Using Semantic Patterns in Web Search and Assessment of Professionally Oriented Texts in a Foreign Language for Training Students in Higher Education Institutions of Mineral Resource Profile

https://doi.org/10.3991/ijet.v17i05.28231

Yuliya Murzo(✉), Natalia Chuvileva, Aleksandra Schetinina
Saint-Petersburg Mining University, Saint-Petersburg, Russia
Murzo_YuE@pers.spmi.ru

Abstract—The article aims to analyse the possibility to use methods of web search and identification of semantic text patterns with a view to automatising the web search and assessment of professionally oriented texts used to train students at foreign language departments of higher education institutions of mineral resource development profile. The work provides an overview of relevant AI methods that may be employed to perform the tasks mentioned above and analyses a number of similar works. It offers a structure of patterns that can be used to find relevant research articles and describes approaches to assessment of the texts found. It also proposes the front-end structure of an application that can be tasked with web search and subsequent assessment of texts. The case study presents semantic analysis and assessment of a professionally oriented text written in English. The research done shows good prospects for using Semantic Web technologies for web search and assessment of texts available on the Internet not only for training students but also, in broader formulation, for teaching and learning in a chosen direction. This is ensured by flexibility of methods for semantic pattern search and identification. With respect to further development of the research, the authors consider designing an operational application for text search and assessment and also outcome analysis for a variety of directions of learning within the mineral resources development domain.

Keywords—pattern, semantic web, artificial intelligence, professionally-communicative, foreign-language, technical terms vocabulary, mineral-resources

1 Introduction

The two widely known technologies, namely Natural Language Processing (NLP) [1] and Semantic Web [2], are essentially semantic technologies, but they interact with different aspects of data. A combination of these two technologies allows to address an extended class of problems in the course of processing texts, in particular, scientific and research papers within the mineral resources development domain. Using NLP for extracting data from text documents is instrumental for identification of semantically related professionally oriented lexical terms that can be further classified against selected criteria (in particular, attributed to mineral resources development domain). This approach allows to calculate the proximity of semantic patterns identified in a text to direction-specific criteria that can be developed for any of the domains concerned. Therefore, it is possible to develop automated applications that will autonomously search for relevant text documents such as scientific articles, review papers, research reports, etc. The relevance will be achieved through identification of direction-specific patterns in the texts with the use of the NLP tools followed by classifying the texts against a domain or subdomain of interest. Since the degree of proximity between the text and the domain is measurable, the value can be used to estimate the extent of proximity of a text to the target knowledge area. This way, setting the threshold value for the degree of proximity of the texts found to the formulated reference templates allows to automatically search for texts of target quality only, given that quality means proximity to the above mentioned domain templates. Considering the above, the task is subdivided into the following operations:

- Creating domain templates for the texts under study;
- Classifying a text against domain templates;
- Calculating the degree of proximity of the text under study to the domain template;
- Deciding on including the text in the learning course based on the criterion of proximity to the domain template.

The Materials and methods section presents Analysis of related works, Problem statement, Input data for creating domain templates and their structure, Using knowledge graphs for domain template storage, Criteria of proximity of the found texts to domain templates, and Case study. The Conclusion gives a retrospective analysis of the work and defines the goals for further development of the research.

2 Materials and methods

2.1 Analysis of related works

Development of automated training systems has been gaining relevance in the course of the last two years due to greater demand on distance learning methods [13, 14] as a consequence of the COVID-19 pandemic. The quality of the developed training systems and courses directly affects student satisfaction with their learning experience and its outcomes [17,36,37]. Using semantic technologies in education has been widely discussed, with emergence of a standalone trend called SWBE (Semantic Web Based Education) [3], which sets out key approaches of designing educational systems based on Semantic Web. These systems draw on wide use of ontologies connected both to teaching and learning process and to knowledge areas involved. Ontologies allow us to define the rules applied in achieving certain educational purposes, and in fact, introducing the ontology processor in the architecture of education information systems made it possible to change over from scrutinizing WBE (Web Based Education) systems to

SWBE systems [4]. An ontology can be defined as an explicit specification of a conceptualisation [5]. A description of any ontology includes definitions of terms and their interconnections. Taken together, the terms are then superimposed onto a chosen subject area and are limited by ranges of possible values [6]. One of the key uses of ontologies in data systems engineering is to improve interaction between people or computers [7, 22]. Ontologies can be developed and enriched through a variety of methods [25], and also be extended with data found in texts, as is shown in one of the related works [26], as well as integrate with other ontologies [32]. Today knowledge management systems in various domains are commonly organized on the basis of ontologies [27 to 30]. This way, domain and educational ontologies can be used as framework to design information systems in line with SWBE approach where it is possible to automatise new tasks, for instance search for and assessment of education content based on estimation of degree of proximity of the found education content (articles, webpages, etc.) to the developed ontology pertaining to a SWBE-driven educational information system.

