontological images of founded documents or their fragments.

Acknowledgments

This work was supported by the Ministry of Science and Higher Education of the Russian Federation (state assignment project No. 0723-2020-0036).