International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075, Volume-9 Issue-12, October 2020

Ontology-Based Metasearch Engine in Electronics Area

Tatyana Ivanova

Abstract: Paper The goal of search engines is to return accurate and complete results. Satisfying concrete user information needs becomes more and more difficult because of inability in it complete explicit specification and short comes of keyword-based searching and indexing. General search engines have indexed millions of web resources and often return thousands of results to the user query (most of them often inadequate). To increase result's precession, users sometimes choose search engines, specialized in searching concrete domain, personalized or semantic search. A grand variety of specialized search engines may be found (and used) in the internet, but no one may guarantee finding of existing in the web and needed for the concrete user resources. In this paper we present our research on building a meta-search engine that uses domain and user profile ontologies, as well as information (or metadata), directly extracted from web sites to improve search result quality. We state main requirements to the search engine for students, PHD students and scientists, propose a conceptual model and discuss approaches of it practical realization. Our prototype metasearch engine first perform interactive semantic query refinement and then, using refined query, it automatically generate several search queries, sends them to different digital libraries and web search engines, augments and ranks returned results, using ontologically represented domain and user metadata. For testing our model, we develop domain ontologies in the electronic domain. We will use ontological terminology representation to propose recommendations for query disambiguation, and to ensure knowledge for reranking the returned results. We also present some partial initial implementations query disambiguation strategies and testing results.

Keywords : Semantic metasearch engine, semantic search, federated search, ontology.

I. INTRODUCTION

PhD students and scientists needed from many resources in the realm of learned or studied domains: tutorials, manuals, books, news, software information and code sources, scientific papers, etc. Some of them, as tutorials, can be found in the web, others are managed by web 2.0 tools (as news and collaboration), but a largest part of scientific information is stored in Digital Libraries (DL). Digital libraries are a set of electronic information resources and associated technical capabilities for creating, organizing, searching and using them by humans. Digital libraries store information resources (papers, tutorials, etc), described by metadata, containing information about creator, owner, type of representation, reproduction, access rights, short domain description. Metadata also may contain links or relationships between resources and other data or metadata. Searching scientific resources in the web is principally different from searching it in digital libraries. Digital library resources typically are stored in databases, and hence they are deep web resources. There are valuable difficulties in crawling and indexing such resources on the one hand, and specialized searching approaches, based on specific library metadata may be used to facilitate searching in digital libraries on the other. That is why digital libraries typically use embedded search tools.

Traditional (surface web) search engines use syntax based (keyword-based) search. They use web robots for crawling and indexing web pages, and can index digital library content if they implement Z39.50, or Open Archives Initiative (OAI) search protocols. The basis for search usually is syntactic term matching between the user's queries and previously created from the search engine indexes. Semantics, that user implicitly associates with the search string are not captured. Thus, a search query is typically very broad, often ambiguous, and specific library metadata are only partially used as part of various search strategies. That is why general search engines may return some scientific papers, relevant to the query, but it list is incomplete, they may not be the relevant ones, and usually appear far from the beginning of the list. That is why native searching tools are the best tools for searching papers in digital library. On the other hand, there are thousands digital libraries in the web, and one must know for libraries, contain resources in it scientific area and search every of them to find needed resources. This include specialized skills in usage several different user interfaces and usually search will take much time. We have found several federated search engines, searching in sets of digital libraries (*Infomine*, *Infoplease, Microsoft Academic Search*, *WorldWideScience,* and some others), but it evaluation leads to conclusion that they return very few results in our domain (electronics, testing and diagnosis of electronic circuits), and some of them are working very slowly. That is why we decide to find the best digital libraries in our research area and create federated metasearch engine, that perform semantic searching, augmenting and reranking returned from them search results.

In this paper we present our research on building a meta-search engine that uses domain and user profile ontologies, as well as information (or metadata), directly extracted from web sites to improve search result quality. We state main requirements to the search engine for students, PHD students and scientists, propose a conceptual model of federated search engine for searching scientific resources and discuss approaches of it practical realization.. It can make some interactive semantic query refinement, automatically generate several search queries, sends them to digital libraries and web search engines, augments and ranks returned results, using ontologically represented domain and user metadata.