The role of data warehouses in semantic data systems has increasingly often been implemented by knowledge graphs [8], which combine the capacity of graph database (RDF) [34, 35], graph data analysis tools and ontologies storage, and of easy user interface, such as Metaphactory [9]. Knowledge graphs underpin numerous systems that complete tasks in certain domains, for example in telecommunication monitoring systems [20]. With the view to developing and using SWBE systems, knowledge graphs offer a convenient range of tools for storing education content and ontologies, and for data analysis by means of the extensive Semantic Web toolkit.

Knowledge graphs are also widely used in the field of education. The definition of a recommendation for creating a learning path by means of a knowledge graph is presented by Shi et al [10]. Lin et al [11] propose a new system to assess the activities of a university department based on multifaceted knowledge network (UFES-KG) which integrates heterogeneous information about teachers.

Knowledge graphs can also be applied to address the task of entity classification, which presents some features of interest with regard to education content assessment; for instance, Li et al [12] propose a method of text fragment classification using a knowledge graph.

Analysis of related works shows that the SWBE field is fairly well established in terms of designing the architecture of educational information systems. However, the attention to using direction-specific ontology based systems intended for web search and assessment of education content has been insufficient.

2.2 Document content

Figure 1 presents a component scheme for an information system intended for automated web search and assessment of training texts by applying text semantic patterns and ontologies.

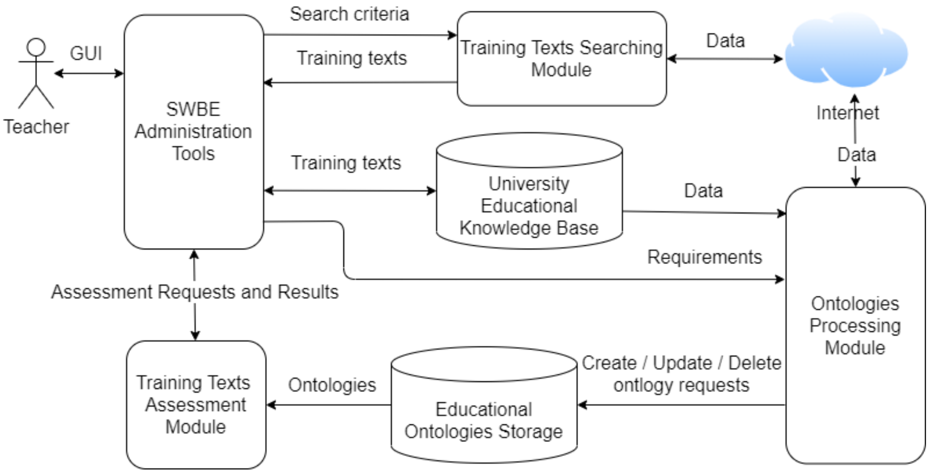

Fig. 1. Component scheme of an information system intended for automated web search and analysis of training texts

The system components are as follows:

- Training Texts Searching Module intended for automated web search of training texts in agreement with a given set of parametres.
- SWBE Administration Tools, a set of administrative tools to operate an information system, allowing interaction of a user in the capacity of "Teacher" with the information system by means of graphic interface (GUI).
- University Educational Knowledge Base, a university knowledge base that contains all digital education content used in the teaching and learning process. While developing education content for foreign language courses, the methods proposed by Yu. M. Sischuk and Veronika Sharok [15, 16] can be effectively used.
- Ontologies Processing Module intended for management of educational ontologies. The module, directed by user requirements, supports creation, updating and deleting of ontologies used for SWBE-driven teaching and learning.
- Educational Ontologies Storage intended for storing and providing fast access to ontologies used by SWBE to support teaching and learning process.
- Training Texts Assessment Module intended for assessment of training texts for compliance with certain ontologies that contain domain semantic patterns. In the course of assessment, degree of proximity of a found training text to a certain ontology is calculated, and upon comparing the amount received against a set threshold value a decision is made whether to use the text in teaching and learning process.

