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Memory Islands¹: an approach to cartographic visualization

Abstract: The term “Memory Islands” was inspired by the ancient “Art of Memory” which described how people in the antiquity and the Middle Ages used spatialization to increase their memory capacity. The method of “loci” (plural of Latin locus for place or location) consists of creating a virtual map and associating each entity to designated areas on the map. In this paper, we propose a new method in the field of automated cartography based on the notion of Memory Islands for hierarchical knowledge. We first describe our novel method for cartographic visualization of knowledge (e.g. ontology and its skeleton which is taxonomy), we then show how the technique of “Memory Island” helps to navigate through information contents to memorize their locations and to retrieve them. We also discuss the design principles of this approach. Finally, we present an experimental prototype that is intended to evaluate the psychological relevancy of Memory Islands. We present also some preliminary empirical results showing that the use of Memory Islands provides advantages for non-experienced users tackling realistic browsing and visualization tasks.

Keywords: automated cartography; human-computer interaction; information visualization; ontology; hierarchy

1. Introduction

Formal ontologies as tools for conceptualisation and domain knowledge representation² have recently started to be widely applied, especially in the fields of semantic technologies, knowledge organization and digital libraries. The reasons for the ontologies reach outside their artificial intelligence and expert systems domain is their ability to support semantic linking, user interaction and data visualization. For instance, if a knowledge classification scheme data is presented as an ontology this not only opens many options for

¹ Art of memory (Ars Memoriae) is a general term for mnemonic principles and techniques used to organize memory impressions, improve recall, and assist in the combination and 'invention' of ideas (Yates, 1966).

² Ontology is usually referred to as a formal and explicit description of concepts (classes) in a domain of discourse (Noy & McGuinness, 2001). The term conceptualization can be understood here as an abstract, simplified view of the world, which needs to be represented for some purpose. It contains the objects, concepts and other entities that are presumed to exist in some area of interest, and the relations that exist between them (Gruber, 1993; Sowa, 2000). There are many mathematical definitions of ontology, such as those by Amann & Fundulaki (1999) that can help in understanding how ontology can be processed by programs.

accessing and managing its use by computer programs but also offers powerful ways in which it can be presented and visualized for use by humans.

Ontology enables many complex semantic relationships, associations and interactions in a knowledge system to be formalised for processing by machines which provides multiple ways of presenting or operating on the same set of data. However, rendering this complexity and making it practical for end-users is not a trivial task. For this reason, ontology visualization has attracted much interest with many research projects developing and testing methods, trying to find the best way of visualizing ontologies in order to achieve favourable outcomes for end-users.

Wang & Parsia (2006) were among those arguing that effective presentation of hierarchies can be a big help for users. Similarly, Katifori et al. (2007) argued that there is a growing demand for effective ontology visualization for design, management and browsing. However, they pointed out there is no ideal solution for all applications and, consequently, a viable solution would be to provide the user with several visualizations, so that he/she can choose the most appropriate for his/her current needs. In general, the other authors highlighted the low levels of user satisfaction in relation to the support of ontology visualization and exploration provided by current ontology visualization tools. This issue is particularly problematic for inexperienced users, who rely on effective tool support to abstract from representational details and to be able to make use of the contents and the skeleton of ontologies.

To address these issues, we propose a novel cartographic visualization approach for ontology and hierarchical knowledge called *Memory Islands*, as an aid to knowledge navigation and memorization. In this paper, we discuss design principles for this approach. We then describe a preliminary implementation of our approach by using a real-life application: the *InPhO* ontology. Finally, we present our protocols and experiments to evaluate *Memory Islands*.

2. Information visualization and ontology visualization

Information visualization has become a truly wide-ranging and interdisciplinary field of research and a vibrant global industry and a plethora of visualization methods and techniques have occurred at an accelerated pace across a wide range of disciplines. Our own research focuses on the science of visual representation of “data” i.e. on units of information which have been abstracted in some schematic form, including their attributes or variables.

The topic data visualization itself could be taken to subsume two main foci: statistical graphics and thematic cartography. Cartographic visualization is primarily concerned with representation constrained in a spatial domain; statistical graphics apply to any domain in which graphical methods are

employed in the service of statistical analysis. There is a lot of overlap, but more importantly, they share common historical themes of intellectual, scientific, and technological development (Friendly, 2009). Literature in this field provides many useful hints and advice on basic requirements. According to Schneiderman (1996) who defined *information visualization mantra* as being “overview first, zoom and filter”, the information visualization should also enable detail-on-demand, relationship views, it should keep a history of actions and allow extractions of sub-collections and query parameters.