Revised Manuscript Received on October 10, 2020.
* Correspondence Author
Tatyana Ivanova *, Technical University of Sofia, College of Energy and Electronics, Botevgrad, Bulgaria tiv72@abv.bg

For testing our model, we develop domain ontologies in the electronic domain.

II. REQUIREMENTS TO THE SCIENTIFIC PAPER METASEARCH ENGINE

The proposed metasearch engine is intended to fetch scientific papers, tutorials, presentations, and other learning or scientific resources, needed to students for supporting learning or scientific research. It should provide easy, effective and precise search in digital libraries, searching some specific resources in the web, as well as natural language question answering. It should be flexible, personalized, and easy-to use. More precisely, it should:

1. Propose some guidance for users in formulating effective queries. This is useful not only for beginners. Different search engines have some specifics and rapid understanding them is very important even for domain experts to use it maximal capabilities. Good way to do this is combining traditional keyword search with view-based and semantic search by displaying related concepts and it relationships using view-based UI.
2. Supporting automatic or semiautomatic dynamic selection of appropriate search engines or digital libraries depending from searched domain, type of searched resources or query type.
3. Supporting the needed set of advanced searching options for explicit specification of preferred resource types, searching domains, search strategies, or other user preferences
4. Possibilities in reclassifying the result set using different criteria (as domain relevance, material type, conference or journal valuability, number of citations, etc.)
5. Adaptability, extensibility and maximal domain independence.
6. Adequate searching performance

III. RELATED WORK

As we will use technologies for semantic search and federated search, we will make short analysis of popular web search engines, using some of these type technologies.

A. Semantic Search Engines

Semantic search is the indexing and searching approach, intended to improve search accuracy by understanding searcher intent and clarify contextual meaning of terms both in searching and indexing. To use this approach, machine-processable metadata about resources are needed. Because of insufficient amount of such metadata, difficulties in it generation and immaturity of semantic web technologies, these modern technologies are not yet widely used. There is grand number of research projects and some well working search engines in the web, using semantic technologies. Some of them (for example Hakia, Powerset, or Lexxe) are developed as semantic search engines, and others (as google or bing) are traditional good keyword-based search engines, extended by using semantic or intelligent technologies.

GoPubMed(http://gopubmed.com/) is the first semantic search engine on the internet - launched in 2002. It is a knowledge-based search engine for biomedical texts. Ontogator[1] is a web service – based tool, that uses semantic view-based search and provide web service to external applications through an API. It uses the SUMO ontology class hierarchy to support graphical interface. This approach has been implemented in the open source tool Ontogator, that has been applied in developing semantic web portals. Semsearch [3] is a keyword-based semantic search engine having layered architecture, google-like query interface and supporting relatively complex queries and quick response. Hakia (http://hakia.com/) is a semantic search engine for searching Web, News, Blogs, hakia Galleries, Credible Sources, Video, and Images. It use new semantic technology called QDEXing, SemanticRank algorithm, ontological semantics, fuzzy logic, computational linguistics, and mathematics. Lexxe is an Internet search engine that uses natural language processing for queries (semantic search). Searches can be made by using questions, as "What Is Difference Between Fpga And Microcontroller?", as well as keywords and phrases. Ask (http://www.ask.com/) is one of the popular web search engines. It combines keyword-based search, natural language processing and question answering. Swoogle, Corese, Watson are search engines for searching semantic web documents. Some of them (as Swoogle) propose easy-to use graphical tools for visualizing ontologies or checking it consistence. Assistance in semantic query formulation, natural language processing capabilities, higher precision and clustering of returned results are the main strengths of semantic search engines. It drawbacks are the low recall and performance (they usually work slowly and return too few results). Most of them (with the exception of google or Bing) don't search digital libraries and other valuable scientific information sources. The biggest search engines Yahoo! And MSN promotes it semantic searching capabilities (mainly including the listing of search suggestions as queries are entered and a list of related searches) on the base of semantic technologies purchased from Powerset in 2008. On July 29, 2009, Microsoft and Yahoo! announced a deal in which Bing would power Yahoo! Search. Google also has emerging semantic search capabilities.