Interaction of the system components is described in Table 1.

Table 1. System components interaction

Request generating component	Request type	Request processing component	Response
SWBE Administration Tools	Set the criteria for education content search	Training Texts Searching Module	Confirms receivingsearch criteria
	Request/ Save education content	University Educational Knowledge Base	Confirms successful operation
	Set/ Update/ Delete requirements to ontologies used in teaching and learning process	Ontologies Processing Module	Confirms operations on requirements
	Request assessment of a training text for consistency with the educational ontology	Training Texts Searching Module	Communicates the results of assessing the text for consistency with the educational ontology
Educational Texts Searching Module	Web search of training texts in agreement with the set criteria	The Internet	Search results
Ontologies Processing Module	Data search to expand the educational ontologies	The Internet	Search results
	Data search to expand the educational ontologies	University Educational Knowledge Base	Search results
	Create/ update/ delete ontology requests	Educational Ontologies Storage	Result of processing a request
Educational Texts Assessment Module	Query for ontology	Educational Ontologies Storage	The requested ontology

The system of components presented underpins the following functions:

1. Automated web search for training texts followed by proximity estimation with regard to educational ontologies.
2. Enriching educational ontologies with data from the university database and the Internet.

2.3 The role of domain templates in an educational ontology and input data used to create them

A domain template is a list of domain terminology to be found in training texts. Creating domain templates for teaching foreign language courses in higher education institutions of mineral resources development profile is proposed to be built upon basic professional vocabulary lists worked out for every direction of learning. Domain templates are introduced as separate classes in a foreign language educational ontology, as shown in Figure 2.

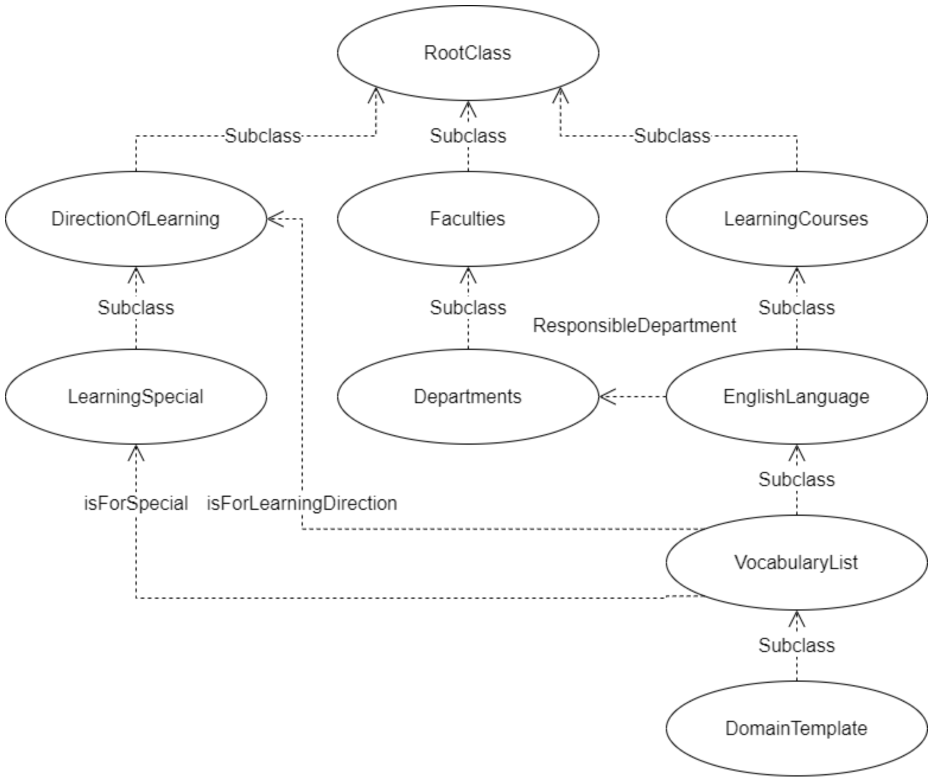

Fig. 2. A fragment of educational ontology including a domain template class and the related classes

As shown in the diagram, domain templates are related to basic professional vocabulary lists developed for English language courses for every direction of learning and learning specialisation.