When it comes to visualization of ontologies one would find that this is not an easy task due to the complexity of data involved including a hierarchy of concepts, concept attributes, concept relationships and relationship roles. This is further complicated when concepts have thousands of instances attached to them. This problem is usually addressed in ontology visualization by reducing ontologies to an approximation of a hierarchical structure that constitutes what is sometimes termed a “skeleton”. Usually, this skeleton gives a useful approximation of the ontology.

The main problem in ontology visualization is related to its size. Once the ontology becomes large the question is how to show its entire structure on a limited presentation space such as a computer or tablet screen. On the one hand, the information on display needs to be coarse-grained enough to provide an overview of the ontology to ensure that the user can maintain an overall mental model of the ontology. On the other hand, according to the second point of visualization mantra, i.e. zoom, an exploration process needs to be supported, where the user can effectively home in on parts of the ontology, thus changing the level of analysis, while at the same time not losing track of the overall organization of the ontology. The method of “Memory Islands” which we propose in this paper should help in resolving this problem by means of a cartographic approach to ontology visualization.

3. Approach

The name “Memory Islands” was inspired by the ancient “Art of Memory”, which described how people in the antiquity and the Middle Ages used spatialization to increase their memory capacity. This idea was transposed for the content of electronic books or digital media content in general (Ganascia, 2007).

The idea behind our approach is inspired by the method of “loci” (plural of Latin locus for place or location) in the “Art of Memory”, and it consists of creating a virtual map and associating each entity to designated areas on the map (Yates, 1966). Based on the idea, we transform structured knowledge into a 2D space representation that maps a logical structure to its contents (a hierarchical structure represented in a plane), each concept associated with a designated point on the map. This corresponds to an increase of dimensions, which is quite unusual in information visualization, since the usual aim is to reduce data

dimensions. The main goal is not to focus on a particular item, but to represent a wide variety of hierarchical structures and to stimulate human memory with an easy-to-remember picture, which facilitates user interactions with the content (same goal as the sense-making task). In this paper we use the term sense-making to refer to a specific ontology engineering task where the user is primarily concerned with understanding the contents and overall structure of the ontology, i.e., acquiring an overview of the concepts covered by the ontology and the way they are organized in a taxonomy.

Our approach is a new attempt in the field of cartographic visualization as it examines the problem of automated cartography, proposing a cartographic representation using the notion of Memory Islands for an ontology or tree-structured knowledge. This cartographic visualization task consists of: (1) extracting concepts, relationships (e.g. taxonomy) and the other types of information from sources; (2) automatically building the geographic representation corresponding to the given knowledge; (3) designing a user-interactive interface to display the cartographic result to help the user to navigate and memorize that knowledge.

As shown in Figure 1, in the domain of visualization, label placement is subject to serious label overlap problems. Our approach to solving the lack of space for label display was to implement a zoom function, similarly to the solution used in map services (e.g. *Google Maps* or *Apple Maps*). This provides a larger space to place labels at a higher zoom level.

{insert Fig1}

Figure 1: An example of label overlaps for visualization tool³

The visualization tools that support the zoom function or public map services usually have a maximum zoom level that is often given or pre-defined. The *Memory Islands* application, however, needed an automatic zoom level in order to represent all information of the given knowledge. We achieve this by applying Point-Feature Label Placement (PFLP)⁴ algorithms which determine the maximum zoom level (increase the zoom level until there is no label overlaps). Our prototype algorithm is summarized in Table 1.

Table1: *Memory Islands Prototype*

³ Visualisation created by an isomap function in R (package *vegan*) (borrowed from the InPho Data Blog <http://inpho.cogs.indiana.edu/datablog/the-shape-of-philosophy-pt-2/#more-323>).

⁴ Cartographic label placement refers to the text insertion process on maps and is one of the most challenging problems in cartographic information visualization known as the Point-Feature Label Placement (PFLP) problem. This is dealt with by various computer methods i.e. algorithms for automatic placing of text labels adjacent to point features on a map or diagram so as to maximize legibility.