There are many researches on semantic search engines, specialized in bioinformatics [6]. [7], [9]. Recently, semantic search engines are proposed in electronic health [10], for searching GOVID information [11], in computer science [12], Semantic Web of Things[13], for searching Academic Resources on Engineering [14], and many other areas.

Latest trend is to develop semantic applications, working well in non-international languages. *Ontological Search Engine* called IBRI-CASONTO [5] supports both Arabic and English language. It also supports two types of search: a keyword-based search and a semantics-based search. [8] propose a non-ontology-based search engine for searching Web data represented in UNL (Universal Networking Language). This search engine is based on semantic graph matching (semantic expansion for graph nodes and relation matching based on relation meaning).

Retrieval Number: 100.1/ijitee.L80141091220
DOI: 10.35940/ijitee.L8014.1091220

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication

B. Federated search engines

The biggest pat of scientific information is presented in scientific papers, which are stored in digital libraries (DL), and is a part of hidden web content. Scientific papers are described by standard set of metadata and use restricted vocabularies, including a set of common words (as articles, conjunctions, and common verbs), common research dictionary and domain-specific dictionary. There are several DL metadata standards, every library has its own specifics and efficient searches require sending specific (may be different for different libraries) queries to satisfy the same information needs, and augment in the appropriate way returned results. In other words, we should develop a federated metasearch engine, if simultaneous usage of several DLs is needed. There are many (well, or not so well working) research projects, or web search engines, performing federated search. [4], for example presents Noesis - a search tool for Atmospheric Science which is a meta-search engine and a resource aggregator that uses domain ontologies to provide some semantic search capabilities Noesis uses ontologies to help the user in query specification and improving search results precision and recall. Noesis uses a three step algorithm to search resources: Query Analysis, Semantics Presentation and Resource Search. It searches through search web services provided by third parties like www.yahoo.com and www.google.com for web-pages, data, education material and publications related to Atmospheric Science. Infomine is a federated search engine for the Deep Web and a source of the lot of other reference information. Infomine has been built by a set of university libraries in the United States and propose searching in different categories, including scientific databases. Infomine "˜mines' information from databases, electronic journals, electronic books, bulletin boards, mailing lists, online library card catalogs, articles, directories of researchers, and many other resources. It can be searched by subject categories (including engineering and computer science) and propose search refinement by using search options. When a few categories are chosen, it performance is relatively good, but our experimental testing by sending tens of queries show that it returns relatively few results in the area of electronics.

We have found several other federated search engines, searching scientific information sources in the internet, as Infoplace (information portal, proposing number of encyclopedias, almanacs, an atlas, and biographies), WorldWideScience.org - a global science gateway comprised of national and international scientific databases and portals, providing real-time searching and translation of multilingual scientific literature (http://worldwidescience.org/wws/result-list/fullRecord:fpga/preferredLanguage:en/.) The latest works in some cases very slow. Microsoft Academic Search [2] is a free search engine for academic papers and resources principally in the field of computer science, having good performance and returned sufficient number of results in the realm of electronics (as our preliminary tests show). It database consists of the bibliographic information (metadata) for academic papers published in journals, conferences proceedings and the citations between them and use vertical search technology. UTNetCAT is the Web-browsable online catalog of the University of Texas at Austin libraries. DeepDyve is a powerful, professional "Deep Web", search engine Researchers and students can use it for searching Wikipedia or deep web resources within multiple categories: Life Sciences and Medical, Physical Sciences, Humanities and Social Sciences, IT and Engineering, and others.

Many researches on federated search have done recently. An Overview Federated Search Systems Employed in Different Libraries is presented in [16]]. Federated search engine for open educational linked data is presented in [19].