2.4 Using knowledge graphs for domain template storage

SWBE technology requires to semantically organise the training information the systems operate. Knowledge graphs built on RDF data store allow for subject-predicate-object data organisation [18]. A knowledge graph for a SWBE system is based on rules determined for the educational ontologies in use and can include a semantic network where the nodes are not only knowledge graph objects but also external entities (for instance, those pertaining to a university database, with IRI used as a node). The advantage of storing ontologies in the form of knowledge graphs is the possibility to keep the record of all changes made to the ontologies stored and to provide access to those records [33]. A fragment of a knowledge graph containing an example of a domain template, examples of texts included in the learning course and the key elements of knowledge graph related to them is presented in Figure 3. The tools used to build the presented knowledge graph fragment also included a FOAF ontology [31].

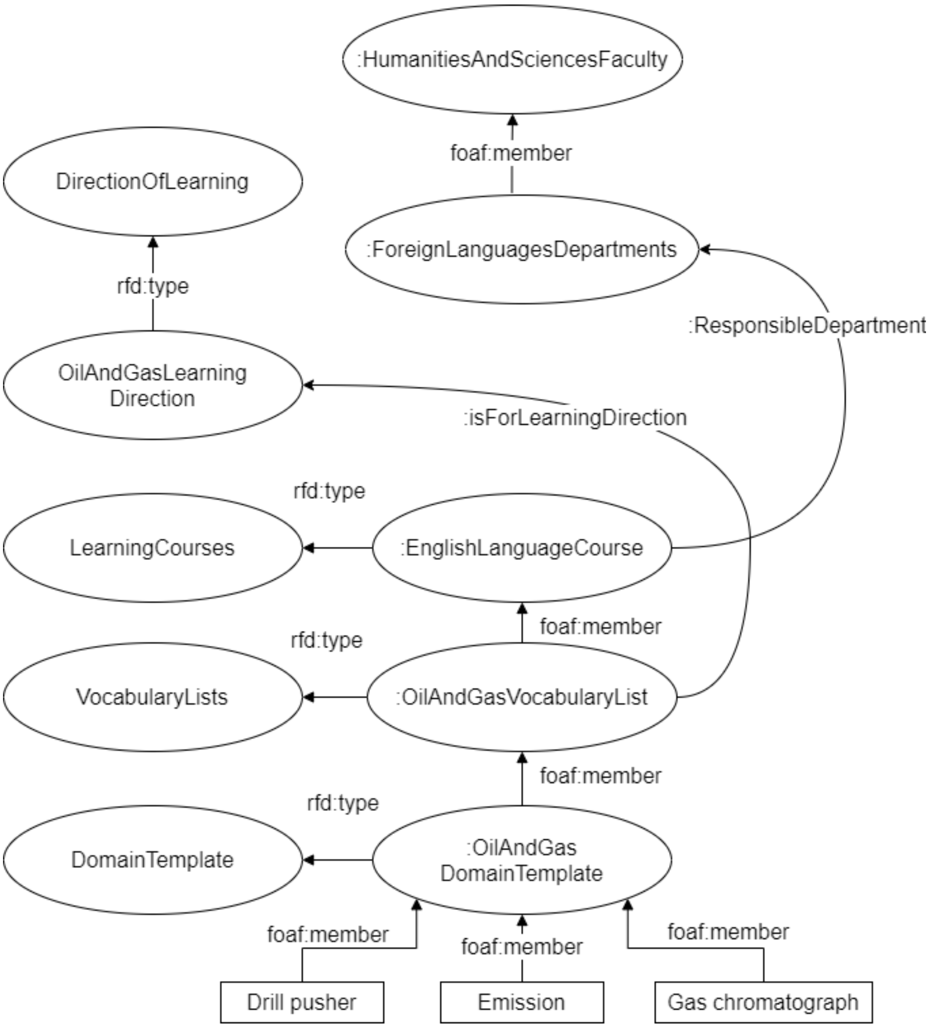

Fig. 3. Fragment of a university SWBE system knowledge graph

Figure 3 shows *rdf:type* links that define types of knowledge graph elements and *foaf:member* links that define their group membership. The*: ResponsibleDepartment* link shows that the learning course is taught by a certain university department, while the *isForLearningDirection* shows that the basic professional vocabulary list pertains to a certain direction of learning. The fragment presented demonstrates the proposed approach to designing a knowledge graph to ensure the efficiency of SWBE involving automatic web search and assessment of training texts.

