

Semantically Driven Presentation of Context-Relevant Learning Material

Alexander Streicher¹, Wolfgang Roller¹

¹ Fraunhofer IOSB, Karlsruhe, Germany

Abstract. In this paper we present our work on a new approach for an intuitive presentation of semantic relationships for the results of a semantic search algorithm. The underlying semantic search retrieves the most relevant learning material according to the context of the user. It provides the user with qualified learning material which is intelligently retrieved based on the current working situation. To ease the understanding how the presented result list has been generated a new presentation form is introduced. The preliminary results of our work are shown in a prototype implementation used for radar image interpretation. The aim is to optimally assist the image interpreters by offering relevant help and learning material.

Keywords: e-learning, semantic visualization, semantic retrieval, image interpretation

1. Introduction

Specialists in complex working environments face the challenge to be always up-to-date with their knowledge. They have to keep up with the often rapid development in their field of work. Assistance systems can aid them in their working tasks whereas e-learning systems can offer task-related information and learning material. With a combination of assistance and e-learning systems employees are capable of adapting to new scenarios and challenges as well as to solve new problems and to refresh and update their knowledge. In some areas employees must continuously update their knowledge because of the transient character of their field of work. This renders the learning process as lifelong learning instead of a one-time learning at school or in a qualification program. Assistance systems and e-learning systems can help the user to deal with situations when experience and background knowledge are not sufficient to solve new and unexpected problems. In this paper we present an approach how to present context relevant information of an interlinked assistance and e-learning system. The application scenario is e-learning for image interpretation.

The work of an image interpreter perfectly fits the description of a complex working environment. Image interpreters not only must be able to recognise various complex objects but they also require background knowledge for the correct and sound interpretation of the images. Different sensor and imaging parameters, a high variety in appearance of objects around the globe and time pressure create a challenging and demanding working environment. One of the most demanding tasks is the analysis of complex facilities, such as airfields, harbours and industrial installations, because they require immense technical background knowledge and deep understanding of the processes in such facilities. An additional difficulty arises with the use of complex imaging sensors, for instance radar image sensors. One manifestation of such a radar sensor is the Synthetic Aperture Radar (SAR) sensor. SAR is an imaging technology based on reflections of microwave pulses emitted by a radar sensor. Due to the complex imaging geometry and the very different reflection properties of objects in the microwave band, special training and substantial experience are required in order to be able to identify objects in this kind of images.

¹ <firstname.lastname@iosb.fraunhofer.de>

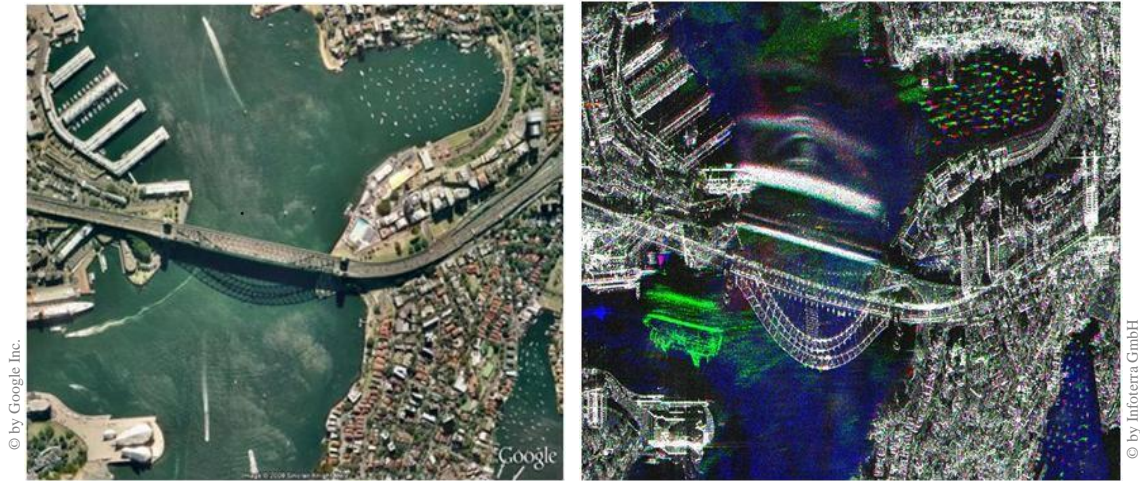


Fig. 1: Images of the sydney harbour bridge. Optical image (left) and radar image (right). The radar image shows the specific SAR radar effects (e.g. flipped down buildings, ghosting effects etc.)