An on-line and non indexing implementation of federated search engine, FOSSICK, that aggregates OpenSearch based results from various user selected search engines is presented in [15]. Modern trend in federated search is to combine federated and semantic approaches both in searching and presentation of results. Examples are: the method of and system for personalized federated search is presented in [17], a semantic federated search engine for domain-specific document retrieval is presented in [18], Federated semantic search using terminological thesauri for learning object discovery [20]. Searching digital libraries is the main purpose of the Google tool Google Scholar that indexes the full text of scholarly literature (free or charged, including the biggest and the best digital libraries) in many publishing formats and disciplines. The main drawback of Google Scholar is it returned results limit (only 1000 results), that make a grand number of indexed papers practically reachable only by using bibliographic search. Despite the large number of various libraries and searching tools, usually it is difficult to find the needed scientific papers or tutorials the realm of the good search engines usually is too broad and it is difficult to find the exact sources. In this paper we will present and discuss the conceptual model, augmenting semantic and federated search technologies, as well as the needed terminological and bibliographic data from Web to improve searching quality in the narrow scientific area. Possibilities to use our model in other scientific areas will be discussed. We also present some initial partial implementation and preliminary testing results.

IV. SEMANTIC METASEARCH ENGINE – DEFINITION AND CONCEPTUAL MODEL

There are a lot of various search engines, working well in some realms in the Internet. Most of them have good indexing and searching capabilities in some realm, but user goals often are more specific, or cover several subdomains, indexed by two or more search engines. Metasearch is the needed approach in this case, but working on the internet metasearch engines usually have broad coverage, and return very few results in closely specific domains. That is why the good focused search engines, combining results from different sources in closely specific areas and reranking them, using various strategies, are needed. It should use semantic technologies to overcome natural languages ambiguity and achieve high precision and recall. As a term "Semantic focused metasearch engine" is not defined, as Google search show, we will first define it:

Definition: ***Semantic focused metasearch engine*** (**SFME)** is web searching tool, that query Web search engines (or other web sources) to retrieve valuable amount of results in previously chosen domain, and can use various clustering or reranking strategies and semantic technologies to present them to the user.

The conceptual model of **SFME** is shown on the figure 1**.** It Should propose rich advanced search interface (as well as simple search one) and semantic query refinement tool for supporting precise and clear query specification. Then it sends the query to previously chosen and tested search engines, and augments and reranks returned results, using precise analysis of returned result metadata (or result analysis), based on specific domain thesauruses and/or ontologies (Fig. 1). Building such search engine is domain and tack-specific, as we should previously choose the best for the concrete domain sources (after testing a number of web searching tools or resources), develop needed thesauruses and ontologies, specify and test major augmenting or reranking strategies. The model and main amount of programming code is domain – independent, and after doing previously discussed tacks, we may customize the tool for other domains. Developing terminological and semantic sources (thesauruses, dictionaries or ontologies is uneasy tack, but more and more relatively appropriate may be found in the internet, and customize the concrete search tack. Ontology enrichment tool (Fig.1) may be used for semiautomatic ontology enrichment in the process of usage of the **SFME.**

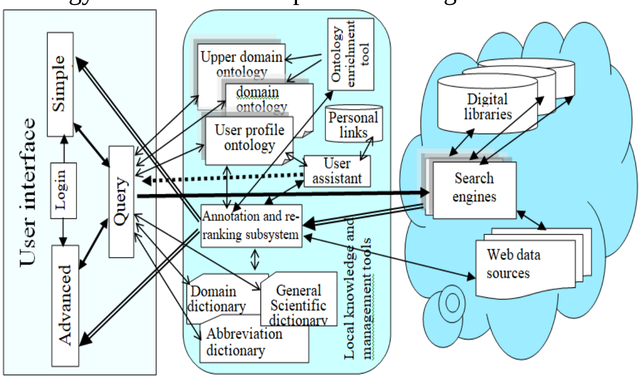

Fig. 1. The conceptual model of SFME

Our aim is to develop personalized SFME for students and scientists in the realm of electronics.