2.5 Criteria of training texts proximity to domain templates

Domain templates contain lists of professional vocabulary selected in accordance with certain parametres. The number of terms in a domain template, the frequency of their use in professionally oriented texts and level of complexity are determined by expert method and show the quality characteristics of the domain template itself. In this context, it is advantageous to have the opportunity of estimating the proximity of the texts found by web search to domain templates in automated mode and of deciding on their usability based on comparing the calculated criteria against the set threshold values. In order to estimate the proximity of a text to a domain template, the following criteria are proposed:

- Terminology coverage (*Cov*). The criterion is defined as the percentage of terms present in a found text in relation to the number of those listed in the domain template. Suppose N is the number of terms listed in the domain template, with N_{text} being the number of terms pertaining to the domain template that appear in the found text. In this case Terminology coverage is determined by the following formula:

$$Cov = \frac{N_{text}}{N} 100\% \tag{1}$$

- Frequence of using the terms pertaining to a domain template (*Freq)*, determined as the percentage ratio of terms pertaining to the domain template to the overall number of words in a found text. Suppose S_{text} shows how many times the terms listed in the domain template appear in the text, with S being the total number of words in the text. The frequence of using the terms pertaining to the domain template is determined by the following formula:

$$Freq = \frac{S_{text}}{S} 100\% \tag{2}$$

These criteria are calculated for every text found in the course of web search. The text is further used in the teaching and learning process if the proximity criteria values do not fall below the threshold values:

$$Cov \geq Cov_{\min}, Freq \geq Freq_{\min}. \tag{3}$$

2.6 Case study

As an example of real-world application of the proposed method let us consider creation of an*: OilAndGasDomainTemplate* domain template drawing upon basic vocabulary lists, accessible for analysis and processing, which are normally used by foreign language departments of higher technical education institutions to assess student knowledge. The terms included in a basic vocabulary list have the following characteristics:

- Frequence rating, showing how often the term is used in professionally oriented texts pertaining to the domain under study. The rating is calculated over the totality of texts used in the teaching and learning process, and its value ranges as (0,1). The ratio is relative, with its value directly related to the number of times the term appears in the texts.
- Complexity of a term. This criterion is determined by expert assessment of the foreign language department teachers, with the value expressed in whole numbers in the range of [1,10]. The assessment is relative, with the value directly related to the difficulty students have while using the term.

A fragment of basic vocabulary list for *Oil And Gas* domain in CSV format is given below:

```
TERM, FREQUENCY_OF_USE,COMPLEXITY
Exploration team,0.176,2
Extended reach drilling,0.202,3
Facility,0.687,1
Feasibility,0.332,3
Flaring of gas,0.319,2
Flow line,0.308,2
Flushing,0.128,2
FPSO (floating production storage and offtake),0.022,5
Fractionation,0.436,2
```

To develop a domain template a sample of *N* terms is drawn, with frequence of use *F* or higher and complexity not below *C*. The sample is then converted into OWL [22,24] and imported into the ontologies storage as*: OilAndGasDomainTemplate* domain template. A fragment of the domain template created with the use of Protégé [21] visual ontology editor is presented below:

```
<!-- http://webprotege.stan-
ford.edu/RCoLJJ0RAKRgJICLqX7wkH3 -->

    <owl:NamedIndividual  rdf:about="http://web-
protege.stanford.edu/RCoLJJ0RAKRgJICLqX7wkH3">
          <rdf:type rdf:resource="http://webprotege.stan-
ford.edu/RiXFFWhCGMp3aAwubruEZP"/>
          <rdf:type>
              <owl:Restriction>
                  <owl:onProperty rdf:re-
source="http://xmlns.com/foaf/0.1/member"/>
                  <owl:someValuesFrom rdf:re-
source="http://www.w3.org/2001/XMLSchema#string"/>
              </owl:Restriction>
          </rdf:type>
        <rdfs:label>OilAndGasDomainTemplate</rdfs:label>
```

```
      </owl:NamedIndividual>

  <!-- http://webprotege.stan-
ford.edu/R7eVZ4vNa9QejCk9HvEkhpO -->

    <owl:NamedIndividual rdf:about="http://web-
protege.stanford.edu/R7eVZ4vNa9QejCk9HvEkhpO">
          <rdf:type rdf:resource="http://webprotege.stan-
ford.edu/RCy7F9j5hUTm8DKbUEmrDCh"/>
            <foaf:member rdf:resource="http://web-
protege.stanford.edu/RCoLJJ0RAKRgJICLqX7wkH3"/>
            <rdfs:label>Facility</rdfs:label>
      </owl:NamedIndividual>

      <!-- http://webprotege.stan-
ford.edu/R7kMNnlasMFM1ERCUyr5ODE -->

        <owl:NamedIndividual rdf:about="http://web-
protege.stanford.edu/R7kMNnlasMFM1ERCUyr5ODE">
              <rdf:type rdf:resource="http://web-
protege.stanford.edu/RCy7F9j5hUTm8DKbUEmrDCh"/>
          <foaf:member rdf:resource="http://web-
protege.stanford.edu/RCoLJJ0RAKRgJICLqX7wkH3"/>
            <rdfs:label>FPSO (floating production storage
and offtake)</rdfs:label>
      </owl:NamedIndividual>

      <!-- http://webprotege.stan-
ford.edu/R9KtJWTKv8ilhmwCv5Hxrye -->

      <owl:NamedIndividual rdf:about="http://web-
protege.stanford.edu/R9KtJWTKv8ilhmwCv5Hxrye">
          <rdf:type rdf:resource="http://webprotege.stan-
ford.edu/RCy7F9j5hUTm8DKbUEmrDCh"/>
          <foaf:member rdf:resource="http://web-
protege.stanford.edu/RCoLJJ0RAKRgJICLqX7wkH3"/>
          <rdfs:label>Flow line</rdfs:label>
      </owl:NamedIndividual>
```