SAR is used in a wide variety of application scenarios, e.g. pollution detection, cartography, ice layer and biomass monitoring as well as reconnaissance and surveillance. SAR signatures of objects differ significantly from those in an optical image because of specific SAR effects (for an example see Fig. 1). To ease the interpretation task assistance systems are being developed which help the user to classify objects in an aerial image. Although these systems can offer a wide variety of tools, e.g. for image processing, image annotations or automatic classification [3], the human-factor in the interpretation process still remains the essential element of correct and sound interpretation. The interaction with an assistance system can be utilized to gather information of the context of the user. For example, it collects information on objects which have already been recognized. This knowledge about the current state of the task can be used in order to provide the user with useful help and learning material, e.g. learning units of an e-learning system. The advantage is that the users get help when they need it most, i.e. when they reach the limits of their current knowledge and experience. We present an approach for semantic retrieval of relevant learning units with an intuitive visualization of the semantic relationships. The semantic search provides the user with qualified learning material which is intelligently retrieved based on the current working situation [12] [15]. In contrast to systems where the information retrieval is solely based on text retrieval methods this method finds linked concepts as well.

2. Semantic Search

The search space for the presented semantic retrieval is spanned using an ontology which is based on the *Simple Knowledge Organization System (SKOS)* [13] principle. SKOS provides an elementary vocabulary to describe basic structures of concept schemes. Because of its simplicity a SKOS-based ontology facilitates interoperability (e.g. ontology alignment) since the amount of ontology concepts and properties are well-defined and limited. With the logical basis of the ontology language semantic reasoning gets possible [8]. The technical details of the used semantic retrieval algorithm have been presented in [12].

2.1. Information Model

Basis for the search process is a domain ontology that encompasses concepts of the specific field of work. In the scenario for radar (SAR) image interpretation we chose the domain of airfields. The ontology contains concepts which cover the topic about airfields (e.g. hangar, tower, runway etc.) and it can be enriched with other related ontologies, for example the alignment with an ontology for geometrical aspects. The second part of the semantic model encompasses the learning units. Each learning unit has to be mapped to the concepts of the domain ontology. The mapping is done using a special relation in the ontology which has a binding weight property. This binding weight is computed for each concept accessible through relations starting from the learning unit to the domain ontology. This can be seen as an activation energy which spreads through the semantic network [6]. The calculated binding weights are used as relevance values for the result ranking of learning units, i.e. it determines the position of the learning units in the result list.

In Fig. 3 on the left you can see the semantic retrieval results as a normal ranking list. When the user navigates to a list entry the linked concepts for the marked entry are displayed. Histogram indicators encode the global frequencies of each search keyword (on the right in Fig. 3). The number of hits in these frequency classes is directly related to the position of the position of the entry in the result list. This answers question (1). The frequency classes are obtained by clustering the concepts according to their title values. As distance metric text similarity has been used after normalizing the keyword title values by syntactic text editing and linguistic stemming. To offer high affordance only the top ten most relevant results are presented at first.

Fig. 4 shows the inverse scenario. When the user marks a search keyword only those list entries are highlighted for which the keyword had an influence in the semantic spreading activation of the semantic search. This answers question (2), i.e. which influence a particular search keyword had on the result list.

4. Application

The described semantic search and visualization have been implemented in a working prototype for the intelligent interlinking of an assistance and e-learning system in the field of (SAR) image interpretation. In our application scenario the image interpreters interact with an assistance system for infrastructure image interpretation and with an e-learning system which provides help and learning content. As reliable algorithms for automated object recognition in aerial images are hardly available, these systems are often based on interactive approaches [4]. Such an assistance system supports image interpreters to perform a full analysis of a complex object arrangement, for example it helps to decide whether a radar image shows a civilian or military airfield. Singular objects (buildings, roads etc.) are marked by the user in the image and the system makes use of a probabilistic scene model to classify the function of the singular objects as well as the type of the overall facility. The classification results are presented to the user as recommendations.