V.IMPLEMENTATION AND PRELIMINARY RESULTS

To develop a **SFME** for students and scientists for searching scientific papers and tutorials in the realm of electronics we will follow subsequent methodology:

A.Methodology for developing SFME

We propose the following main steps for developing SFME:

1. Search web for thesauruses, dictionaries and ontologies, related to the domain, of papers.
2. Collect the main domain terminology, presenting the concrete domain, where our tool will search
3. Find well working web search engines and test it capabilities (precision, recall, performance, possibilities to fetch metadata or other additional information)
4. Choose the best ones; make comprehensive study and preliminary tests of it searching capabilities and possibilities in customization and other information retrieval capabilities
5. Searching, various web information sources, containing scientific information (about conferences, journals, papers, scientists), making preliminary evaluation of it capabilities to return scientific information.
6. Developing initial versions of our ontologies and other local lexical sources
7. Developing (or reusing, if possible) the program code of SFME
8. Initial testing
9. Evaluation, usage and extensions.

B. Used web sources

In step 1 and 5 we choose the following web sources: Thesauruses and dictionaries: We download electronical terminology for building ontology from Big PLD-Glossary (http://www.fpga- guide.com/glossary/glossary.html), save it and use both for domain ontology development and terminology extraction from returned resource snippets. We also download from the web a collection of at about 500 terms, including general words and typical for scientific research consepts. As these terms are not appropriate for query refinement, we will not include it in the ontologies, and use it only for syntactic and lexical text analysis. We use web source for electronical terminology (that is not in our ontologies) from http://www.abbreviations.com/acronyms/ELECTRONICS/ (at about 50000 concepts). We download, save and search locally the resource when needed to determine is a term electronical or not. We also download ACM classification schema and use it in the process of upper ontology building and lexical text analysis. We also use web ontologies as FOAFRealm, PEOnto and DISCO in theprocess of building our profile ontology, and some ontologies, containing concepts in the area of electronics. Used Search engines: In step 3, we make brief exploration of at about 50 search engines: 7 semantic search engines, 11 federated search engines (mainly searching DLs), 17 native DL search engines, and 12 general search engines. We decide to test comprehensively some of the best general search engines (Google, Yahoo, Bing), semantic search engine Ask, DL search engines in the realm of electronics, engineering and computer technologies ACM, IEEE Xplore, IET DL, and metasearch engines Microsoft_Academic_Search and Research Gate. Research Gate is not only the search engine, but a professional network for scientists. It manages scientist's profiles from all scientific branches, search major digital libraries (using federated, bibliographic information-based search, or semantic search, based on abstract similarity). Unlike most of major popular search engines (including Google, Yahoo and Bing) it returns more than 1000 results, and use different ranking algorithm. Sometimes some of it first results can't be find using Google and the same query, as they appear after first 1000 Google results and become unreachable.

C. Preliminary tests of chosen engines searching capabilities

We divide possible queries in 4 types according to it potential ambiguity: general (ambiguous), including one concept, used not only in the electronic area, more specific, including one concept, used mainly in our domain, disambiguated, including extra term, making ambiguous query more clear, and more specific, disambiguated, where clear information need is specified. We show examples of such queries and number of returned results in table 1 and fig. 2, the average results from 30 queries of every type in fig 2, number and average number of relevant returned results (checking first 50 results) - on figure 3

Table 1. Example queries and number of returned results

query / engine	ACM	IET DL	IEEE	GOOGLE SCHOLAR	MAS	Research gate
general (ambiguous)						
board	61263	651	28798	2430000	10157	91777
testing method	1162	105800	788	159000	382	2229
more specific						
fpga	14629	489	18329	383000	9432	10948
"integrated circuit"	7889	500	102157	1250000	3375	2225
disambiguated						
"field programmable gate-array"	22125	125	4503	48900	1075	3245
fpga testing	529	0	1009	21600	307	127
more specific, disambiguated						
fpga testing algorithm	413	0	294	11800	37	20