Therefore, by managing such sample parametres as *N, F,* and *C,* we can set quality parametres of a domain template and so the requirements to professionally oriented texts written in English used in teaching and learning process. The assessment of a text obtained by web search will be discussed in the next section.

3 Conclusion

The proposed method of using semantic patterns for web search and assessment of professionally oriented training texts in a foreign language intended for students of higher education institutions of mineral resources development profile complies with the general approach to developing SWBE systems. With the view to implementing the method, the work proposes a framework of an information system that interacts with ontologies storage and processor as required by overall architecture of SWBE.Domain templates intended for web search and assessment of texts in a foreign language are designed as part of an educational ontology for a foreign language course. The authors also propose to choose basic vocabulary lists in a foreign language commonly used to assess student knowledge as the source of input data essential to create a domain template. The article presents part of framework of a foreign language course educational ontology, which shows the way of incorporating a domain template intended for web search and assessment of texts in an educational ontology. The developed ontologies including domain templates are stored in the knowledge graph of a university SWBE system, with a fragment of such graph also presented in the article. The proximity of the texts found to the existing domain templates is estimated by means of calculating the proximity criteria, such as, first, terminology coverage defined as the percentage of terms present in a found text in relation to those listed in the domain template, and second, frequence of use of the terms pertaining to a domain template determined as the percentage ratio of terms pertaining to the domain template to the overall number of words in a text. As a case study the article investigates an example of creating a domain template for “Oil And Gas” learning direction built on a related basic vocabulary list. The work includes a fragment of a file containing input data and a corresponding fragment of a domain template in OWL format. In addition, the work proposes a tool for managing the quality parametres of a domain template by setting the sample size, the minimum frequence of using a term and maximum acquisition difficulty. As further development of the investigation it is considered appropriate to develop an application that implements the proposed method and to carry out quantitative analysis of parametres for estimating the proximity of the found texts to domain templates depending on the parametres of sample drawn from a related basic vocabulary list.

4 References

[1] Foundations of Statistical Natural Language Processing, ISBN-13: 978-0262133609, The MIT Press; 1st edition (June 18, 1999) Language: English 620 pages ISBN-10: 0262133601 ISBN-13: 978-0262133609

[2] Pascal Hitzler, Markus Krtzsch, and Sebastian Rudolph. 2009. Foundations of Semantic Web Technologies (1st. ed.). Chapman & Hall/CRC. https://doi.org/10.1201/9781420090512

[3] Devedžić, V. (2006). Semantic Web and Education. In Integrated Series in Information Systems. Springer US. https://doi.org/10.1007/978-0-387-35417-0