Input:	User's Ontology file
Output:	The representation of Memory Islands
Step1:	Parse the ontology
1a:	Extract automatically the concepts and their relations from the given file and related web-sources.
1b:	Construct an ordered weighted tree to manage the information to visualize. Each concept is associated to a node in this tree
1c:	Re-order the tree if needed
Step 2:	Perform automated cartography algorithm to create a geographic representation of that tree structure. Associate each node to a specific location in the resulting map.
Step 3:	Initialize the map size according to the zoom-level (begin at level-1), and then initialize the labels according to the given configuration (random placement to begin)
Step 4:	Apply label placement algorithm to place the labels in the map
4a:	If Successful (no overlaps)
4a.1:	go to Step 5
4b:	Failure (at least one overlap accurate)
4b.1:	Increase zoom level. (Map size increase by four times.)
4b. 2:	Appropriate increase in the label size, make sure that the size increment for labels is less than the map
4b. 3:	Save current label placement configuration for next zoom level and go to Step 3
Step 5:	Create images for each zoom-level
Step 6:	Automatically create web-scale user interface

4. Implementation

Memory Islands application uses four subsystem components: Ontology Parsing, Automated Cartography, Label Placement & Image Generation and User Interface Generation (Figure 2).

{insert fig2}

Figure 2: *Memory Islands architecture: four subsystem components*

In the following sections we illustrate our implementation using the example of the *InPhO* ontology and describe *Memory Islands* sub-components. The activity diagram of our implementation is shown in Figure 5.

4.1. Indiana Philosophy Ontology

The *Indiana Philosophy Ontology (InPhO)* is a project on modelling the discipline of philosophy by Indiana University (Bloomington, USA). *InPhO* is a system that combines statistical text processing, information extraction, human expert feedback and logic programming to populate and extend a dynamic ontology for the field of philosophy. The *InPhO* is integrated in the editorial workflow of the *Stanford Encyclopedia of Philosophy (SEP)*⁵ to provide important metadata features such as automated generation of cross-references, semantic search, and ontology driven conceptual navigation (Buckner, Niepert & Allen, 2007). Figure 3 shows an example of *Memory Islands* for the *InPhO* ontology.

{Insert Fig 3}

Figure 3: *Memory Islands for the InPhO ontology*

4.2. *Memory Islands sub-system components*

Ontology Parsing - The sub-system *Ontology Parsing* extracts information from the given ontology source and additional features from associated web-sources such as Wikipedia, dictionaries or encyclopedias. With the *InPhO* cases, we used the *InPhO API*⁶ to access the supplementary information in their site and the articles in the *Stanford Encyclopedia of Philosophy* (Figure 4). In this sub-system, we also introduce some algorithms for re-ordering the tree structure.

{Insert Fig4}

Figure 4: *Visualization of the InPhO Ontology.*

Figure 4 illustrates how users can access the web source of the concept or instance with the help of *Memory Islands*. In this example the accessed site is *SEP*.

Automated Cartography - This part of the system deals with map generation. The *Automated Cartography* algorithm generates the map (island), which also includes the function for reshaping (e.g. using a curve to replace a line) and the mechanism for the coloration of the map.

⁵ *Stanford Encyclopedia of Philosophy (SEP)*. SEP is an online encyclopedia of philosophy implemented and managed by Stanford University since 1995. Concepts or general themes are freely available. The ontology *InPhO* has more than 250 ideas of philosophy with thousands of instances associated with the ideas (The exact number depends on the version of ontology). SEP is available at <http://plato.stanford.edu/>.

⁶ *InPhO API* is available at <https://inpho.cogs.indiana.edu/docs/>.

Label Placement & Image Generation - Is the part of the system, for placing the labels, we use stochastic algorithms similar to Simulated Annealing (SA) (Christensen, Marks & Shieber, 1995)⁷. In automated cartography, using SA to resolve PFLP has the following advantages :

- stochastic methods have the ability to jump out of local minima; PFLP by using SA can have a result better than PFLP by Tabu Search (TS) and Genetic Algorithms (GA) (Christensen, Marks & Shieber, 1995).
- no need to define the parameter (e.g. the size of Tabu List, etc.) for each problem to get the best result.
- Normally it's faster than the classic GA algorithms.

The way we use the label placement algorithms is displayed in the activity diagram of our implementation (Figure 5). In order to help the user experience better navigation and understanding of ontology, we used the final configuration (of label placement) of the previous zoom-level as the initial state of the next level. This method provides a higher possibility for a label already displayed in the last zoom-level to show-up in the next level in the same position. The SA accepts the worse re-placement and therefore, it can jump out of the local optima. When we display the labels in the final map, we do not include the label of a concept that is obscured by a label of a more general concept.