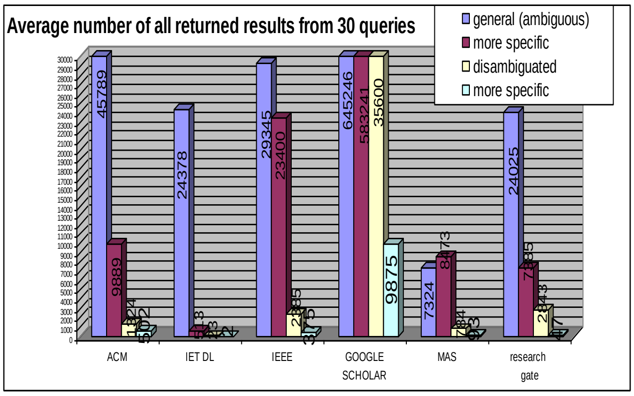

Fig. 2. Average of all retuned results

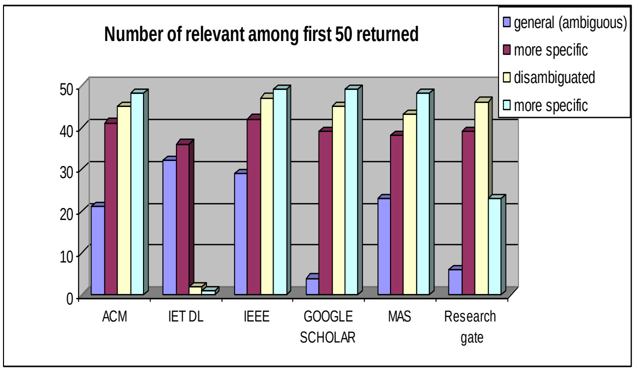

Fig. 3. Number of relevant among first 50

Our conclusions are that DL search engines return enormous amount of results, more of them are irrelevant, and it is very important to disambiguate search query before sending it to the search engines. Searching in scientific digital libraries is based only in word matching (no one of DL search engines have semantic capabilities) and disambiguation by adding extra words leads to excluding relevant results (for example, if author don't explain in the abstract that FPGA mean *"***F***ield-***P***rogrammable* **G***ate* **A***rray" then the query "***F***ield-***P***rogrammable* **G***ate* **A***rray" will not return this paper, but query* FPGA do! That is why query disambiguation is needed only for short and ambiguous should be very careful, and made only in the user control. We will use ontological terminology representation to ensure making relevant recommendations to the user in query disambiguation, and to present information for reranking the returned results. When sending queries to bigger library, including papers from several domains, disambiguation should be clearer, and more disambiguation words should be used. When sending queries to carefully chosen small domain library, disambiguation should be less restrictive to avoid exclusion of relevant results, and less disambiguation words should be used.

D. Developed ontologies

In step 6, we have developed initial versions of scientist profile ontology and electronical domain ontologies: upper domain ontology and domain ontology. For Upper domain ontology we use ACM classification. We use only these it elements, related to our domain, and add some extra classes to simplify mapping between upper (coarse-grained) and our domain ontology (fine-grained). Our domain ontology include classification of electronical concepts and processes, and it interdependencies, presented in the way, maximally simplifying search query disambiguation process. A part of ontology schema is shown on fig 4. (Opened in protégé editor).