[4] Mitrovic, A., and Devedzic, V., 2004, A model of multitutor ontology-based learning environments. International Journal of Continuing Engineering Education and Lifelong Learning 14(3):229-245. https://doi.org/10.1504/IJCEELL.2004.004971
[5] Gruber, T. (1993). Toward principles for the design of ontologies used for knowledge sharing. Technical Report KSL93-04, Knowledge Systems Laboratory, Stanford University.
[6] Uschold, M. (Ed.). (1998). Knowledge level modelling: Concepts and terminology. Knowledge Engineering Review, 13(1), 5–29. https://doi.org/10.1017/S0269888998001040
[7] Uschold, M., & Jasper, R. (1999). A framework for understanding and classifying ontology applications. In Proceedings of the IJCA-I99 workshops on ontologies and problem-solving methods. Stockholm, Sweden.
[8] Introducing the Knowledge Graph: things, not strings. May 16, 2012. http://googleblog.blogspot.com/2012/05/introducing-knowledge-graph-things-not.html
[9] Haase, P., Herzig, D. M., Kozlov, A., Nikolov, A., & Trame, J. (2019). Metaphactory: A platform for knowledge graph management. Semantic Web, 10(6), 1109-1125. https://doi.org/10.3233/SW-190360
[10] Daqian Shi, Ting Wang, Hao Xing, Hao Xu, A learning path recommendation model based on a multidimensional knowledge graph framework for e-learning, Knowledge-Based Systems, Volume 195, 2020, 105618, ISSN 0950-7051, https://doi.org/10.1016/j.knosys.2020.105618.
[11] Qika Lin, Yifan Zhu, Hao Lu, Kaize Shi, Zhendong Niu, Improving University Faculty Evaluations via multi-view Knowledge Graph, Future Generation Computer Systems, Volume 117, 2021, Pages 181-192, ISSN 0167-739X, https://doi.org/10.1016/j.future.2020.11.021.
[12] Qi Li, Jun Qi Dong, Jiang Zhong, Qing Li, Chen Wang, A neural model for type classification of entities for text, Knowledge-Based Systems, Volume 176, 2019, Pages 122-132, ISSN 0950-7051, https://doi.org/10.1016/j.knosys.2019.03.025.
[13] Bobrova L. V., Sibirev V. N. Methodological challenges in presenting information to long distance students of Environment and Science Ecology, Environment and Conservation. 2018. №2. pp. 815-821. http://www.envirobiotechjournals.com/article_abstract.php?aid=7846&iid=230&jid=3
[14] Fedorova, M.A., Tsyguleva, M.V., Vinnikova, T.A., Sishchuk J.M. Distance Education Opportunities in Teaching a Foreign Language to People with Limited Health Possibilities. Astra Salvensis. Vol. 6, 2018.P. 631 - 637
[15] Yuliya Murzo, Svetlana Sveshnikova, Natalia Chuvileva, Method of Text Content Development in Creation of Professionally Oriented Online Courses for Oil and Gas Specialists, International Journal of Emerging Technologies in Learning (iJET), Vol 14, No 17 (2019), https://doi.org/10.3991/ijet.v14i17.10747
[16] Sishchuk Yu.M. German borrowings in russian mining-and-geological terminology. Journal of Mining Institute. 2016. Vol.219, p.504-507.
[17] Sharok Veronika V Role of socio-psychological factors of satisfaction with education in the quality assessment of university International Journal for Quality Research. 2018. №12. pp. 281-296. http://ijqr.net/paper.php?id=671
[18] Aidan Hogan, Eva Blomqvist, Michael Cochez, Claudia D'amato, Gerard De Melo, Claudio Gutierrez, Sabrina Kirrane, José Emilio Labra Gayo, Roberto Navigli, Sebastian Neumaier, Axel-Cyrille Ngonga Ngomo, Axel Polleres, Sabbir M. Rashid, Anisa Rula, Lukas Schmelzeisen, Juan Sequeda, Steffen Staab, and Antoine Zimmermann. 2021. Knowledge Graphs. ACM Comput. Surv. 54, 4, Article 71 (May 2022), 37 pages. https://doi.org/10.1145/3447772