{Insert Fig 5}

Figure 5: *The activity diagram of our implementation*

User Interface Generation - For *Memory Islands* we have designed a web-scale user interactive interface (Figure 3, 4, 6) based on HTML 5 to display our cartographic result, which has integrated a small search engine. The user can access this everywhere, even from mobile devices.

{Insert Fig6}

Figure 6: *Search function of Memory Islands.*

5. Experimental evaluation

5.1. Methodology

⁷ Simulated Annealing (SA) is a stochastic gradient-descent method that allows movement in directions other than that of the gradient (Kirkpatrick, Gelatt & Vecchi, 1983; Cerny, 1985).

In order to evaluate our new approach for cartographic visualization, we need to compare it with other hierarchical structured knowledge visualization techniques. We have done a series of preliminary empirical evaluations on the different interfaces for visualization considering the following aspects with the participants possessing different levels of expertise:

- An experiment for the running time of each components of our implementation;
- The quality of the visualization: this experimental protocol is mainly about knowledge retrieval in order to test each point from Shneiderman's visualization mantra (Shneiderman, 1996);
- The psychological experimental protocol: browsing, understanding (Song et al., 2010), and remembering

5.2. Experiment of application runtime

In this section we describe an experiment designed to see how the application and also the island generation algorithm is evolved when the characteristics of an ontology changes. For example, we increased the number of nodes in the ontology and fixed other variables such as average number of children all over the tree, maximum number of children of a node in the tree and so on. We set up an experiment by generating virtual ontologies in which we can control their characteristics. Then we measured the runtime of each module. We ran different ontologies that are generated with the same characteristics at least three times and then computed the average value of the runtime. Figure 7 shows several pie charts of the time taken by the application when the number of nodes (concepts) is 300, 500 and 700, respectively.

{Insert Fig7}

Figure 7: The runtime for our implementation of Memory Islands⁸

5.3. Visualization mantras

To get an insight into ontology retrieval we designed a number of tasks for users to complete on a given ontology representation. We prepared tasks that test each point of the visualization mantras:

1. Overview: users are asked to guess the general domain of ontology or to guess by determining which portion of ontology contains the most or the least number of nodes;
2. Zoom: to check the zoom task, we asked questions such as how many descendants of a given node can the users find, etc.;
3. Filter: no questions asked for this type of task, as *Memory Islands* do not provide a function of hiding parts of the island;
4. Details-on-demand: users had to search for a specific node and either the ancestor or descendant node of that node;

⁸ Polyle is the name of Automated Cartography algorithms. LabelPlmt: Label Placement; AdjTree: algorithms for re-ordering tree structure. imgGen: generation images. ParseOnt: Parse Ontology.

5. Relate: the task was to find the relationship among the items. Thus, we asked users to compare two nodes of the same ontology and set some small task such as counting its children in order to make comparisons;
6. History: we asked the users what part of ontology they used for previous questions to check how well the users kept the information in their mind when exploring an ontology;
7. Extract: we did not check this mantra, because *Memory Islands* do not provide this function.

We had in total 20 participants with different levels of expertise:

- Zero knowledge of ontology: 9 users
- Have background in the field of ontology: 11 users

Four ontologies (*InPhO* ontology, *Software Ontology (SWO)*⁹, *Material Ontology*¹⁰ and *ONTODerm* ontology¹¹) were used for this task. In Figure 8 and 9 we can see how these two groups of users spent their time answering each type of question from different representations.

{Insert Fig8}

Figure 8: *Time Spent for non-experts*

{Insert Fig9}

Figure 9: *Time Spent for experienced users*

5.3. Psychological experimental protocol

This experimental protocol contains three tasks which are generally used for the evaluation of hierarchical data visualization: ontology browsing, ontology understanding and ontology remembering. We did a preliminary empirical test with the visualization tool *Gephi* (Bastia, Heymann & Jacomy, 2009) and the method of indented list (Katifori et al., 2006).

5.3.1 Ontology browsing

Navigating through the content of ontology is the main purpose of this task. During the task, we investigated ontology browsing with different interfaces by asking users to answer a set of questions. The answers we obtained from

⁹ *Software Ontology (SWO)* is a resource for describing software tools. SWO was created as a part of the JISC funded SWORD project (*Software Ontology for Resource Description*). It is available at: <http://theswo.sourceforge.net/>.