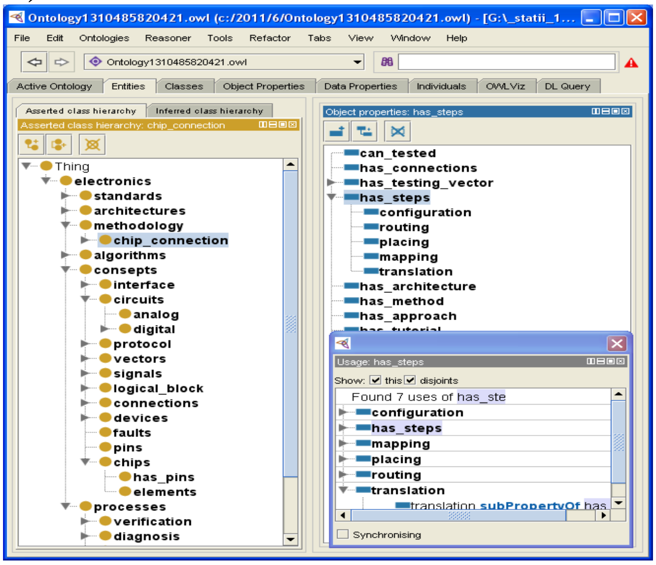

Fig. 4. A part of domain ontology

E. Query disambiguation and sending strategies

Our preliminary experiments show that quality of returned results is in short dependence of the quality of the query and of the chosen search engine. We divide possible queries in two main types: Queries for searching research papers, surveys, tutorials, queries for seeking response to a question. Our experiments, made by sending 20 queries of each type to five above DL search engines, three the biggest web search engines, and three semantic search engines (Ask, Hakia, SenseBot). Our findings are: For question responding, the best search engine is Ask.

For searching tutorials, both precision and recall are better for general searching engines, and disambiguation, included word “tutorial”. For searching surveys, DL search engines return the best results when disambiguation words “survey” or “overview” are used. Using these findings, we propose the following search strategies: For finding the answer, the question should be formulated shortly, but clearly using natural language patterns as “What does ***term*** mean” or “What is ***term”, and sent to the*** semantic search engine ask. For finding a tutorial, clear and short description of the domain (3-4 popular words, describing main concepts or processes), and word “tutorial” should be sent to good general search engine (Google, Yahoo, Bing). For finding a survey, clear and short description of the domain (3-4 popular words, describing main concepts or processes), and words “survey” or “overview” should be sent to appropriate DLs. When searching research paper, Appropriate DLs or federated search engines are recommended, and disambiguation using subclass helps in clear formulation of user needs, whereas disambiguation using supperclass is useful only if the term has many different meanings (for example, if search engine does not support selection of searching domains), but in many cases, there is better disambiguation strategy (for example, concept may be disambiguated by adding a process, related to them, processes may be disambiguated by adding a concept, related to them).

VI. CONCLUSION AND FUTURE RESEARCH

This paper presents a research on improvement of the search quality of scientific information in the internet. A concept ***Semantic focused metasearch engine*** (**SFME**) is defined, and conceptual model of such meta-search engine for scientists and students, is presented. It uses domain and user profile ontologies, as well as information (or metadata), directly extracted from web sites to improve search result quality. We state main requirements to such search engine and present our preliminary research about search engines and disambiguation strategies that should be used in such meta-search engine development in the area of electronics. We also specify our development methodology, and describe partial realization of the search engine (Java servlets, ontologies), following this methodology. Development of ranking and clustering algorithms and evaluation are ahead. We also plan to enrich our ontologies with Bulgarian language terminology (labels, descriptions) and evaluate our metasearch prototype in searching digital resources written in Bulgarian.

ACKNOWLEDGEMENT

The author would like to thank the Research and Development Sector at the Technical University of Sofia for the financial support.