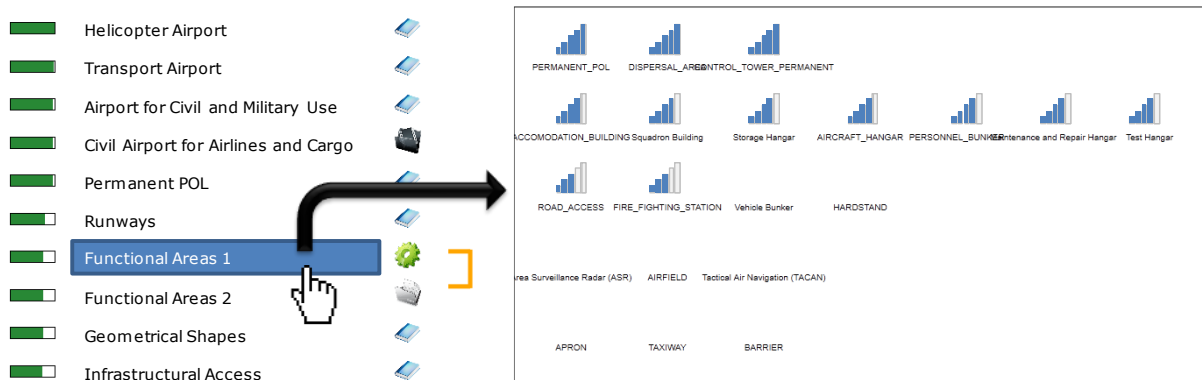


Fig. 3: Visualization of semantic retrieval results. (left) Ranking list, and (right) linked concepts to highlighted list entry sorted in frequency classes.

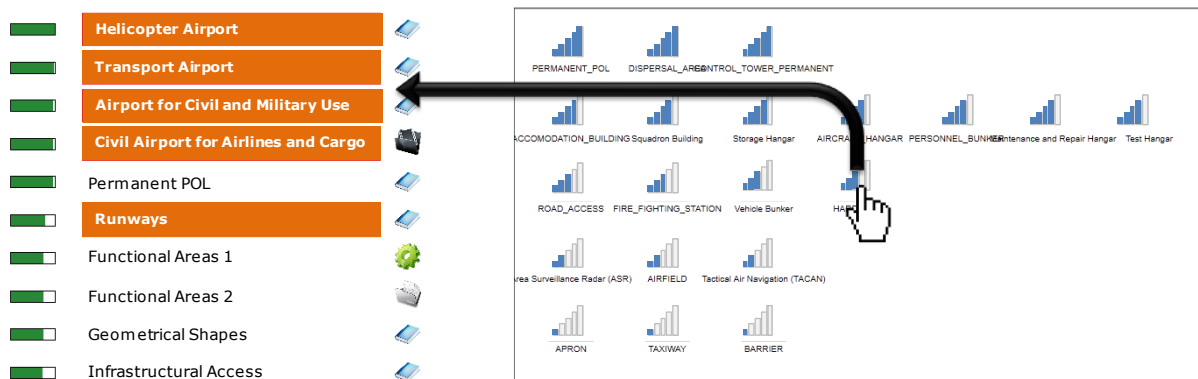


Fig. 4: Inverted view of the semantic retrieval results visualization. (left) Ranking with highlighted entries which are affected by the marked search keyword 'HARDSTAND' (below mouse pointer).

The other involved system is a customized e-learning system [16]. It includes a comprehensive e-learning course about radar image interpretation for reconnaissance as well as knowledge about image interpretation. These two systems have been interlinked by a semantic search algorithm which finds the most relevant help- and learning material according to the user's current working situation [12] [15].

The presented visualization method is the last step in the interlinking process, i.e. when the suggested retrieval results are shown to the user. We implemented our visualization concept in an interactive web-based prototype using freely available, standard-oriented libraries. The GraphML²-based, partially serialized ontology-structure of the retrieval results is rendered on the client-side with the JavaScript libraries jQuery³ and Raphaël⁴. All data in the interlinking process is communicated by web-service interfaces, for example the input data for the semantic search from the assistance system. Because of the usage of standard software with liberal licenses the presented visualization concept and its implementation can be transferred to other application scenarios.

5. Related Work

Using ontologies in e-learning systems and linking assistance systems has been done in [1] and [15]. Ontologies can be used to model teaching knowledge as well as to enable machine-based logical reasoning [10] and semantic search [9]. In the context of true information retrieval pure semantic search lacks in the ability to rank the results which renders the search process as plain data retrieval only. Combined with weights in the semantic network a mechanism based on the spreading activation principle [6] is able to produce scores for each accounted concept to enable a ranking of the results. Spreading activation in information retrieval can be seen in [7]. An approach similar to ours but without reference to context-aware e-learning is shown in [14] in which a search architecture is presented that combines classical search techniques with spreading activation techniques to execute semantic searches in websites. Rather than using keywords as user input for the semantic search it is possible to provide the search terms automatically by a preceding system, e.g. by an assistance system. This can be seen as intelligently interlinking multiple assistance systems. Interlinking of assistance systems and e-learning systems has been presented by [12] and [15]. They give a description of how to interlink an assistance system [3] for use in image interpretation of SAR images with an e-learning application [16].

The visualization of complex graphs is an ongoing and active research topic. One speciality is the visualization of ontologies. Most visualization methods render the ontology graph as planar 2-D view [11], others extend the visualization to 3-D and project the graph onto a sphere [5].

An intuitive visualization method suitably for e-learning applications is presented [2]. They show how to apply cartographic metaphors to learning maps for e-learning systems.