¹⁰ *Material Ontology* is an infrastructure for exchanging material information and knowledge. Documentation on Material Ontology is available at: <http://musigny.rds.toyo.ac.jp:8080/>.

¹¹ *ONTODerm* is a domain ontology for dermatology. It is available at: <http://www.ncbi.nlm.nih.gov/pubmed/18713597>.

various participants were meant to indicate how well they were able to browse and navigate taxonomies.

5.3.2. *Ontology understanding*

This task tested how well participants could understand an ontology using the three interfaces. The percentage of correct answers was meant to help us compare the visualization approaches.

5.3.3. *Ontology remembering*

The main purpose of the third task was to test how well the three interfaces could help users remember the positions of the classes on a previously visited path. In this task, we asked participants to revisit the previously visited classes after performing the browsing and understanding task. If participants could remember the approximate positions of the previously visited nodes, they were able to finish this task quicker and more accurately. It should be mentioned that one of the hypotheses of *Memory Islands* is that it should assist the memory and facilitate remembering of the ontology.

For this part of the evaluation we had in total 15 participants with different levels of expertise; the same ontologies were used as in the testing described in the previous section. Figure 10 shows the overall correct rate for each visualization tool.

{insert Fig10}

Figure 10: Overall correct rate for each visualization tools of the three tasks

5.4. *Discussion*

The results shown in Figure 7, indicate that when the number of nodes is low (e.g. at 300 nodes), the most usage time (for the different node numbers of the application) is spent on image tile generation, while all other modules use the same proportion of the remaining time. But when the number of nodes was increased to 500 and 700, the label placement module also increased significantly. The reason for this is the fact that we fixed the average number of children per parent, so that when the number of nodes increases, the probability of increasing the depth of skeleton of an ontology becomes higher. This could lead to a generation of an island in which we have less space to place labels. Furthermore, when we have a higher number of nodes, we have to place more labels.

From the results shown in Figure 8, we can see that non-experienced users spent less time when using *Memory Islands* to complete the task and that the time required to complete the task increased when the Node link diagram and Indented list were used. The same amount of time was spent on the tasks, when users were asked to compare features of two nodes from the same ontology at the same time. On other tasks, although users always spent less time on their tasks when using *Memory Islands* as opposed to a Node Link diagram, the difference was not significant. When it comes to experienced users (Figure 9), the results show a similar distribution of time spent per task to those measured for non-experienced users but with a smaller difference between values recorded for each visualization tool. This may be explained by the fact that experienced users could easily understand the tree structure and/or ontology based on their previous knowledge and thus could navigate through the ontology and answer questions quicker.

For the task of guessing the domain and portion of a node (the 'overview' task from visualization mantra), we can see that both groups needed less time to complete the task when using *Memory Islands* (Figures 8 and 9). This can be explained by the fact that users tend to be familiar with map representations and are able to understand the overview objective easily (previously referred to as sense-making). When groups are compared the results show that *Memory Islands* is more advantageous for non-experts.

For the part of the psychological experimental protocol, the results in Figure 10 indicate that *Memory Islands* offers a noticeable advantage when it comes to ontology browsing and the ontology remembering task¹². Regarding the ontology understanding task our experiment was not able to provide any conclusive evidence, since users are more familiar with *Indented List* than with *Memory Islands* and *Gephi*. Feedback received from experienced users indicated that even though they had worked on ontology before they were not sufficiently knowledgeable about the *Memory Islands* method in order to be able to use it to its full advantage. For instance, they did not realize that they could interact with an island. This is an interesting point that should be further explored and backed up with the research from the human computer interaction (HCI) field. The learning curve of users when they first interact with a new interface is a very important factor in determining the training process and for planning user interface evaluation and testing.

6. Conclusions and future research

¹² Examples for project memory-island and some of the experiment results are available at www.poleia.lip6.fr/~polyle/v2012/ex.html.

In this paper, we proposed a new approach for the visualization of ontologies called *Memory Islands* that can help advance the application of documentary and bibliographic classifications in information and knowledge discovery. We illustrated the progress we made towards an architecture for building a cartographic representation automatically from a given ontology. We also put forward a set of design principles that can help to implement the architecture successfully. We created a web-scale user interactive interface and protocols for the experimental evaluation of our implementation of *Memory Islands*. In summary, we have shown that *Memory Islands* performed better in retrieving, browsing and remembering ontology.