REFERENCES

1. E. Makela, E. Hyvonen, and S. Saarela, Ontogator—a semantic view-based search engine service for web applications. In Proceedings of the 5th International Semantic Web Conference (ISWC 2006), Nov 2006.
2. Available: http://en.wikipedia.org/wiki/Microsoft_Academic_Search
3. Y. Lei, V. Uren, E. Motta, Semsearch:A search engine for the semantic web. In:Proceedings of the 15th International Conference on Knowledge Engineering and Knowledge Management(EKAW),2006.
4. S. Movva, R. Ramachandran, X. Li, P. Cherukuri, S. Graves, Noesis: A Semantic Search Engine and Resource Aggregator for Atmospheric Science, American Geophysical Union, Fall Meeting, 2006.
5. A. Sayed, and A. Al Muqrishi, IBRI-CASONTO: Ontology-based semantic search engine. Egyptian Informatics Journal, 18(3), 2017, pp.181-192.
6. W. Hu, H. Qiu, J. Huang, and M. Dumontier, BioSearch: a semantic search engine for Bio2RDF. Database, 2017.
7. A.J. Soto, P. Przybyła, and S. Ananiadou, Thalia: semantic search engine for biomedical abstracts. Bioinformatics, 35(10), 2019, pp.1799-1801.
8. M. Farouk, M. Ishizuka, and D. Bollegala, Graph Matching Based Semantic Search Engine. In Research Conference on Metadata and Semantics Research (pp. 89-100). Springer, Cham, October. 2018.
9. A. Allot, Y. Peng, C.H. Wei, K. Lee, L. Phan, and Z. Lu, LitVar: a semantic search engine for linking genomic variant data in PubMed and PMC. Nucleic acids research, 46(W1), 2018, pp.W530-W536.
10. R. Lelong, C. Cabot, L.F. Soualmia, and S. Darmoni, Semantic search engine to query into electronic health records with a multiple-layer query language. In Proceedings of the 2nd SIGIR workshop on Medical Information Retrieval (MedIR), 2016.
11. A. Esteva, A. Kale, R. Paulus, K. Hashimoto, W. Yin, D. Radev, and R. Socher, Co-search: Covid-19 information retrieval with semantic search, question answering, and abstractive summarization, arXiv preprint, 2020.
12. B. G. Humm, and H. Ossanloo, A semantic search engine for software components. In Proceedings of the International Conference WWW/Internet, 2016. (pp. 127-135).
13. A. Kamilaris, S. Yumusak, and M.I. Ali, December. WOTS2E: A search engine for a Semantic Web of Things. In 2016 IEEE 3rd World Forum on Internet of Things (WF-IoT), 2016, (pp. 436-441). IEEE.
14. A. Fidalgo-Blanco, M.L. SEIN-ECHALUCE, F.J.G.P. ALVO, and M.S. NCHEZ-CANALES, Validation of a Semantic Search Engine for Academic Resources on Engineering Teamwork. INTERNATIONAL JOURNAL OF ENGINEERING EDUCATION, 36(1), 2020, pp.341-351.
15. D. Chhanga, and X. Shukla, Fossick: An implementation of federated search engine. International Journal Of Computer Science Engineering And Information Technology Research (IJCSEITR), 6, pp.69-78, 2016.
16. T. Hussain, Federated Search Systems Employed in Different Libraries: An Overview. Journal of Advancements in Library Sciences, 2(1), pp.57-62, 2018.
17. R. Barve, et al. Method of and system for conducting personalized federated search and presentation of results therefrom. U.S. Patent Application 16/865,770, 2020.
18. M. Dragoni, A. Rexha, H. Ziak, and R. Kern, . A semantic federated search engine for domain-specific document retrieval. In Proceedings of the Symposium on Applied Computing, April 2017 (pp. 303-308).
19. M. Mosharraf, and F. Taghiyareh, Federated search engine for open educational linked data. Bull. IEEE Tech. Comm. Learn. Technol, 18(6), 2016.
20. D. Koutsomitropoulos, G. Solomou, and K. Kalou, Federated semantic search using terminological thesauri for learning object discovery. Journal of Enterprise Information Management, 2017.

AUTHORS PROFILE

Tatyana Ivanova has completed she's Bachelor and Master degrees at the Sofia University, Bulgaria. She has been a doctor in artificial intelligence systems and associate professor at Technical Uuniversity of Sofia since 2012. She is a Vice-head of the Department of Electronics and Electricity at the College of Energy and Electronics - Botevgrad. She has been working in the field of intelligent technologies, ontological modelling, semantic WEB and e-learning for at about 20 years and is an author or co-author of seven textbooks and 78 scientific publications, almost all of which are in the listed areas and are cited in more than 60 sources, almost all of which are from abroad.