6. Conclusion

In this paper we presented a new concept for the visualization of semantic search results. The semantic search is part of an interlinking system for which a new idea has been presented as how to make the semantic relationships of the most relevant search results transparent to the user. The intuitive concept of a simple ranking list with additional attributes is combined with an extraction of the semantic structure behind the search results. The standard-oriented approach of the ontology schema allows for interoperability to other domains, direct reusability and feasible maintenance. Further research includes the automatic population of the ontology from given content as well as the integration of collaborative ontology engineering methods. Regarding the presentation layer an idea is to combine the presented visualization concept with the concepts of learning maps.

² GraphML is an XML-based file format to represent graph-like structures, <http://graphml.graphdrawing.org>.

³ jQuery is a free cross-browser JavaScript library to facilitate client-side scripting of HTML, <http://jquery.com>.

⁴ Raphaël is a free JavaScript library that to create vector graphics on the web, <http://raphaeljs.com>.

7. References

- [1] R. R. Amorim et al., "A Learning Design Ontology based on the IMS Specification", *Educational Technology & Society*, 9(1), pp. 38–57, 2006.
- [2] B. A. Bargel, J. Schröck, D. Szentes, W. Roller. "Using Learning Maps for Visualization of Adaptive Learning Path Components", *International Journal of Computer Information Systems and Industrial Management Applications*, Vol. 4, pp. 228-235, 2012.
- [3] A. Bauer, J. Geisler, "Decision support for object recognition from multi-sensor data", *Future security: 3rd Security Research Conference Karlsruhe, Thoma, Klaus (eds.)*, Congress Center Karlsruhe, Germany. Fraunhofer IRB Verlag, pp. 321-326, 2008.
- [4] A. Bauer, O. Herschelmann, G. Kamerman, "Exploiting context for assisted aerial image interpretation", *Electro-Optical Remote Sensing, Photonic Technologies, and Applications IV*, SPIE, 2010.
- [5] A. Bosca, D. Bonino and P. Pellegrino, "OntoSphere: more than a 3D ontology visualization tool", *Proceedings of SWAP 2005, the 2nd Italian Semantic Web Workshop, Trento, Italy, December 14-16, 2005, CEUR Workshop Proceedings*, 2005.
- [6] A. M. Collins, E. F. Loftus, "A spreading-activation theory of semantic processing", *Psychological Review*, 82(6), pp. 407-428, 1975.
- [7] F. Crestani, "Application of Spreading Activation Techniques in Information Retrieval", *Artificial Intelligence Review*, 11(6), pp. 453-482, 1997.
- [8] S. Decker, M. Erdmann, D. Fensel, R. Studer, "Ontobroker: Ontology based Access to Distributed and Semi-Structured Information", *Database Semantics: Semantic Issues in Multimedia Systems*, Kluwer Academic Publisher, pp. 351-369, 1998.
- [9] R. Guha, R. McCool, E. Miller, "Semantic search", *WWW '03: Proceedings of the 12th international conference on World Wide Web*, New York, NY, USA: ACM, pp.700-709, 2003.
- [10] N. Henze, P. Dolog, W. Nejdl, "Reasoning and Ontologies for Personalized E-Learning in the Semantic Web", *Educational Technology & Society*, Volume 7 (Issue 4), pp. 82-97, 2004.
- [11] A. Katifori, C. Halatsis, G. Lepouras, C. Vassilakis, and E. Giannopoulou, "Ontology Visualization Methods - A Survey," *ACM Comput. Surv.*, vol. 39, no. 4, p. 10, 2007.
- [12] N. Mareth, A. Streicher, A. Bauer, W. Roller, "Context-aware retrieval of learning units", *Proceedings of the IADIS International Conference e-Learning 2010*, Vol.1, pp. 357-364 , 2010.
- [13] A. Miles, B. Matthews, M. Wilson, D. Brickley, "SKOS core: simple knowledge organisation for the web", *DCMI '05: Proceedings of the 2005 international conference on Dublin Core and metadata applications*, Dublin Core Metadata Initiative, pp. 1-9, 2005.
- [14] C. Rocha, D. Schwabe, M. P. Aragao, "A hybrid approach for searching in the semantic web", *WWW '04: Proceedings of the 13th international conference on World Wide Web*, New York, NY, USA, ACM, pp. 374-383, 2004.
- [15] A. Streicher, N. Dambier, W. Roller, "Semantic Search for Context-Aware Learning". *7th International Conference on Next Generation Web Services Practices (NWeSP)*, pp. 346–351, 2011.
- [16] D. Szentes, B.-A. Bargel, A. Berger, W. Roller, "Computer-supported training for the interpretation of radar images", *7th European Conference on Synthetic Aperture Radar*, Friedrichshafen, Germany, 2008.