In the future, we plan to improve the performance of each part of our *Memory Islands* technology and the quality of the resulting map. We would also like to extend our work to the large-scale ontologies and add more cartographic features to our visualization approach.

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References

- Amann, B.; Fundulaki, I. (1999). Integrating ontologies and thesauri to build RDF schemas. In: *ECDL-99: Proceedings of the Third European Conference on Research and Advanced Technology for Digital Libraries, Paris, France, September 22-24, 1999*. Edited by S. Abiteboul, A.-M. Vercoustre. Berlin; Heidelberg: Springer. (Lecture Notes in Computer Science 1999), pp. 234-253.
- Bastian, M.; Heymann, S.; Jacomy, M. (2009). Gephi: an open source software for exploring and manipulating networks. In: *Proceedings of the 3rd International AAAI Conference on Weblogs and Social Media, May 17-20, 2009, San Jose, California*. Menlo Park, CA: The AAAI Press. Available at: <https://gephi.org/publications/gephi-bastian-feb09.pdf>.
- Buckner, C.; Niepert, M.; Allen, C. (2007). InPhO: The Indiana philosophy ontology. *APA Newsletters - Newsletter on Philosophy and Computers*, 7 (1), pp. 26-28. Available at: https://inpho.cogs.indiana.edu/papers/v07n1_Computers.pdf.
- Christensen, J.; Marks, J.; Shieber, S. (1995). An empirical study of algorithms for point-feature label placement. *ACM Transactions on Graphics (TOG)*, 14 (3), pp. 203-232. Available at:

<http://dash.harvard.edu/bitstream/handle/1/2032678/AnEmpiricalStudy.pdf?sequence=2>

- Friendly, M. (2009). Milestones in the history of thematic cartography, statistical graphics, and data visualizations. Available at:
<http://euclid.psych.yorku.ca/SCS/Gallery/milestone/milestone.pdf>
- Ganascia, J. G. (2007). AC³ - Automatic cartography of cultural contents. In: *[Proceedings of] Pixelization Paradigme: First Visual Information Expert Workshop, VIEW 2006, Paris, France, April 2006: revised selected papers*. Edited by P. P. Lévy et. al. Berlin; Heidelberg: Springer-Verlag. (Lecture Notes in Computer Science 4370), pp. 253-263.
- Gruber, T. R (1993). A translation approach to portable ontology specifications. *Knowledge Acquisition*, 5(2), pp. 199-220.
- Katifori, A. et al. (2006). A comparative study of four ontology visualization techniques in Protege: experiment setup and preliminary results. In: *Proceedings of the 6th conference on Information Visualization, IEEE Computer Society, Washington, DC, USA*.
- Katifori, A. et al. (2007). Ontology visualization methods: a survey. *ACM Computing Survey*, 39 (4), article no. 10. Available at: <http://dl.acm.org/citation.cfm?id=1287621>.
- Noy, N, F.; McGuinness, D.L. (2001). Ontology development 101: a guide to creating your first ontology. *Development*, 32 (1), pp. 1-25.
- Shneiderman, B. (1996). The eyes have it: a task by data type taxonomy for information visualizations. In: *Proceedings of the 1996 IEEE Symposium on Visual Languages, VL '96, Boulder, Colorado, 3-6 September 1996*. Washington, DC: IEEE Computer Society, pp. 336.
- Song, H. et al. (2010). A comparative evaluation on tree visualization methods for hierarchical structures with large fan-outs. In: *Proceedings of the 28th international Conference on Human Factors in Computing Systems - CHI '10, Atlanta, Georgia, April 10-15. New, York, NY: ACM Press, pp. 223-232 Available at: <http://research.microsoft.com/en-us/um/redmond/groups/cue/publications/chi2010-pittatree.pdf>*
- Sowa, J. F. (2000). *Knowledge representation: logical, philosophical and computational foundations*. Pacific Grove, CA: Brooks/Cole.
- Wang T. D.; Parsia, B. (2006). Cropcircles: topology sensitive visualization of owl class hierarchies. In: *5th International Semantic Web Conference, ISWC 2006, November 5-9, 2006, Athens, GA, USA*. Edited by I. Cruz et. al. Berlin; Heidelberg: Springer Verlag, pp. 695-708.
- Yates, F. A. (1966). *The art of memory*. Chicago, IL: University Of Chicago Press.

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