[19] RFC standard. “Internationalized Resource Identifiers (IRIs)”, https://www.ietf.org/rfc/rfc3987 [last viewed Oct 17, 2021]
[20] Krinkin, Kirill, Alexander Vodyaho, Igor Kulikov, and Nataly Zhukova. 2021. "Method of Multilevel Adaptive Synthesis of Monitoring Object Knowledge Graphs" Applied Sciences 11, no. 14: 6251. https://doi.org/10.3390/app11146251
[21] Visual Ontology Editor “Protégé”: https://protege.stanford.edu/
[22] Web Ontology Language (OWL): https://www.w3.org/OWL/
[23] Kulikov I., Vodyaho A., Stankova E., Zhukova N. (2021) Ontology for Knowledge Graphs of Telecommunication Network Monitoring Systems. In: Gervasi O. et al. (eds) Computational Science and Its Applications – ICCSA 2021. ICCSA 2021. Lecture Notes in Computer Science, vol 12956. Springer, Cham. https://doi.org/10.1007/978-3-030-87010-2_32
[24] OWL-S. https://www.w3.org/Submission/OWL-S/
[25] Natalya F Noy and Deborah L McGuinness. Ontology development 101: A guide to creating your first ontology. Stanford knowledge systems laboratory, 2001.
[26] Paul Buitelaar, Philipp Cimiano, and Bernardo Magnini. Ontology learning from text: methods, evaluation and applications, volume 123. IOS press, 2005.
[27] Dieter Fensel. Ontology-based knowledge management. Computer, 35(11):56–59, 2002. https://doi.org/10.1109/MC.2002.1046975
[28] Nicola Guarino. Formal ontology, conceptual analysis and knowledge representation. International journal of human-computer studies, 43(5-6):625–640, 1995. https://doi.org/10.1006/ijhc.1995.1066
[29] York Sure and Rudi Studer. A methodology for ontology-based knowledge management. Towards the semantic web: Ontology-driven knowledge management, pages 33–46, 2003. https://doi.org/10.1002/0470858060.ch3
[30] Natalya F Noy, Monica Crub´ezy, Ray W Fergerson, Holger Knublauch, Samson W Tu, Jennifer Vendetti, and Mark A Musen. Protege-2000: an open-source ontology-development and knowledge-acquisition environment. In AMIA Annu Symp Proc, volume 953, page 953, 2003.
[31] Friend of a Friend (FOAF) ontology. http://xmlns.com/foaf/spec/
[32] Helena Sofia Pinto and João P Martins. 2001. A methodology for ontology integration. In Proceedings of the 1st international conference on Knowledge capture (K-CAP '01). Association for Computing Machinery, New York, NY, USA, 131–138. https://doi.org/10.1145/500737.500759
[33] Silvio Domingos Cardoso, Marcos Da Silveira, Cédric Pruski, Construction and exploitation of an historical knowledge graph to deal with the evolution of ontologies, Knowledge-Based Systems, Volume 194, 2020, 105508, ISSN 0950-7051, https://doi.org/10.1016/j.knosys.2020.105508
[34] Resource Description Framework (RDF) Standard: https://www.w3.org/RDF/
[35] RDF Schema 1.1 Standard: https://www.w3.org/TR/rdf-schema/
[36] Thoo, A. C., Hang, S. P., Lee, Y. L., & Tan, L. C. (2021). Students’ Satisfaction Using E-Learning as a Supplementary Tool. In International Journal of Emerging Technologies in Learning (iJET) (Vol. 16, Issue 15, p. 16). International Association of Online Engineering (IAOE). https://doi.org/10.3991/ijet.v16i15.23925
[37] Ma, H., & Li, J. (2021). An Innovative Method for Digital Media Education Based on Mobile Internet Technology. In International Journal of Emerging Technologies in Learning (iJET) (Vol. 16, Issue 13, p. 68). International Association of Online Engineering (IAOE). https://doi.org/10.3991/ijet.v16i13.24037

5 Authors

Yuliya Murzo is a Senior Teacher of the Department of Foreign Languages of Saint-Petersburg Mining University, 21st Line of Vasilevskiy Island 2, 199106, Saint-Petersburg, Russia.

Natalia Chuvileva is Associate Professor of the Department of Foreign Languages of Saint-Petersburg Mining University, 21st Line of Vasilevskiy Island 2, 199106, Saint-Petersburg, Russia (email: Chuvileva_NV@pers.spmi.ru).

Aleksandra Schetinina is a Senior Teacher of the Department of Foreign Languages of Saint-Petersburg Mining University, 21st Line of Vasilevskiy Island 2, 199106, Saint-Petersburg, Russia (email: schetinina_at@pers.spmi.ru).

Article submitted 2021-11-11. Resubmitted 2021-12-20. Final acceptance 2021-12-21. Final version published as submitted by the authors.